# Jan 2026 MDG Proposed Updates

Document Bookmarks provided for each Item listed below

| Revision Type | Reference | Section Description (Red indicates Change of name from existing) | Description of Revision | New or Deletion | Primary POC |
|---|---|---|---|---|---|
| MDG | ALL Chapters | MANY | Editorial update throughout MDG to change "Shared Use" to "Shared-Use" to be consistent with MUTCD | | Alford / Fiant |
| MDG | 1.4 | Definitions | Updated definitions for consistency with MUTCD | | Alford |
| MDG | 2.3.1.1 | Planning Resources | Updated Streetlight Data Row to indicate account access provided through Office of Planning rather that Office of Roadway Engineering. Also, removed safety data available timeframe years in Walk.Bike.Ohio row. | | Alford |
| MDG | Table 3-2 | Mean Walking Speeds for Disabled Pedestrians and Users of Various Assistive Devices | Corrected walking speed for Above-knee amputee row in table | | Alford |
| MDG | Figure 3-3 | Example of Mutual Yielding Zones Illustrating Intersection Sight Distance Case A | Update figure to show current MUTCD bike symbol marking | | Alford |
| MDG | Figure 3-4 | Intersection Sight Distance Bike Case B | Update figure to show current MUTCD bike symbol marking | | Alford |
| MDG | Figure 3-5 | Intersection Sight Distance Bike Case C1 – Two-Stage Crossing Scenario | Update figure to show current MUTCD bike symbol marking. Also update the figure legend. | | Alford |
| MDG | Figure 3-6 | Intersection Sight Distance: Bike Case C1 – Single Crossing Scenario | Update figure to show current MUTCD bike symbol marking | | Alford |
| MDG | Figure 3-7 | Intersection Sight Distance Case C2 | Update figure to show current MUTCD bike symbol marking | | Alford |
| MDG | Figure 3-12 | Pedestrian Crossing Shared-use Path or Separated Bikeway (shown) Sight Triangle | Update figure to show current MUTCD bike symbol marking | | Alford |
| MDG | Figure 3-13 | Spatial Dimensions for People Using Typical Mobility Devices | Revise to change the 72" Max vertical dimension to be 80" Min | | Alford |
| MDG | 3.6.2 | Shy Spaces | Update the "Intermittent Vertical Elements" section to reword mention of OMUTCD and associated language | | Alford |
| MDG | Figure 3-16 | Bikeway Shifting Tapers | Update figure to show current MUTCD bike symbol marking | | Alford |
| MDG | 3.7.1 | Utilities | Update last paragraph to provide correct reference to OMUTCD | | Alford |
| MDG | 4.3.2 | Pedestrian Zone Design - Pedestrian Zone Framework | Update Width section to provide additional clarification on the constrained condition and what to do if R/W takes are involved. | | Alford |
| MDG | Figure 4-6a | Potential Treatments for Mid-block Crossings with RRFB (3-Lane section with existing drives and 35 MPH or less posted speed) | Update figure to correct sign colors to make the warning signs black on yellow rather that black on white | | Alford |
| MDG | Figure 4-6b | Potential Treatments for Mid-block Crossings with PHB (3-Lane section with existing drives and greater than 35 MPH posted speed) | Update figure to correct sign colors to make the warning signs black on yellow rather that black on white | | Alford |
| MDG | Figure 4-6c | Potential Treatments for Mid-block Crossings with RRFB (5-Lane section with existing drives and 35 MPH or less posted speed) | Update figure to correct sign colors to make the warning signs black on yellow rather that black on white | | Alford |

# Jan 2026 MDG Proposed Updates

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| Revision Type | Reference | Section Description (Red indicates Change of name from existing) | Description of Revision | New or Deletion | Primary POC |
|---|---|---|---|---|---|
| MDG | Figure 4-6d | Potential Treatments for Mid-block Crossings with PHB (5-Lane section with existing drives and greater than 35 MPH posted speed) | Update figure to correct sign colors to make the warning signs black on yellow rather that black on white | | Alford |
| MDG | 4.5.1.1 | Crosswalk Markings | Update MUTCD references and associated TEM references | | Alford |
| MDG | 4.5.1.2 | Yield Markings | Update MUTCD references | | Alford |
| MDG | 4.5.5 | Raised Crossings | Updated bullet point referencing "Raised Crosswalk" sign to indicate "Speed Hump" sign | | Alford |
| MDG | 4.8 | Work Zones | Updated OMUTCD references | | Alford |
| MDG | Figure 5-9 | Shared-Use Path Stops or Yields | Update Figure Reference to be call out OMUTCD Table 2C-3 (instead of Table 2C-4) | | Alford |
| MDG | Figure 5-10 | Shared-Use Path Stops or Yields near Railroad Crossing | Update Figure Reference to be call out OMUTCD Table 2C-3 (instead of Table 2C-4) | | Alford |
| MDG | Figure 5-11 | Road Stops | Update Figure Reference to be call out OMUTCD Table 2C-3 (instead of Table 2C-4) | | Alford |
| MDG | Figure 5-12 | Multi-lane Road Uncontrolled with Advance Yield Line | Update Figure Reference to be call out OMUTCD Table 2C-3 (instead of Table 2C-4) | | Alford |
| MDG | 5.7.1 | Signs and Traffic Control | Update OMUTCD reference | | Alford |
| MDG | 5.7.2 | Pavement Markings | Update OMUTCD reference | | Alford |
| MDG | 5.8 | Shared Use Paths - Use of Limited Access Right of Way | New section providing guidance if considering a SUP within limited access right of way | New | Alford |
| MDG | Many | Many | Revised uses of "shared lane" and replaced with "shared-lane" to be consistent with usage in MUTCD | | Alford |
| MDG | 6.2 | On-Road Bicycle Facilities - Bicycle Routes | Add an additional bullet point under Signing and Markings to recommend to bicycle facility owners of non-numbered Bicycle Routes utilize the Non-Numbered Bicycle Route Signs as described in OMUTCD 9D.06. | | Fiant |
| MDG | Figure 6-1 | On-Road Bikeway Types | Update figure to show new Bike Symbol per MUTCD | | Alford |
| MDG | 6.3.1 | Shared Lanes | Update speed criteria and also update OMUTCD references. Update Shared Lane Signs section to refer to use of R4-19 Bicycle Passing Clearance sign and updated info related to "IN ROAD" plaque rather than "SHARE THE ROAD" plaque. Other clarifying updates for consistency with MUTCD. | | Alford |
| MDG | Figure 6-2 | Shared-Lane Markings Lateral Placement | Update R9-20 sign image for clarity and consistency with MUTCD | | Alford |
| MDG | Figure 6-3 | Longitudinal Placement and Intersection Navigation Examples of Shared-Lane Markings along a Roadway | Update figure to remove shared lane intersection guide markings per Section 9E.09 P 04 line B. | | Alford |
| MDG | 6.3.4 | Bicycle Lanes | Under header, "Bicycle Lanes on One-Way Streets" added clarifying language for counter-flow bike lane and also updated OMUTCD references. Added clarifying language addressing "EXCEPT BICYCLES" plaque. Removed reference to experimentation for use of Green Colored pavement (this is now standard element in MUTCD). | | Alford |
| MDG | Figure 6-5 | Shared-Lane Marking and Bike Lane on Steep Street | Update figure to show new Bike Symbol per MUTCD | | Alford |
| MDG | Figure 6-6 | Typical Bike Lane Pavement Markings and Traffic Control Signs | Update figure to show new Bike Symbol per MUTCD | | Alford |
| MDG | Figure 6-7 | Example of Door Zone Markings in Constrained Bike Lane Conditions | Update figure to show new Bike Symbol per MUTCD | | Alford |
| MDG | Figure 6-8 | Design Criteria for Back-in Angled Parking | Update figure to show new Bike Symbol per MUTCD | | Alford |

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|---|---|---|---|---|---|
| MDG | 6.3.5 | Buffered Bicycle Lanes | Update "Striped Buffer Markings" to clarify placement and use of diagonal lanes and buffer requirements | | Alford |
| MDG | Figure 6-9 | Typical Striped Buffer Treatments | Update figure to show new Bike Symbol per MUTCD | | Alford |
| MDG | 6.3.6 | Raised Bicycle Lanes | Corrected Signcode callout for BIKE LANE sign | | Alford |
| MDG | Figure 6-10 | Raised Bike Lane Examples | Update figure to show new Bike Symbol per MUTCD | | Alford |
| MDG | Figure 6-12 | Vertical Elements in the Street Buffer Zone | Update figure to show new Bike Symbol per MUTCD | | Alford |
| MDG | Figure 6-13 | Examples of Separated Bike Lane Drainage Configurations | Update figure to show new Bike Symbol per MUTCD | | Alford |
| MDG | Figure 6-14 | Example of Accessible On-Street Parking at Intersection | Update figure to show new Bike Symbol per MUTCD and remove reference to Interim Approval for Green Colored Pavement | | Alford |
| MDG | Figure 6-15 | Example of Accessible Mid-block On-Street Parking | Update figure to show new Bike Symbol per MUTCD and remove reference to Interim Approval for Green Colored Pavement | | Alford |
| MDG | Figure 6-16 | Transition to Shared Lane | Update figure to show new Bike Symbol per MUTCD and remove reference to Interim Approval for Green Colored Pavement and also correct bike box toward bottom of image and updated signage shown | | Alford |
| MDG | Figure 6-17 | Transition to Conventional Bike Lane | Update figure to show new Bike Symbol per MUTCD and remove reference to Interim Approval for Green Colored Pavement | | Alford |
| MDG | Figure 6-18 | Transition to Conventional Bike Lane on Intersecting Street | Update figure to show new Bike Symbol per MUTCD and remove reference to Interim Approval for Green Colored Pavement | | Alford |
| MDG | Figure 6-19 | Transition from One-Way to Two-Way Separated Bike Lanes at Protected Intersection | Update figure to show new Bike Symbol per MUTCD and remove reference to Interim Approval for Green Colored Pavement and also correct two-stage turn box for the south side of intersection | | Alford |
| MDG | Figure 6-20 | Transition from One-Way to Two-Way Separated Bike Lanes with Two-Stage Turn Box | Update figure to show new Bike Symbol per MUTCD and remove reference to Interim Approval for Green Colored Pavement and Two-Stage Bicycle Box | | Alford |
| MDG | Figure 6-21 | Transitions between Offset Intersections with Two-Way Separated Bike Lanes | Update figure to show new Bike Symbol per MUTCD and remove reference to Interim Approval for Green Colored Pavement and correct TWLTL markings | | Alford |
| MDG | Figure 6-25 | Example of Bikeshare Stations Installed Within a Roadway | Update figure to show new Bike Symbol per MUTCD | | Alford |
| MDG | 6.5.1 | General Bikeway Design at Intersections & Crossings | Updated language related to supplemental use of green colored pavement to be consistent with MUTCD. Also updated language related to Two-Stage Bike Turn Box to remove reference of needing experimental approval and added additional clarifying language on two-stage turn box use. Other clarifying updates in "Bike Boxes" section. | | Alford |
| MDG | Figure 6-26 | Bicycle Crossing Pavement Markings | Update figure to show new Bike Symbol per MUTCD and remove reference to Interim Approval for Green Colored Pavement and correct dotted bike crossing markings | | Alford |
| MDG | Figure 6-27 | Two-Stage Bike Turn Box Pavement Markings | Update figure to show new Bike Symbol per MUTCD and remove reference to Interim Approval for Green Colored Pavement and also update bottom left example | | Alford |
| MDG | Figure 6-28 | Two-Stage Left Turn Box Placement | Update figure to show new Bike Symbol per MUTCD and remove reference to Interim Approval for Green Colored Pavement and Two-Stage Bicycle Box | | Alford |
| MDG | Figure 6-29 | Bicycle Box Configuration Across One Lane of Through Traffic | Update figure to show new Bike Symbol per MUTCD and remove reference to Interim Approval for Two-Stage Bicycle Box. Also add green colored markings on this Figure | | Alford |
| MDG | Figure 6-30 | Protected Intersection Design Components | Update figure to show new Bike Symbol per MUTCD and remove reference to Interim Approval for Green Colored Pavement | | Alford |
| MDG | Figure 6-32 | Separated Bike Lane to the Left of a Right-Turn Lane (left) or Transitioning to a Shared RightTurn Lane (right) | Update figure to show new Bike Symbol per MUTCD and remove reference to Interim Approval for Green Colored Pavement | | Alford |

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| Revision Type | Reference | Section Description (Red indicates Change of name from existing) | Description of Revision | New or Deletion | Primary POC |
|---|---|---|---|---|---|
| MDG | 6.5.3 | Bicycle Lanes at Intersection Design | Update Approach Markings to indicate condition of use of dotted markings. Clarified language in, "Right-Turn Only Lane with Separated Bike Lane" | | Alford |
| MDG | Figure 6-33 | Buffered Bike Lane Treatments at Merge Areas | Update figure to show new Bike Symbol per MUTCD and remove reference to Interim Approval for Green Colored Pavement | | Alford |
| MDG | Figure 6-34 | Buffered Bike Lane Treatments Approaching Intersections | Update figure to show new Bike Symbol per MUTCD and remove reference to Interim Approval for Green Colored Pavement | | Alford |
| MDG | Figure 6-35 | Bicycle Lane Treatment for high turning volumes from a shared through/right motor vehicle lane | Update figure to show new Bike Symbol per MUTCD | | Alford |
| MDG | Figure 6-36 | Example Bike Lane Approach to a Right Turn Only Lane | Update figure to show new Bike Symbol per MUTCD (July updates provided tactile indicators and those are to remain) | | Alford |
| MDG | Figure 6-37 | Example Bike Lanes on Streets under 35 mph with Right Turn lanes < 200 Ft. in Length | Update figure to show new Bike Symbol per MUTCD and remove reference to Interim Approval for Green Colored Pavement | | Alford |
| MDG | Figure 6-38 | Example Bike Lanes on Streets over 35 mph or Right Turn Lanes > 200 ft. in Length | Update figure to show new Bike Symbol per MUTCD (July updates provided tactile indicators and those are to remain). Also remove IA reference. | | Alford |
| MDG | Figure 6-39 | Through Lane Drops to Right Turn Lane with Bike Lane | Update figure to show new Bike Symbol per MUTCD and remove reference to Interim Approval for Green Colored Pavement | | Alford |
| MDG | Figure 6-40 | Example Right Turn Only Lane with Shared-Lane Markings | Update figure to show new Bike Symbol per MUTCD (July updates provided tactile indicators and those are to remain). Also remove IA reference. | | Alford |
| MDG | Figure 6-41 | Through Lane with Shared-Lane Markings when Bike Lane Ends before Intersection | Update figure to show new Bike Symbol per MUTCD | | Alford |
| MDG | Figure 6-42 | Intersection Approach Options for Raised Bike Lanes | Update figure to show new Bike Symbol per MUTCD (July updates provided tactile indicators and those are to remain). | | Alford |
| MDG | 6.5.5 | Counter Flow Bike Lanes Intersection Design | Provided signcode for EXCEPT BICYCLES plaque and deleted sentence directing type of signal lense to use (since Bicycle Signal Head is now to be used). | | Alford |
| MDG | Figure 6-43 | Signing for Counter-flow Bike Lanes | Need feedback from FHWA. Is this Figure of concern? | | Alford |
| MDG | Figure 6-45 | Example Paved Shoulder Markings to Accommodate Bicycling | Update figure to show new Bike Symbol per MUTCD | | Alford |
| MDG | Figure 6-46 | Motorist Bypass Lane with Bicycle Lane | Update figure to show new Bike Symbol per MUTCD and add bike crossing markings | | Alford |
| MDG | Figure 7-1 | Actual Corner Radius vs. Effective Turning Radius | Correct figure to show diagonal lines oriented correctly | | Alford |
| MDG | Figure 7-2 | Typical Truck Apron Layout at a Protected Intersection | Update figure to show current MUTCD bike symbol marking | | Alford |
| MDG | Figure 7-11 | Schematic Examples of Mini-Roundabouts and Neighborhood Traffic Circle | Update Figure to show YIELD control on the left graphic rather than STOP control | | Alford |
| MDG | 7.8.3 | Vertical Deflection | Update OMUTCD References | | Alford |
| MDG | 7.8.4 | Street Width Reduction | Under header "One-Lane Pinch-Points" update sign nomenclature in bullet list for Designers to consider | | Alford |

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|---|---|---|---|---|---|
| MDG | 7.8.5 | Routing Restriction/Traffic Diversion | Update sign nomenclature under "Regulatory Signage" heading | | Alford |
| MDG | Figure 7-13 | Diagonal Diverter | Update figure to show current MUTCD bike symbol marking and also add "ALL-WAY" plaques on the STOP signs shown in graphic | | Alford |
| MDG | Figure 7-14 | Median Island Diverter | Update figure to show current MUTCD bike symbol marking and revise to show the R3-5R signs to be mounted overhead | | Alford |
| MDG | Figure 7-15 | Forced Turn - Directional Closure | Update figure to show current MUTCD bike symbol marking | | Alford |
| MDG | Figure 7-16 | Forced Turn - Right-In/Right-Out | Revise to show per MUTCD Section 2B.28 P 02, the R3-5R signs shall only be mounted overhead | | Alford |
| MDG | 8.3.1 | Pedestrian Signals | Update OMUTCD reference | | Alford |
| MDG | 8.3.2 | Pedestrian Detection | Update OMUTCD reference | | Alford |
| MDG | 8.3.3 | Signal Timing and Reducing Pedestrian Delay | Update OMUTCD reference | | Alford |
| MDG | 8.3.4.1 | Leading Pedestrian Intervals (LPIs) | Add this language to first bullet point, "When APS units are not provided, the minimum walk time should be LPI time plus 7 seconds as mentioned in Section 4I.06 of the OMUTCD." | | Alford |
| MDG | 8.3.4.3 | Concurrent Pedestrian Phase with Permissive Vehicle Turns | Update sign callout reference and also update OMUTCD reference | | Alford |
| MDG | 8.3.4.4 | Exclusive Pedestrian Phases | Update OMUTCD references | | Alford |
| MDG | 8.4.2 | Bicyclist Detection | Update language to indicate that Detection shall be provided with bicycle boxes. Also, remove reference to interim approval for bicycle boxes and two-stage bicycle boxes. Also update OMUTCD references. | | Alford |
| MDG | 8.4.3 | Signal Design Considerations | Revise to indicate all signl indications shall be the same size. Also added callout for R10-41c sign Bicycle Signal sign. Updated OMUTCD references | | Alford |
| MDG | Figure 8-3 | Accessible Pedestrian Pushbutton Locations with Separated Bike Lane | Update figure to show new Bike Symbol per MUTCD | | Alford |
| MDG | 8.4.4 | Signal Timing and Reducing Bicycle Delay | Update OMUTCD references | | Alford |
| MDG | 8.4.5.1 | Phasing Schemes | Removed reference to require use of standard traffic signal face or bicycle signal face when Bike movement is separate from vehical movement (now MUTCD requires bicycle signal face). Deleting the following statement, "Any of the signal indication options from Section 8.4.1 may be used to control bicyclist movements for an LPI except for the bicycle signal face." Also updated OMUTCD references | | Alford |
| MDG | 8.5 | Toucan Crossings with Traffic Signals | Removed reference to Figure 8-6 | | Fiant |
| MDG | 8.6 | Pedestrian Hybrid Beacons | Update OMUTCD references | | Alford |
| MDG | 8.6.1 | General Design Considerations | Update OMUTCD references and corrected sign callout | | Alford |
| MDG | 8.6.2 | Pedestrian Hybrid Beacon Timing & Reducing Delay | Revised section to delete last two paragraphs and instead callout reference to 4J.02 and 4J.03 of OMUTCD | | Alford |
| MDG | 8.6.3 | Considerations for Bicycle Traffic | corrected reference to R9-5 sign | | Alford |
| MDG | 8.7 | Warning Beacons | Update OMUTCD references | | Alford |
| MDG | Figure 8-7 | Pedestrian Hybrid Beacon at High Volume Major Road | Update figure to show new Bike Symbol per MUTCD | | Alford |
| MDG | 8.7.1 | Warning Beacons | Update OMUTCD references | | Alford |
| MDG | 8.7.2 | Rectangular Rapid Flashing Beacons | Remove reference to RRFB's being covered under Interim Approval since now in MUTCD. Also updated OMUTCD references. | | Alford |
| MDG | 8.8.1 | Crossing and Conflict Signage | Update OMUTCD references and update langauge related to use of R10-12b sign (Left Turn Yield to Bicycles) | | Alford |

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|---|---|---|---|---|---|
| MDG | 8.8.2 | Bicycle Lane Signage | Updated language regarding use of Bicycle Lane Signage to be consistent with MUTCD | | Alford |
| MDG | 8.8.3 | Warning and Regulatory Signs - Use of Custom Signs | Updated section to refer to new MUTCD | | Alford |
| MDG | 8.9.1 | Pavement Markings - Yield Lines | Update OMUTCD references | | Alford |
| MDG | 8.9.2 | Pavement Markings - Green-Colored Pavement | Add OMUTCD references | | Alford |
| MDG | 9.3.2 | Cloverleaf Interchanges | Editorial update to correct spelling of "degrees" (previously showed "digress") | | Alford |
| MDG | Figure 9-1 | Potential Bike and Pedestrian Treatments at Cloverleaf Interchange On-Ramps | Update figure to show new Bike Symbol per MUTCD | | Alford |
| MDG | Figure 9-2 | Bike and Pedestrian accommodations at free-flow exit ramps | Update figure to show new Bike Symbol per MUTCD | | Alford |
| MDG | Figure 9-5 | Various Bicycle and Pedestrian Treatments at a SPUI | Update figure to show new Bike Symbol per MUTCD | | Alford |
| MDG | 9.4.4 | Roundabout Intersections | Update language related to PHB's, Bicycle Considerations and also updated OMUTCD references | | Alford |
| MDG | Figure 9-20 | Bicycle Lane Transitions and Striping at a Multilane Roundabout | Update figure to show new Bike Symbol per MUTCD | | Alford |
| MDG | Figure 9-21 | Bike Lane Transition to Separated Bike Lane at a Roundabout | Update figure to show new Bike Symbol per MUTCD | | Alford |
| MDG | 10.3.3 | Accommodating Transit Users - Bus Boarding and Alighting Area Accessibility | Revise to indicate boarding and alighting area max grade is less than 2.1% rather than 2.0% max. | | Alford |
| MDG | Figure 10-1 | Passenger Boarding and Alighting Area and Accessible Connections | Revise Figure to indicate 8.0 ft min starts at back of curb rather than face of curb | | Alford |
| MDG | 10.3.4 | Accommodating Transit Users - Passenger Waiting Area | Revise to indicate waiting area max grade is less than 2.1% rather than 2.0% max. | | Alford |
| MDG | Figure 10-12 | Far-side Floating Bus Stop with Intermediate-Level Two-Way Separated Bike Lanes | Update figure to show new Bike Symbol per MUTCD | | Alford |
| MDG | Figure 10-13 | Mid-block Floating Bus Stop with Intermediate-Level One-Way Separated Bike Lane | Update figure to show new Bike Symbol per MUTCD and add missing bike ramp symbol. Remove reference to interim approval. | | Alford |
| MDG | Figure 10-14 | Bicycle Facility Between Travel Lane and Bus Stop | Update figure to show new Bike Symbol per MUTCD | | Alford |
| MDG | 10.6 | Bus-Only Lanes | Added language to clarify use of R3-11 series of signs and also updated references to OMUTCD | | Alford |
| MDG | Table 10-10 | Standard Edge Line and Lane Line Markings for Preferential Lanes | Remove Table and instead reference MUTCD | Deletion | Alford |
| MDG | DWG 10-1.1 | FLOATING BUS STOP DETAILS | Bike symbol needs to be updated per MUTCD.The speed hump marking on the right side of the platform is pointed the wrong direction and should be pointed the same direction as the marking on the left side. | | Alford |
| MDG | DWG 10-1.5 | FLOATING BUS STOP DETAILS | Bike symbol needs to be updated per MUTCD.The speed hump marking on the right side of the platform is pointed the wrong direction and should be pointed the same direction as the marking on the left side. | | Alford |
| MDG | Many | Many | Update Figure callouts with removal of some Figures within chapter | | Alford |
| MDG | 11 | Rail Crossings | Update intro paragraph to refer to OMUTCD Chapter 8 for Rail Crossing info in MUTCD. | | Alford |
| MDG | 11.1 | Provision of Access and Design for Pedestrians and Bicyclists | Delete the following, "Section 5.1.3 discusses the provision of pedestrian facilities based on context and" in first paragraph and updated other MUTCd references. | | Alford |
| MDG | 11.1.1 | Accessible Design at Rail Crossings | Add OMUTCD references and updated Detectable Warnings section to match PROWAG | | Alford |

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|---|---|---|---|---|---|
| MDG | Figure 11-2 | Placement of Detectable Warnings | Delete Figure | Deletion | Alford |
| MDG | Figure 11-3 | Rail Crossing Geometry Examples | Update figure to show new Bike Symbol per MUTCD and also update Figure Name to 11-2 | | Alford |
| MDG | Table 11-1 | Clearing Sight Distance from Stop Position | Updated Table notes to include note superscript callouts | | Alford |
| MDG | 11.3.1 | Grade Crossings 25 Ft. or Less from a Parallel Roadway | Delete last sentence in first paragraph and updated OMUTCD references and other clarifying updates | | Alford |
| MDG | Figure 11-4 | Two-Way Separated Bike Lane Rail Crossing | Update Figure to show gates in correct orientation to avoid trapping a bicyclist. Also update Bike Symbol per MUTCD and update Figure Name. | | Alford |
| MDG | 11.3.2 | Grade Crossings Greater Than 25 Ft. from a Parallel Roadway | Update OMUTCD references and clarify when active traffic control needed | | Alford |
| MDG | 11.5.1 | Signing and Markings | Update OMUTCD references, clarify stop line placement language, revise Dynamic Envelope section, revise Grade Crossing (Crossbuck) Sign (R15-1) section, revise Number of Tracks plaque, and clarified Blank-Out Warning Sign section. | | Alford |
| MDG | Figure 11-6 | Example Dynamic Envelope Markings | Deleting this Figure | Deletion | Fiant |
| MDG | 11.5.2 | Flashing-Light Signals | Add language calling out use of R15-2p (Number of Tracks plaque) when applicable and clarify Ped Signals and Audible Ped Signals section. | | Alford |
| MDG | 11.5.3 | Automatic Gates | Clarifying updates throughout section to provide consistent language with MUTCD | | Alford |
| MDG | Figure 11-7 | Automatic Gates - Separate from Vehicular Gates (Left) & Combined with Vehicular Gates (Right) | Update Figure to be consistent with MUTCD Figure 8E-9. Also renumber Figure Name to be 11-6. | | Alford |
| MDG | Figure 11-8 | Automatic Gate Arm with Gate Skirt | Update Figure to be consistent with MUTCD 8E-12 and renumber to 11-7. | | Alford |
| MDG | 11.5.4 | Supplemental Treatments | Deleted "Pedestrian Swing Gates" section since not covered in 11th Edition of MUTCD | Deletion | Alford |
| MDG | Endnotes | Chapter 11 Endnotes | Deleted Endnotes | Deletion | Alford |

### 1.3.3 Maximum Values

These represent design values that should not be exceeded due to their potential to diminish the value of the treatment (e.g., sign or symbol placement frequency).

## 1.4 Definitions

Commented [AG1]: Definitions updated to be consistent with the 11th Ed. MUTCD

**Accessible** – Describes a facility in the public right-of-way that complies with the Americans with Disabilities Act (ADA) and this guide.

**Alteration** – A change to a facility in the public right-of-way that affects or could affect pedestrian access, circulation, or use. Alterations include, but are not limited to, resurfacing, rehabilitation, reconstruction, historic restoration, or changes or rearrangement of structural parts or elements of a facility.

**Accessible Pedestrian Signal** – A device that communicates information about pedestrian signal timing in non-visual ~~format(s) such~~format such as audible tones~~,~~and/or speech messages~~,~~ and~~/or~~ vibrating surfaces.

**Accessible Pedestrian Signal Detector** – A device designated to assist the pedestrian who has vision, auditory, and/or physical disabilities in activating the pedestrian phase.

**Bicycle Boulevard** – Streets designed to prioritize bicycle traffic by minimizing motorized traffic volumes and operating speeds. They are also commonly referred to as neighborhood bikeways or greenways.

**Bicycle Facilities** – A general term denoting improvements and provisions ~~to~~ that accommodate or encourage bicycling, including bikeways, bicycle boulevards, bicycle detection, shared-~~-~~lane markings, signed bicycle routes, and wayfinding, in addition to parking and storage facilities.

**Bicycle Route** – A road, path, or facility designated for bicycle travel, sometimes using bicycle route signage, where space for bicyclists may or may not be distinct from motor vehicle traffic.

**Bikeway** – A generic term for ~~A~~any road, street, path, or way ~~facility~~ that in some manner is specifically designated ~~intended~~ for bicycle travel, regardless of whether such facilities are designated for the exclusive use of bicycles or are to be shared with other transportation modes. ~~which designates space for bicyclists distinct from motor vehicle traffic.~~ A bikeway does not include shared-~~-~~lanes, sidewalks, signed bicycle routes, or shared-~~-~~lanes with shared-~~-~~lane markings, but does include bicycle boulevards.

**Blended Transition** – A raised pedestrian crossing, depressed corner, or similar connection between the pedestrian access route at the level of the sidewalk and the level of the pedestrian crossing that has a grade of 5 percent or less.

**Clear Space** – (1) A space free of sight distance obstructions to allow motorists and bicyclists in motion to see each other and yield (or stop) accordingly as they approach intersections or driveways. (2) A space free of obstruction for pedestrian maneuverability complying with PROWAG Section R404.

**Clear Width** – The width of a pedestrian or bicycle facility devoid of physical obstructions.

**Crosswalk** – The pedestrian accessible route within a street used to cross a street or portion of a street. Further defined in the Ohio Revised Code, Section 4511.01(LL), as (a) that part of a roadway at an intersection included within the connections of the lateral lines of the sidewalks on opposite sides of the highway measured from the curbs or in the absence of curbs, from the edges of the traversable roadway, and in the absence of a sidewalk on one side of the roadway, the part of a roadway included within the extension of the lateral lines of the sidewalk at right angles to the center line; (b) any portion of a roadway at an intersection or elsewhere distinctly indicated as a pedestrian crossing by pavement marking lines on the surface, which might be supplemented by contrasting pavement texture, style, or color.

~~(1) that part of a roadway at intersections ordinarily included within the real or projected prolongation of property lines and curb lines or, in the absence of curbs, the edges of the traversable roadway; (2) any portion of a roadway at an intersection or elsewhere, distinctly indicated for pedestrian crossing by lines or other markings on the surface;~~ (3) Notwithstanding definitions (1) and (2), there shall not be a crosswalk where local authorities have placed signs indicating no crossing.

Commented [JA2]: The ORC definition matches this text. Let's keep referring to the ORC.

**Cross Slope** – The grade that is perpendicular to the direction of pedestrian travel.

**Curb Line** – A line at the face of the curb that marks the transition between the curb and the gutter, street, or highway.

**Curb Ramp** – A ramp that cuts through or is built up to the curb. Curb ramp types can be perpendicular or parallel, or a combination of parallel, perpendicular, and diagonal ramps.

**Detectable Warning Surface** – A standardized truncated dome grid surface built in, or applied to, walking surfaces to indicate the boundary between a pedestrian route and a vehicular route where there is a curb ramp or blended transition, and at the edge of transit boarding platforms.

**Directional Indicator** – A traversable tactile surfaces comprised of raised bars that may be deployed parallel to the pedestrian path of travel to help pedestrians follow an accessible pathway or navigate a large open space. They may also be deployed across the pedestrian path of travel to provide guidance to pedestrians with disabilities regarding when to turn (e.g., to locate a mid-block curb ramp, bus island, or transit door).

**Engineering Judgment** – The evaluation of available pertinent information including, but not limited to, the safety and operational efficiency of all road users, and the application of appropriate principles, provisions, and practices as contained in design guides, for the purpose of deciding upon the applicability, use, design, operation, or installation of design elements and traffic control devices. Engineering judgment shall be exercised by ~~the designer~~ a professional engineer with appropriate traffic engineering expertise, or by an individual working under the supervision of such an engineer, through the application of procedures and criteria established by the engineer. Documentation of Engineering Judgment should be used.

**First- and Last-mile Connections** – A general term for pedestrian and bikeway facilities designed to help people access transit stops and stations.

**Grade Separated Facilities** – Facilities that support nonmotorized travel utilizing structures over or under traffic facilities, creating a separated pathway across a roadway.

**Hardened Centerline** – a painted centerline supplemented by vertical elements and/or mountable surfaces used to reduce left turn speeds of motorists by reducing the effective turning radius of this maneuver.

**Intersection** – The area where two or more user travel paths meet. Further defined in the Ohio Revised Code, Section 4511.01(KK), as (1) The area embraced within the prolongation or connection of the lateral curb lines, or, if none, then the lateral boundary lines of the roadways of two highways which join one another at, or approximately at, right angles, or the area within which vehicles traveling upon different highways joining at any other angle may come in conflict; (2) Where a highway includes two roadways thirty ft. or more apart, then every crossing of each roadway of such divided highway by an intersecting highway shall be regarded as a separate intersection. If an intersecting highway also includes two roadways thirty ft. or more apart, then every crossing of two roadways of such highways shall be regarded as a separate intersection. If a highway includes two roadways separated by a median, then every crossing of each roadway of such divided highway by an intersecting highway shall be a separate intersection if the opposing left-turn paths cross and there is sufficient interior storage for the design vehicle; (3) The junction of an alley with a street or highway, or with another alley, shall not constitute an intersection unless the public roadway or highway at said junction is controlled by a traffic control device. ~~.~~ (4) At a location controlled by a traffic control signal, regardless of the distance between the separate intersections as defined in (2) above: (a) If a stop line, yield line, or crosswalk has not been designated on the roadway (within the median) between the separate intersections, the two intersections and the roadway (median) between them shall be considered as one intersection. (b) Where a stop line, yield line, or crosswalk is designated on the roadway on the intersection approach, the area within the crosswalk and/or beyond the designated stop line or yield line shall be part of the intersection; and (c) Where a crosswalk is designated on a roadway on the departure from the intersection, the intersection shall include the area extending to the far side of such crosswalk.

**Landing** – Part of a pedestrian accessible route or walkway that provides space for turning, pedestrian pushbutton accessing, or resting. Landings are typically level with a cross slope and grade of 1.56 percent maximum.

**Major Street** – The street normally carrying a higher volume of vehicular traffic.

**Micromobility Device** – A general term describing inline skates, roller skates, skateboards, kick scooters, electric scooters, self-balancing devices, or other small, low-speed, human- or electric- powered transportation devices.

**Minor Street** – The street normally carrying a lower volume of vehicular traffic.

**Mutual Yielding** – A general term describing the responsibility among motorists, bicyclists, and pedestrians to yield the right of way depending upon the timing of their arrival at an intersection or conflict point.

**Pedestrian** – A person on foot ~~or~~, in a wheelchair, or on other devices determined by local law to be equivalent, which might include skates or a skateboard.

**Pedestrian Access Route (PAR)** – A continuous and unobstructed path of travel provided for pedestrians within or coinciding with sidewalks and walkways.

**Pedestrian Curb Cut** – A break or cut in the vertical curb to eliminate curb barriers. Pedestrian curb cuts are typically provided where sidewalk does not exist or the pedestrian access route is at the same elevation as the crossing and a curb separates the PAR from the crossing.

**Physical Barrier** – A physical object that prohibits pedestrian, bicyclist, or motorist movement. This could be a curb, guardrail, fence, street amenities such as benches or planters, etc.

**Pushbutton** – A button to activate a device or signal timing for pedestrians or bicyclists.

**Pushbutton Information Message** – A recorded message that can be actuated by pressing a pushbutton when the walk interval is not timing and that provides the name of the street that the crosswalk associated with that pushbutton crosses and can also provide other information about the intersection signalization or geometry.

**Pushbutton Locator Tone** – A repeating sound that informs approaching pedestrians that a pushbutton exists to actuate pedestrian timing or receive additional information and that enables pedestrians with vision disabilities to locate the pushbutton.

**Ramp** – A pedestrian pathway or access route with a slope greater than 5 percent. A ramp may or may not be part of a curb ramp.

**Running Slope** – Also known as longitudinal slope. The slope that is parallel to the direction of travel.

**Pedestrian Facilities** – A general term denoting a location where improvements and provisions have been made to accommodate or encourage walking pedestrian activity. Pedestrian facilities include, but are not limited to, accessible routes, sidewalks, crosswalks, crossing islands and medians, traffic control features, curb ramps, bus stops and other loading areas, shared shared-use paths, and stairs.

**Separated Bike Lanes** – A bicycle lane that is physically separated from motor vehicle traffic by vertical elements and a horizontal buffer. These are also sometimes referred to as protected bike lanes or cycle tracks.

**Shared--Lane** – A roadway travel lane used by both motor vehicle travel and bicycle travel where no bicycle lane is designated.

**Shared Street** – A street that includes a shared zone where pedestrians, bicyclists, and motor vehicles mix in the same space. Motor vehicle speeds on shared streets are intended to be very low.

**Shared Shared-Use Path** – Multiuse path designed primarily for use by bicyclists, pedestrians, and/or micromobility device users for transportation and recreation purposes. Shared use paths are physically separated from motor vehicle traffic by an open space or barrier. Shared use paths are sometimes referred to as paths. A bikeway outside the traveled way and physically separated from motorized vehicular traffic by an open space or barrier and either within the highway right-of-way or within an independent alignment. Shared-use paths are also used by pedestrians (including skaters, users of manual and motorized wheelchairs, and joggers) and other authorized motorized and non-motorized users.

**Sidepath** – A shared shared-use path located within highway right-of-way adjacent and parallel to a roadway.

**Sidewalk** – A walkway located along a roadway. Further defined in the Ohio Revised Code, Section 4511.01(FF), as that portion of a street between the curb lines, or the lateral lines of a roadway, and the adjacent property lines, intended for the use of pedestrians.

**Vertical Surface Discontinuities** – Vertical differences in elevation between two adjacent surfaces.

**Vibrotactile Pedestrian Device** – An accessible pedestrian signal feature that communicates, by touch, information about pedestrian timing using a vibrating surface.

**Walkway** – A general term used to describe a paved or improved area for use by pedestrians. Walkways include sidewalks, ~~shared~~ shared-use paths, curb ramps, blended transitions, etc.

### 2.3.1.1 Planning Resources

ODOT maintains a variety of transportation system information that project managers can leverage to inform their decision making during the planning and programing process. The following tools provide some important information on existing conditions and can contribute to a prudent and context-sensitive approach to individual projects. **Table 2-1: Planning Resources**

| **Resource** | **Description** |
|---|---|
| Active Transportation Demand and Need Analysis | During WBO's planning process statewide active transportation demand and needs analyses were conducted. The results of the analysis can be viewed in TIMS and provide a general understanding of if there is a high demand or high need in the project area.<br><br>For more information see Walk.Bike.Ohio's Needs Analysis Report and Walk.Bike.Ohio's Demand Analysis Report. |

| | |
|---|---|
| Transportation Information Mapping System (TIMS) | ODOT's web-mapping portal contains many comprehensive datasets that are relevant to multimodal transportation projects. These include:<br>• ADA Pushbutton Inventory<br>• ADA Crosswalk Inventory<br>• ADA Curb Ramp Inventory<br>• ADA Sidewalk Inventory<br>• ADA Refuge Island Inventory<br>• State and US Bike Routes<br>• Road Inventory and Traffic Counts<br>TIMS is a good starting point for project managers to familiarize themselves with existing conditions. It can help identify potential multimodal transportation challenges and opportunities, which should be verified through field work or local expertise.<br>In addition, the Active Transportation Map Viewer provides an online interface to view layers related to active transportation planning, including previously planned bicycle and pedestrian projects. |
| Non-Motorized Database System | The Non-Motorized Database System (NMDS) is a powerful tool for the traffic engineer or planner to organize the agency's non-motorized count data. It provides a dashboard level summary of the system as well as tools to maintain, review, and report data at the path level. From bike lanes to sidewalks to bike paths to trails, the NMDS module helps manage the data. |

| | |
|---|---|
| GIS Crash Analysis Tool | GCAT uses GIS (Geographic Information Systems) to produce data that is spatially located to provide a convenient safety crash analysis tool. It allows users to filter data by type of unit (e.g., bicyclist or pedestrian), crash type and severity, contributing circumstances, and other attributes. GCAT helps project managers identify trends in pedestrian and bicycle crashes within their study area, which in turn can guide countermeasure selection to improve safety. |
| Economic Crash Analysis Tool (ECAT) | The ECAT has the ability to calculate predicted crash frequencies, complete empirical bayes calculations, predict crash frequencies for proposed conditions, conduct alternatives analyses, and complete a benefit-cost analysis. |

| | |
|---|---|
| StreetLight Data | StreetLight Data is an analytics company that organizes and interprets anonymous location data to provide meaningful travel metrics with high spatial accuracy. StreetLight data for Ohio is accessible to any public agency or University within Ohio. It can also be made temporarily available to any consultant working on a public agency's projects; consultant access is limited to use on those public agency projects. To access the account, contact the Office of ~~Roadway Engineering~~Planning. To ensure the most accurate information possible for bicycle and pedestrian volumes, ODOT uses permanent and short-duration counts to validate and calibrate StreetLight and other third-party data sources. More information can be found in the Ohio Nonmotorized Monitoring Program Implementation Plan. |
| Walk.Bike.Ohio | WBO is ODOT's first plan to focus on walking and bicycling policies and programs around the state. The plan guides Ohio's bike and pedestrian transportation policies and investments in infrastructure and programs.<br><br>As part of this, an analysis of bicycle and pedestrian safety data ~~from 2009 to 2018~~ is available for download through their website.<br><br>Additionally, a User Types and Facilities report was also published and covers the impact of land use and network connectivity on the user experience at a high level. |

## 2.3.2 Programing and Funding

ODOT is required by federal law to develop a Statewide Transportation Improvement Plan (STIP) that facilitates the safe and efficient management, operation, and development of surface transportation systems that will

## 3.3 Design Speeds

Design speed is a fundamental design control used to determine various geometric features of a roadway or ~~shared use~~shared-use path as well as some signal timing and street crossing parameters. Motor vehicle design speed consideration in multimodal design is discussed in Chapter 7 of this guide. Additional details for how speeds relate to the design of pedestrian and bicycle facilities is provided in Chapters 4,5, and 6.

### 3.3.1. Pedestrians

Pedestrian speeds can vary based on physical ability, mobility devices used, age, and trip purpose, and in most cases range from 1 to 4 ft/s. 3.5 ft/s is the default assumed pedestrian design speed under most circumstances.7.5 ft/s should be used as the assumed jogging speed of a pedestrian. These speeds are primarily used for determining pedestrian clearance intervals at signalized intersections but are also used for determining sight distances at some uncontrolled crossings. Additional information about accessible pedestrian signal design is available in the OMUTCD and Chapter 8. The OMUTCD provides for an extended pedestrian signal phase at accessible pedestrian signals and longer standard pedestrian signal phase lengths, which depend on the expected pedestrian speeds in a given intersection location.

The use of mobility devices can also affect walking speeds, and speeds can vary for people with disabilities, as shown in Table 3-27. Designers should consider the frequency of users with mobility devices and disabilities and adjust design speeds accordingly.

Table 3-2: Mean Walking Speeds for Disabled Pedestrians and Users of Various Assistive Devices

| Mean Walking Speeds for Disabled Pedestrians and Users of Various Assistive Devices | |
|---|---|
| Disability or Assistive Device | Mean Walking Speed |

| | |
|---|---|
| Cane or crutch | 2.62 ft/s |
| Walker | 2.07 ft/s |
| Wheelchair | 3.55 ft/s |
| Immobilized knee | 3.50 ft/s |
| Below-knee amputee | 2.46 ft/s |
| Above-knee amputee | 1.97~~T~~ ft/s |
| Hip arthritis | 2.24 to 3.66 ft/s |
| Rheumatoid arthritis | 2.46 ft/s |

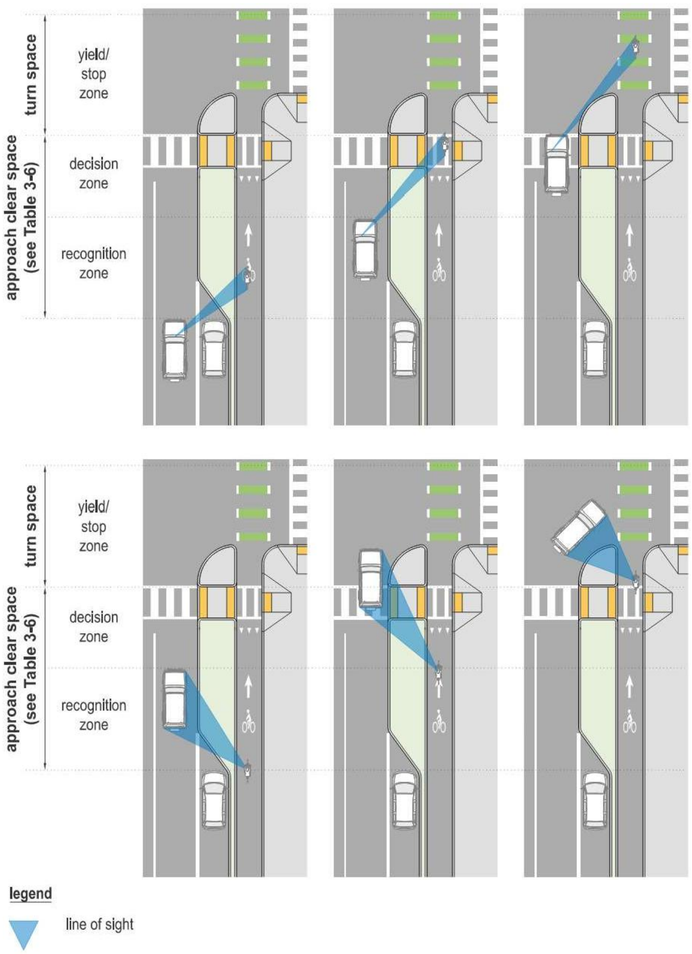
*Source. Human Factors in Traffic Safety*

### 3.3.2. Bicyclists and Micromobility Users

Design speed is the speed used for the design of various geometric features of bicycle/micromobility facilities and street crossing parameters. It is important for designers to recognize that, similar to design for automobiles, the design speed for a bicycle facility should be set at the desired user speed, not necessarily the speed that a bicyclist or micromobility user is physically capable of achieving.

- Through Bicyclist Yields to (or Stops For) Turning Motorist - This scenario occurs when a turning motorist arrives or will arrive at the crossing prior to, or at the same time as, a through moving bicyclist. This scenario can also occur when a bicyclist approaches after a motorist has yielded to other people crossing in the intersection and the crossing is clear for the motorist to proceed. The motorist may begin turning as the bicyclist approaches, requiring the bicyclist to slow and potentially stop while the motorist completes the turning movement.

**Figure 3-3: Example of Mutual Yielding Zones Illustrating Intersection Sight Distance Case A**

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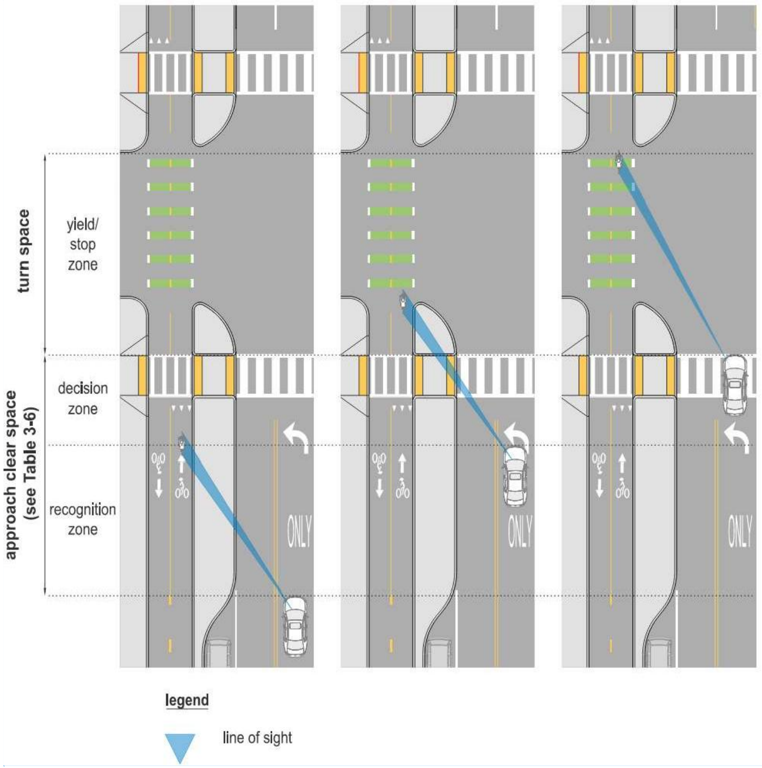
On streets with two-way traffic flow, the operational dynamic of a motorist looking for gaps in traffic creates unique challenges that cannot be resolved through improving sight distance. This is a challenging maneuver because the motorist is primarily looking for gaps in oncoming motor vehicle

traffic and is less likely to scan for bicyclists approaching from behind. Unlike for Bike Case A or Bike Case B on one-way streets where the motorist is decelerating towards the crossing, the motorist in this case will be accelerating towards the crossing once they perceive a gap in traffic. This creates a higher potential for conflicts on roads with the following:

- High traffic volumes and multiple lanes
- Higher operating speeds
- High left turn volumes

Where it is not feasible to eliminate high speed and high-volume conflicts through signalization, turn prohibitions, or other traffic control, it may be necessary to reevaluate whether a side path or two-way separated bike lane is appropriate at the location, or provide an adequate motorist yield zone that allows the motorist to complete the turn while still yielding to crossing pedestrians or bicyclists (see Section 6.5.2).

Figure 3-4: Intersection Sight Distance Bike Case B

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## Bike Case C: Motorist Crossing of a Separated Bike Lane or Side Path/ ~~Shared Use~~Shared-use Path

This case applies when a motorist crosses a separated bike lane or side path and is similar to the cases in the *Guide for the Development of Bicycle Facilities* where a motorist crosses a bike lane or a mid-block path. The bike lane case is expanded upon below, including near-side and far-side intersection scenarios.

### Bike Case C1 — Near-Side Crossing

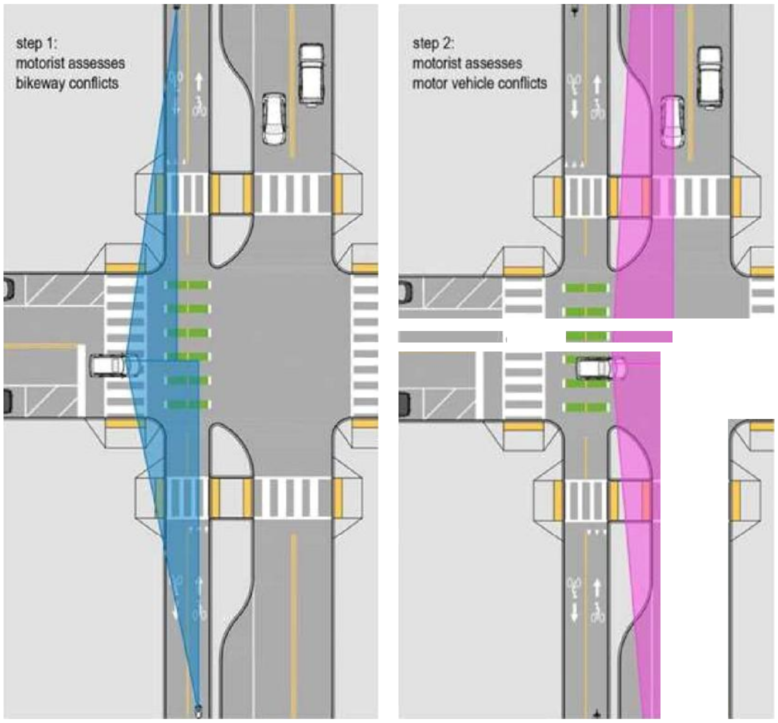
This case applies when a motorist crosses a near-side separated bike lane or side path before continuing straight or turning at an intersection.

The two potential design scenarios are as follows:

*Scenario #1: Two-Stage Crossing*

In this scenario, the motorist assesses both the bikeway conflicts and motor vehicle conflicts from one stopped location, then performs the turning movement when there is a sufficient gap in both the bikeway and motor vehicle traffic (see Figure 3-6). This scenario may be appropriate in locations where the motorist would otherwise block the bike facility for extended periods of time or where bicycle volumes or motorist volumes are anticipated to be high. The equation in Table (3-7) should be used to calculate the departure sight triangle between a passenger vehicle and the bikeway using a time gap ($t_g$) of 4 seconds for the motorist to clear the bikeway. This time gap uses an assumption that the vertex (decision point) of the departure sight triangle is 10 ft. from the edge of bikeway and the bikeway width is no wider than 14 ft. The vertex of the departure triangle between the motorist and the intersecting motorist travel lanes will remain the same, but designers will need to adjust the typical time gap for the appropriate sight distance from L&D Manual Volume 1, Section 201.3.2 to account for the longer distance that the motorist will traverse. As shown in Figure 3-6, the provision of the motorist intersection sight distance will often accommodate the sight distance along the bikeway.

**Figure 3-5: Intersection Sight Distance Bike Case C1 – Two-Stage Crossing Scenario**

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Bike Case C1

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Figure 3-6: Intersection Sight Distance: Bike Case C1 — Single Crossing Scenario

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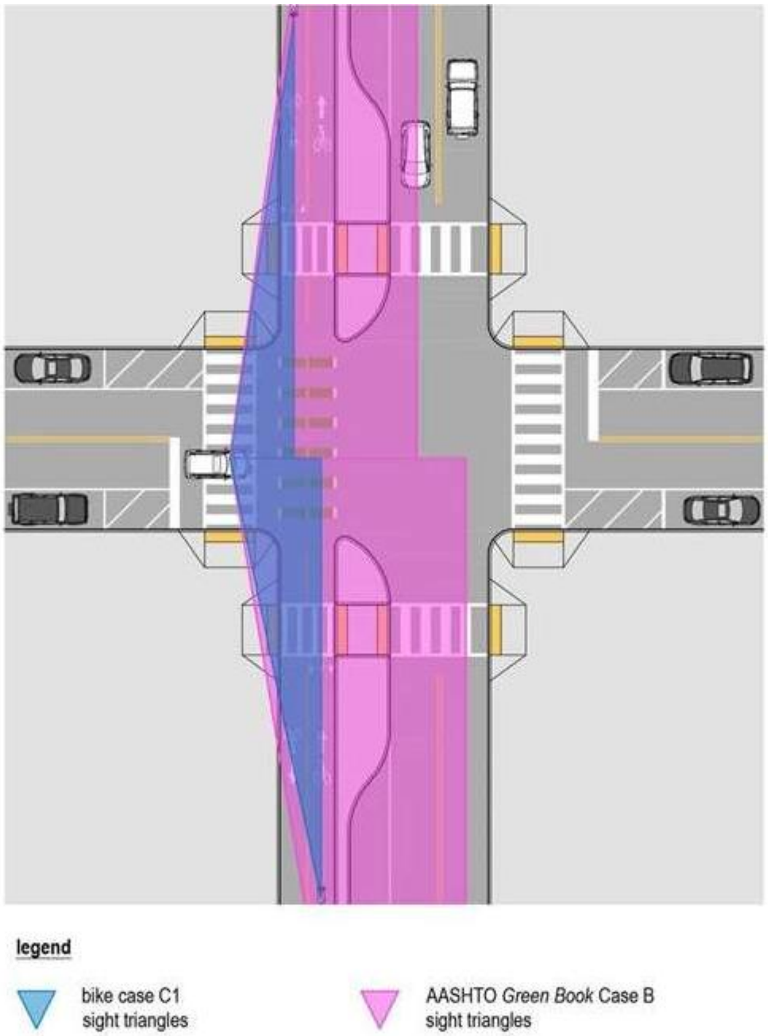


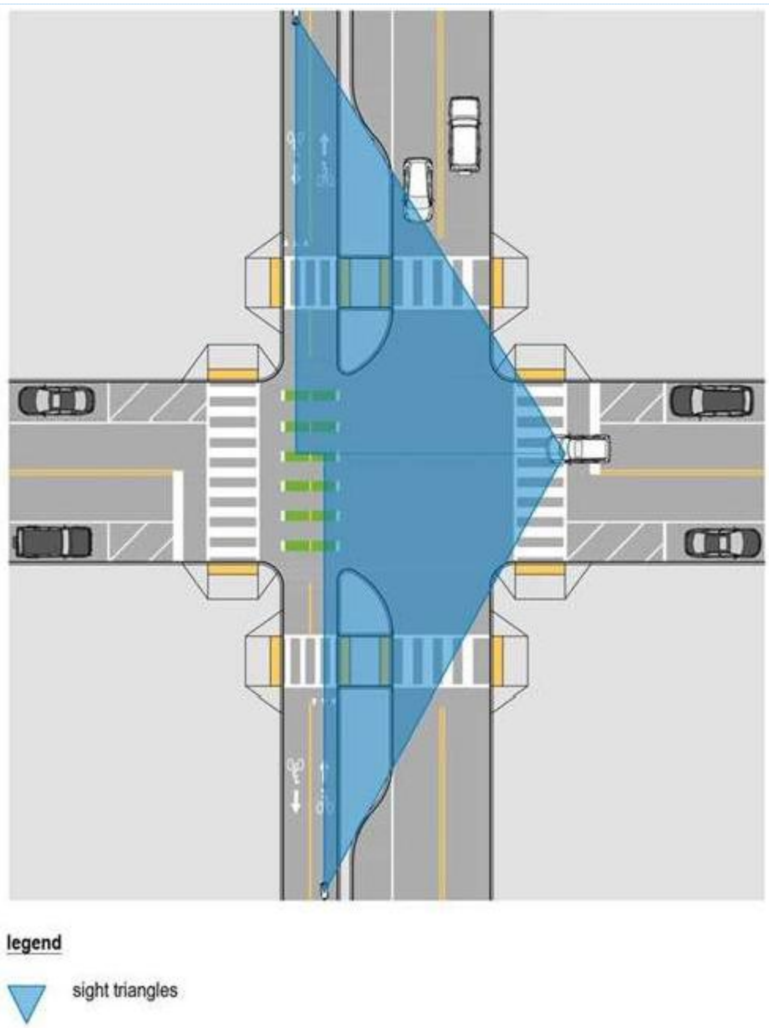

## Bike Case C2 — Far-Side Crossing

This case applies when a motorist crosses a far-side separated bike lane or side path (see Figure 3-T).

Where both the motorist and bikeway approaches are stop-controlled, providing a line of sight between the stopped motorist and the stopped bikeway user is appropriate.

Where the motorist approach is stop-controlled and the bikeway crossing is uncontrolled, the intersection sight distance described in L&D Manual Volume 1, Section 201.3.2.3 should be used to calculate departure sight triangle between the motorist and the intersecting bikeway. The bikeway design speed should be used in the intersection sight distance triangle calculation. The bikeway width and street buffer width should be converted to equivalent lane widths to adjust the time gap (tg) for the crossing of the roadway and the bikeway. In constrained situations, at a minimum the stopping sight distance (for bicyclists) should be provided to allow a bicyclist to slow or stop if a vehicle encroaches into the bikeway.

Figure 3-7: Intersection Sight Distance Case C2

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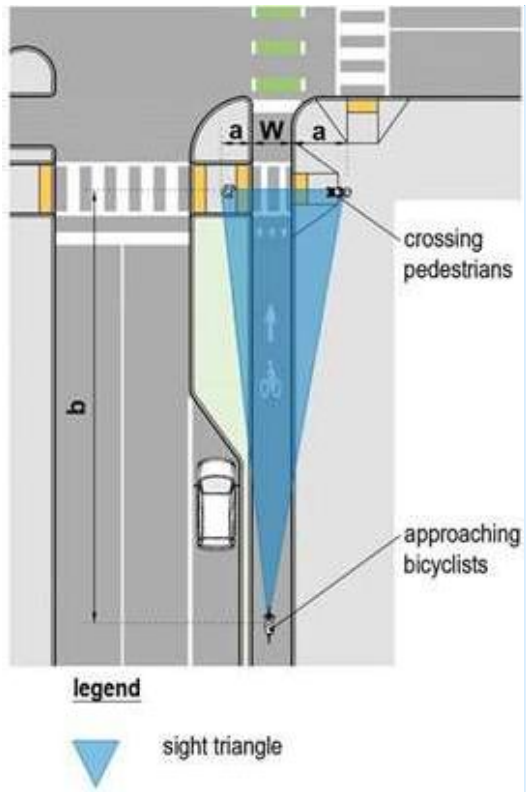
As with Bike Case 8, this case creates a challenging dynamic that is often difficult to resolve by increasing the size of the sight triangle. In urban areas, it may be difficult to increase the sight triangle enough to provide the intersection sight distance to judge gaps that allow a motorist to cross all the travel lanes as well as the

| Pedestrian and Bicyclist Intersection Sight Distance | | |
|---|---|---|
| $b = 1.47 \times V \left(\frac{W}{S_p} + t_s\right)$ | | $a = S_p \times t_s$ |
| where: | | |
| $b$ | = | length ol sight triangle along bicycle facility approach (ft) |
| V | = | design speed of bicycle facility (mph) |
| $a$ | = | length of sight triangle along walkway approach (ft)* |
| $s_p$ | = | speed of pedestrian (ft/s)<br>$S$ (walking) = 3.5 (ft/s)<br>$pS$ (running) = 12.5 (ft/s) |
| $t_s$ | = | pedestrian reaction and stopping tiFNR default = 2.0 (s) |
| $W$ | = | width 0f bicycle facility (ft) |

“If a curb ramp is present for the walkway, the length of o should be the distance between the curb line and the level landing at the top of the curb ramp.

Figure 3-12: Pedestrian Crossing ~~Shared Use~~Shared-use Path or Separated Bikeway (shown) Sight Triangle

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## 3.6 Geometric Design Elements

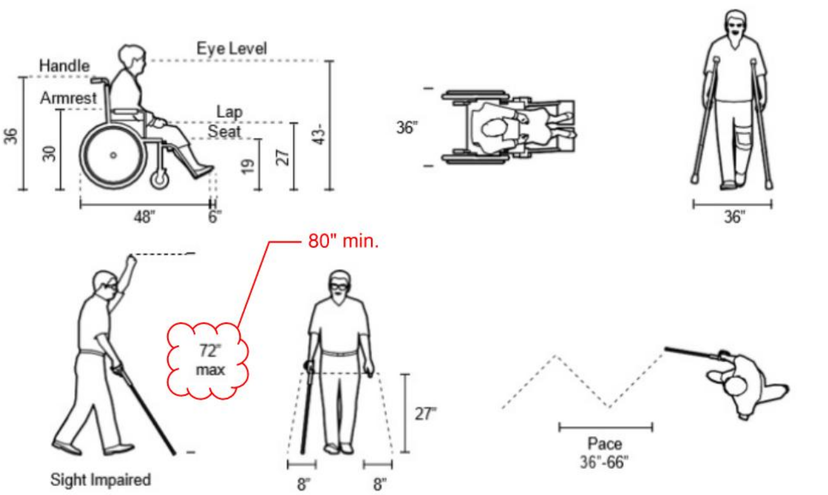
Key controls in geometric design for bicycle and pedestrian facilities are directly related to the characteristics of the various users of the facilities and the characteristics of motor vehicles where the facilities interface with roadways. The L&D and other adopted policies adequately covers the characteristics of motor vehicles and that information is not repeated here. However, in some cases relevant motor vehicle characteristics from the AASHTO “Green Book” are noted or are used in developing bicycle and pedestrian facility geometric design guidance.

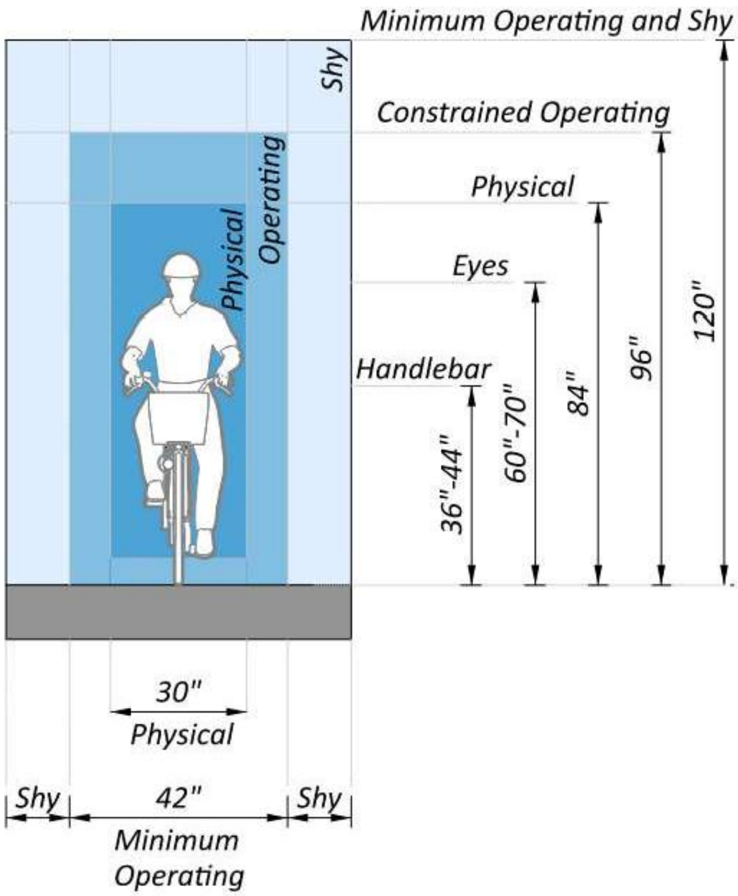
As discussed in Section 3.6.1, the physical dimensions and operating characteristics of people walking and bicycling vary considerably. By choosing geometric design values that fit the upright adult bicyclist, most other users of the bicycle facility will be accommodated. For example, a railing designed to protect an adult

For pedestrians with mobility devices, spatial needs will vary. Figure 3-138 below illustrates the increased space that may be required to accommodate the movements of pedestrians with mobility devices.

To accommodate the side-to-side movement of almost all bicyclists, the minimum effective operating space clear of all obstructions for a bicyclist should therefore be 3.5 ft., which accounts for a 30 inch physical width and 6 inches of space on either side (see Figure 3-14). This operating space should provide a smooth, rideable surface clear of surface defects, joints, and other potential obstructions including drainage grates. Where it is desired to accommodate larger bicycles or larger variations in straight-line travel, the operating width should be increased. Additional discussion of conditions where shy space should be considered is provided in Section 3.6.2.

Figure 3-13: Spatial Dimensions for People Using Typical Mobility Devices






### 3.6.2. Shy Spaces

To maintain comfort and safety of pedestrians and bicyclists, it is important to consider providing clearances to obstructions adjacent to sidewalks and bikeways. For example, a contributing factor in many bicycle crashes is a bicyclist striking another person or object with their handlebar or wheel. Clearances to vertical elements should be provided as shy spaces located outside the operating space of the bicyclist.However, for bikeways within the roadway, it may not always be practicable to provide shy space to parked and moving motor vehicles just as sidewalks are sometimes placed directly adjacent to the curb and moving vehicles. Where minimum shy spaces are not provided, the useable width intended for bicycle travel and pedestrian movement, and the level of comfort for the facility, is likely to be reduced.

This section provides guidance for determining an appropriate clearance distance to obstructions and on the relevance of shy space for common contexts. See Table 3-13 for bicyclist shy spaces to common vertical elements.

Table 3-13: Bicyclist Shy Spaces

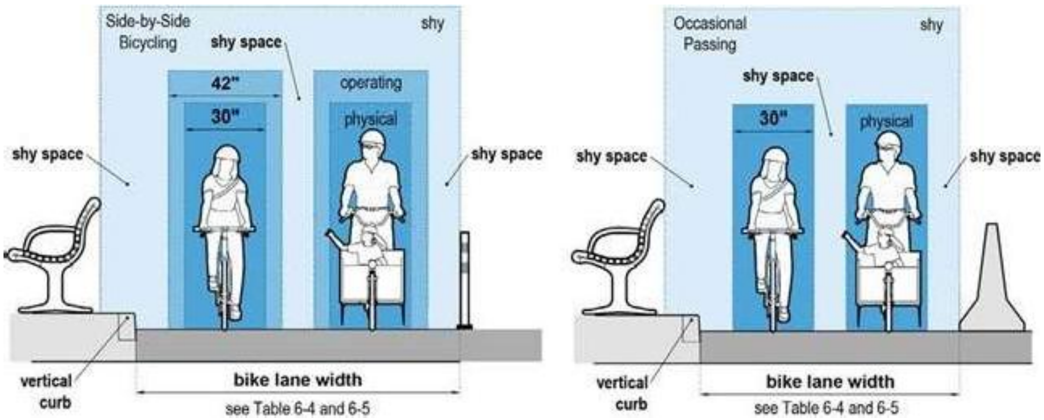
| **Physical Element** | **Shy Space (in.) Minimum** | **Shy Space (in.)** Recommended Range |
|---|---|---|
| Bicycle Traffic | 12 | 24-36 |
| Intermittent (tree, flex post, pole, etc.) | 0 | 24-36 |
| Traffic Signs and Supportive Posts on Curbed Roadways | 12 | 24-36 |
| Traffic Signs and Supportive Posts adjacent to ~~Shared Use~~Shared-use Paths | 24 | 36-48 |
| Continuous (fence, railing, planter etc.) | 12 | 24-36 |
| Vertical Curb | 6 | 12-24 |
| Drainage Feature (inlet or catch basin) | 6 | 12-24 |
| Mountable / Sloping Curb | 0 | 6-12 |

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

## Bicycle Traffic

People walking or bicycling have the potential to collide into other bicyclists or pedestrians (on ~~shared-use~~shared-use paths) where a facility width limits a users' ability to operate side-by-side, to pass other users of the same mode, or to pass other modes. Sidewalks and bikeways should be constructed to serve the expected volume of users to minimize this crash risk. A minimum shy space of 12 inches should be included to accommodate passing or side-by-side bicycling, though this may be reduced to 6 inches in constrained conditions. Where it is desired to accommodate side-by-side bicycling or frequent passing, shy space should be provided between the operating spaces of each user. Where it is not desired to encourage side-by-side bicycling, shy space should still be provided between the physical spaces of each bicyclist to accommodate occasional passing. Figure 3-15 depicts shy space from both physical and operating spaces for side-by-side bicycling and occasional passing scenarios.

Figure 3-15: Bicyclist Shy Space to Vertical Elements Accommodating Side-By-Side Bicycling and Occasional Passing




## Intermittent Vertical Elements

Intermittent vertical elements along the edge of a bicyclists' path, such as trees, signs, utility poles, flexible delineator posts, or other similar objects, can increase the risk of handlebar strikes or bicycle trailers striking vertical elements. Similarly, pedestrians will position themselves away from these obstructions to avoid hitting them with their arm or belongings. Where these features are present, the minimum shy space is 1ft., although the shy space may be eliminated in constrained areas. Exceptions to this guidance are as follows:

- The OMUTCD requires that all ~~no~~ portions of a sign ~~or~~ and its support ~~to~~ be placed ~~less than~~ at least 2 ft. laterally from the near edge of a ~~shared use~~ shared-use path. Where space is available, wider shy spaces should be provided.
- Bicycle-only pushbuttons or pushbuttons on ~~shared use~~ shared-use paths should be located close enough to be pressed without dismounting and placed based on pedestrian accessibility guidelines. The OMUTCD and Chapter 8 provide additional guidance on the location of pushbuttons.
- Lean rails and footrests intended for the use of bicyclists at intersections are an exception to the shy distance guidelines and should be located close enough to be functional from the bikeway. Bikeways may be widened to provide shy distances and allow these treatments to be functional.

## Continuous Vertical Elements

Continuous vertical elements, such as fences, railings, barriers, and walls, can also increase the risk of handlebar and bicycle trailer strikes. In this case, the constant presence of these elements will result in pedestrians and bicyclists attempting to increase their separation from them as these elements create a feeling of enclosure. Where these features are present, a minimum buffer width is 2 ft., but may be reduced to 1 ft. in constrained locations. Where space is available, wider buffers should be provided. Designers may use warning signs, object markers, or enhanced conspicuity and reflectorizing of the obstruction to draw attention to their presence.

## Curb and Gutter

Some curb types can increase the risk of bicycle crashes if struck by a wheel or pedal. The face of curb angle —vertical, sloping, and mountable—and curb height influence the functional width of the bikeway, crash risk to bicyclists, the ability to exit bikeways, and the risk of encroachment into the bikeway by other users. In locations where the bikeway is located between curb on one or both sides, sloping curbs or reduced height vertical curbs (less than 3 inches) should be provided. The following shy distances should be used for the different curb types:

- Where vertical curbs are provided, the minimum shy distance is 1 ft, or 6 inches in constrained conditions.
- Where sloping curbs are provided, there is no minimum shy space adjacent to the curb; however, shy space behind the curb to other appurtenances is still relevant.
- Where mountable curbs are provided, there is no minimum shy space adjacent to the curb; however, shy space to other appurtenances should be carefully considered along the bicyclists expected path of travel if they are permitted to exit the bikeway (such as to access bicycle parking).
- Where curb with integral gutter creates a longitudinal joint parallel to the bikeway, the gutter area is not included in the width of the bikeway but there is no minimum shy space from the edge of gutter.

Some curbs are constructed with integral gutters that include a longitudinal seam parallel to bicycle travel that may deteriorate, resulting in dips or ridges that increase crash risk for bicyclists. Gutters also may have uneven surfaces where street resurfacing activities do not adequately remove asphalt approaching the gutter. Where curbs are provided with integral gutter, the minimum shy space from the bicyclist to the curb is the width of the gutter. See Chapters 4 and 6 for additional information relating to curb selection and design.

Some curb heights may warrant a railing when introduced within a walking area that is separating a lower portion of sidewalk from an upper portion of sidewalk. A railing should be installed when that curb height is greater than 6 inches and consideration should be given to including one when the curb height is at 6 inches. The railing serves as protection and support for pedestrians with vision impairments.

## Vertical Clearance

The vertical clearance to overhead obstructions is a minimum of 10 ft. with 8 ft. permissible in constrained areas for sidewalks, ~~shared use~~shared-use paths, and bikeways. On retrofit projects where any portion of a pedestrian facility has a clearance less than 80 inches., it shall be shielded by a barrier which is detectable with a cane at an elevation no higher than 27 inches.[9] In some situations, vertical clearance greater than 10 ft. may be needed to permit passage of maintenance and emergency vehicles or where equestrian use may be expected. Providing additional vertical clearances can also improve the comfort of a facility in an otherwise constrained location (e.g., a relatively long underpass). Vertical clearance should be considered for underpasses and tunnels, as well as for overhead signs, trees, and other appurtenances that may extend over a bicycle or pedestrian facility.

## 3.6.3. Horizontal Alignment

Basic horizontal geometric design guidelines for motor vehicles will typically result in a facility that accommodates bicyclist and pedestrians. Guidelines for the horizontal alignment of ~~shared-use~~shared-use paths that deviate from a roadway alignment will be discussed in more detail in Chapter 5 as a part of the ~~shared use~~shared-use path design principles.

### Sidewalks

While the horizontal alignment for sidewalks typically follows the roadway, designers may have a situation where the sidewalk is independent of a roadway and in these situations, care should be given to providing consistent design elements. For pedestrians with vision impairments or using mobility devices, sidewalks with straight alignments are preferred for ease of navigation. If any curvature is introduced, it should be gradual and sweeping, with forgiving infrastructure adjacent to the walk, preventing pedestrians with vision impairments from wandering off of the sidewalk because the edge is difficult to detect, and minimize maneuvers for pedestrians with mobility devices.

### Bicycle Tapers

Changing the horizontal alignment of a bikeway may be accomplished without the use of horizontal curves if shifting tapers are used. Tapers should generally occur gradually, with a minimum length as calculated using the formula in Table 3-14. If the bikeway is delineated by paint- only, and if the off-tracking of a bicycle pulling a trailer would not put the trailer into a motor vehicle lane, a maximum taper ratio of 2:1 (longitudinal:lateral) may be considered. See Figure 3-16.

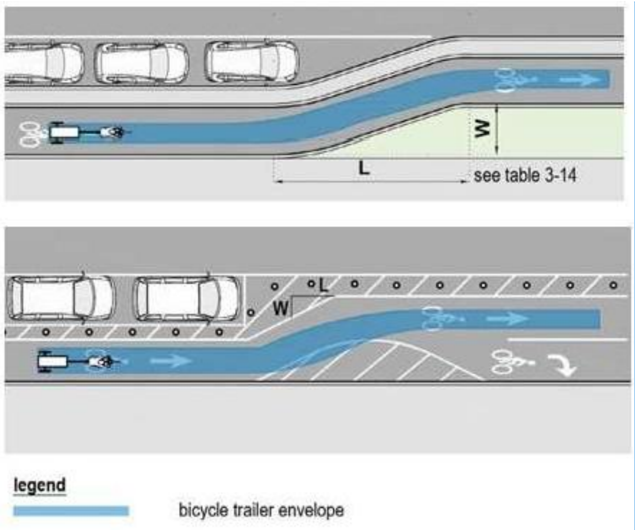
Table 3-14: Shifting Taper Equation

Lane Shift Taper Equation

$$L = \frac{WS^2}{60}$$

| | | |
|---|---|---|
| Where: | | |
| L | | lane shift (ft), minimum 20 ft |
| W | = | width of offset (ft) |
| | " | target motor vehicle operating speed (mph) |

Figure 3-16: Bikeway Shifting Tapers




Commented [BS6]: Figure should be updated to contain the latest MUTCD bike symbol marking

### 3.6.4. Cross Slope

For all facilities that include pedestrians, cross slope design should meet pedestrian accessibility guidelines and shall be a maximum of 1.56 percent to comply with ADA guidance. Cross slopes of 1 percent are more comfortable for people with disabilities and people bicycling with more than two wheels (e.g., cargo bike, adult tricycles, or trailers). In cases where the facility is designed for bicycle use only (e.g., pedestrians are accommodated on a separate walkway), cross slopes may exceed pedestrian accessibility guidelines.

### 3.6.5. Vertical Alignment

For facilities shared by bicyclists and pedestrians and for pedestrian only facilities, longitudinal grades should meet pedestrian accessibility guidelines. A sidewalk or bikeway adjacent and parallel to a roadway should generally match the grade of the adjacent roadway. Where a bikeway runs parallel to a roadway with a grade that exceeds 5 percent, the bikeway grade may exceed 5 percent but should be less than or equal to the roadway grade.

## 3.7 Other Considerations

### 3.7.1. Utilities

It is common to locate utilities within roadway corridors and to take advantage of utility rights-of- way to construct trails and ~~shared use~~shared-use paths. This often creates challenges related to placement of utilities in relation to bicycle facilities.

Addressing utility location may not be practical in retrofit situations where minimal reconstruction is anticipated. However, new construction or substantial reconstruction presents opportunities to proactively address utility placement. Careful consideration of utilities within a roadway corridor can minimize potential utility conflicts and ensure adequate maintenance access for both utilities and bicycle facilities. Utility placement should be coordinated early in the project with utility owners and as part of the drainage and signal design. The following list represents common utility issues that may be encountered when designing bicycle facilities.

#### Adjacent Utility Features

The usable width of bikeways and sidewalks is reduced if a utility feature such as a pole or fire hydrant is located immediately adjacent to a bikeway. See Section 3.6.2 for information on shy distances to obstructions. It is preferable to locate fire hydrants in the buffer adjacent to a sidewalk or bikeway. Designers should coordinate with the local water department to determine exact hydrant placement. Additionally, the placement of valves, pull boxes, manhole lids, and grates could impact the design of curb ramps at pedestrian crossing locations.

Guy wires for overhead pole lines can create a vertical obstruction for pedestrians and bicyclists. The angle of the guy wire within the bicycle and pedestrian facility will require analysis to ensure the wire doesn’t extend into the vertical clear zone and create the risk of a pedestrian or bicyclists running into the wire.

Pad mounted transformers, telecommunication cabinets, and other cabinets for surface utilities can cause obstructions in the pedestrian access route or bicycle path. When designing pedestrian and bicycle facilities, coordinate existing infrastructure with the utility owner and facility design to provide the minimum accessibility width. If relocating these facilities, these facilities should be placed behind the sidewalk or bikeway as right-of-way permits to avoid vertical obstructions that could cause potential sight distance issues for the bicyclists or pedestrian and motorists.

### Underground Utilities

Avoid locating utility covers and large ventilation grates within bikeways to maintain a level bicycling surface and minimize detours during utility work. Where unavoidable, utility covers and large ventilation grates within bikeways should be smooth and flush with the bikeway surface and placed in a manner that minimizes the need for avoidance maneuvers by bicyclists. In addition, keeping manholes flush within one-quarter inch below the pavement surface helps to avoid impacts to winter maintenance equipment. When utility cuts are necessary within a bikeway, the repaired pavement should extend the entire width of the bike lane to prevent uneven riding surfaces.

Due to their typically large size, ventilation grates may present a skidding hazard if located in a bikeway. If placement in a bikeway is unavoidable, designers should consider skid resistant treatments.

For pedestrian facilities, utility covers and grates must meet gap requirements for openings and surface treatment requirements for accessibility guidelines, i.e., /4-inch maximum. If these elements are not accessible, the grate or cover can impact the accessible width of the pedestrian facility.

### Traffic Signal Equipment

The addition of bikeways within the footprint of an existing roadway often results in the need to realign traffic signal heads and detection equipment. Designers shall consider configuration of traffic signal and detection equipment in relationship to alignment of travel lanes to determine whether traffic signal modifications are necessary. Additionally, the placement of signal cabinets should be considered when assessing sight lines to ensure that the equipment will not result in sight obstructions. See Chapter 8 for a discussion of bicycle signals and placement of pushbuttons.

Some pedestrian signal equipment is required to meet ADA requirements and is discussed in Chapter 4. Other pedestrian signal elements can include rapid rectangular flashing beacons and pedestrian hybrid beacons. For design information related to these elements, see ~~Chapter 8,~~ OMUTCD Part~~s~~ 4 ~~and 9,~~ and TEM Parts 4 and 9.

## 3.7.2. Lighting

A properly lit area creates a comfortable and functional environment for all street users. A well-lit street provides drivers with more opportunity to see the bicyclists or pedestrians in the roadway and to stop or maneuver to avoid them. For both pedestrians and bicyclists, lighting directly impacts real and perceived safety, influencing one's decision and willingness to walk or bike in an area.

support the design of accessible shared streets. The FHWA Accessible Shared Streets Guide and the NACTO Urban Street Design Guide both provide guidance on best practices for shared streets.

## 4.3.2 Pedestrian Zone Framework

The space between the curb, or edge of pavement on uncurbed roadways, and the property line plays an important role in:

- providing safe and efficient movement of pedestrians of all ages and abilities; access to
- properties, on-street parking, and transit; space for above ground street utilities, traffic control,
- street scaping, green infrastructure, and

street furniture; and • space for outdoor dining, street vendors, and other community life.

This space can include three zones: the pedestrian through zone, the frontage zone, and the buffer zone. Each performs unique functions in the overall operation of the street, and each interfaces with adjacent private property uses. Although boundaries between zones may blur and blend, the overall function of each zone generally remains consistent. Figure 4-1, Figure 4-2, and Figure 4-3 demonstrate the pedestrian zone for three different contexts.

**Figure 4-1: Curbed Roadway**

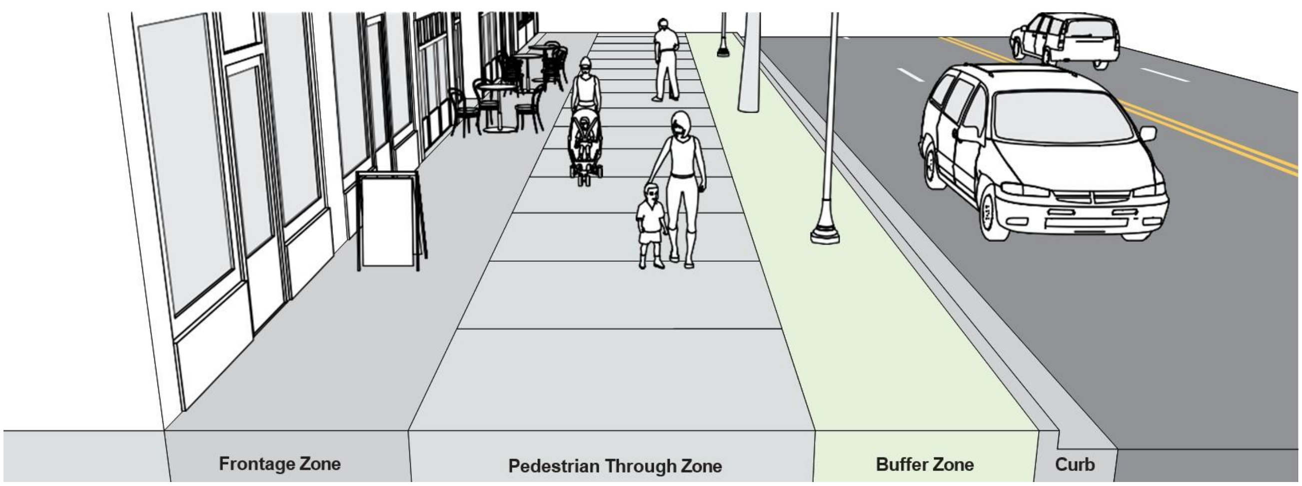


**Figure 4-2: Uncurbed Roadway**

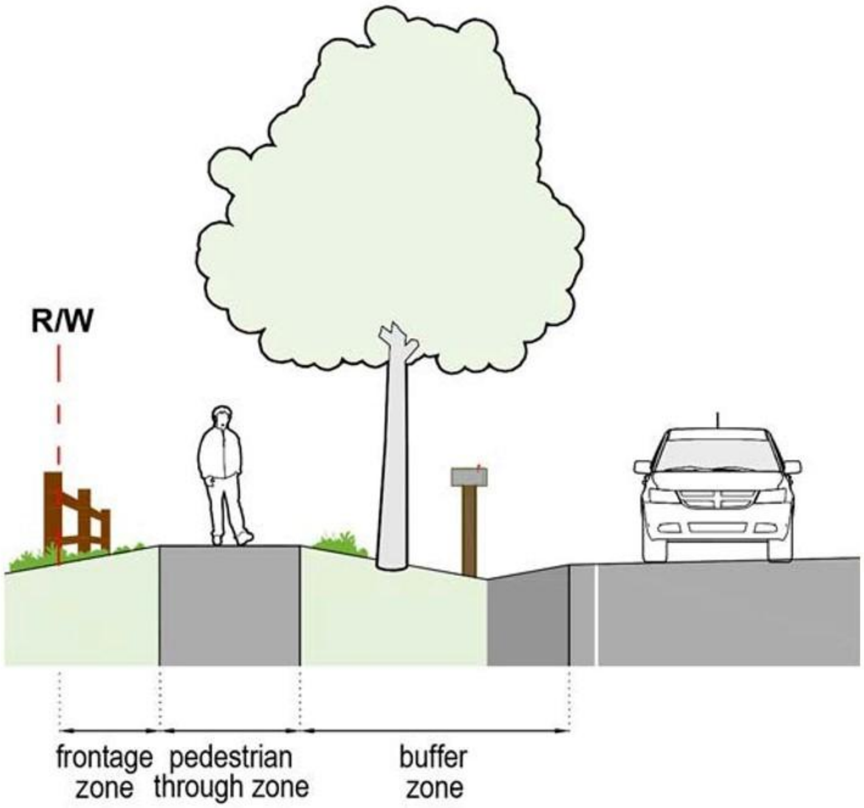



**Figure 4-3: Uncurbed Roadway Where No Sidewalk Is Provided**

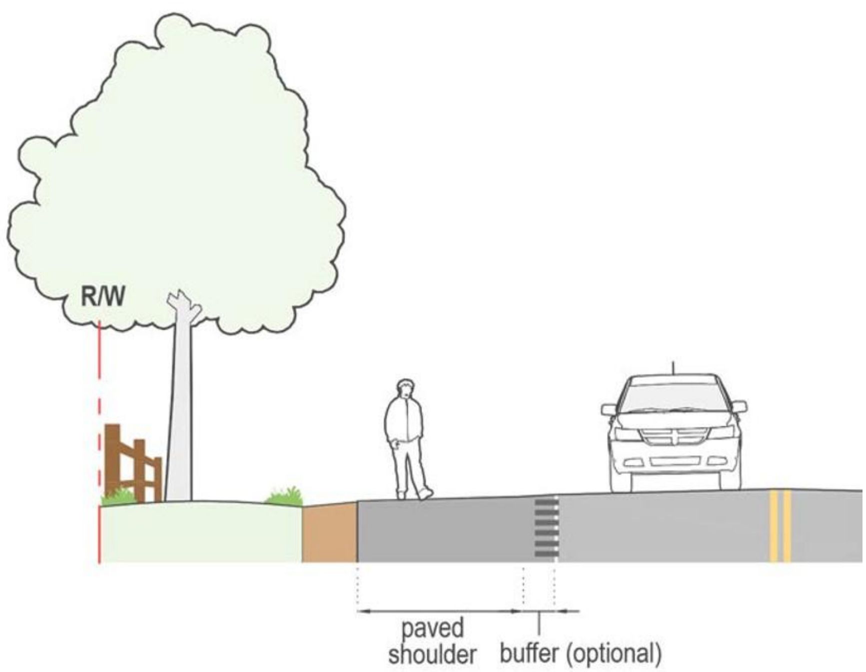


**Table 4-1: Pedestrian Zone with Sidewalk Widths for Different Land Uses**

| Land Use | Frontage Zone Minimum Width (FT) (A) (B) (E) | Minimum Pedestrian Through Zone Sidewalk Width (FT) | Minimum Buffer Zone Width (FT) (C) (D) (E) | |
|---|---|---|---|---|
| | | | Posted Speed <= 35 MPH | Posted Speed > 40 MPH (F) |
| Central Business District | 2 – 6 | 8 - 14 | 4 – 8 | 6 - 10 |
| Commercial | 2 – 6 | 6 – 8 | 4 – 8 | 6 - 10 |
| Residential | 2 | 5 – 7 | 4 – 6 | 6 - 8 |

A. 2 ft. Frontage Zone is the minimum, and a 1 ft. Frontage Zone may be used in constrained environments. A 6 ft. Frontage Zone is the minimum width to accommodate sidewalk cafés.

B. In rare, constrained conditions, the Pedestrian Through Zone width can be reduced to 4 ft, although this width does not provide adequate space for pedestrians passing in opposite directions and requires a minimum of a 5 ft. wide by 5 ft. long passing sections every 200 ft. (see PROWAG Section R302.4).

C. Where trees are desired and permitted within the buffer, the buffer width must sustain the longterm health and vitality of trees and accommodate the urban lateral offset or clear zone as appropriate.

D. When a buffer cannot be provided, then the minimum curb- attached sidewalk width is 7 ft. for residential areas and 8 ft. for all other contexts. All roadways with curb-attached sidewalks or buffers should be constructed with vertical curbing.

E. Curb width is not to be included in Pedestrian Through Zone/Sidewalk Width or Buffer Zone Width.

F. On roadways without curbs, buffer widths equal to or greater than the clear zone appropriate for the roadway are desirable. See L&D Manual Volume 1, Figure 600-1.

**Table 4-2: Pedestrian Zone with Shoulder Widths for Rural Areas**

| Roadway Characteristics | Pedestrian Through Zone Shoulder Width (FT) | Buffer Zone Width (FT) |
|---|---|---|
| Highway (ADT > 2,000 and less than 1 dwelling unit per acre) | See L&D Manual Volume 1, Figure 301-3 of (5 ft. minimum) | 1.5 ft. to 4 ft.[1] |
| Highway (ADT < 2,000) | See AASHTO's A Policy on Geometric Design of Highways and Streets for combined traveled way and shoulder widths for local roads, collectors and Arterials | N/A |

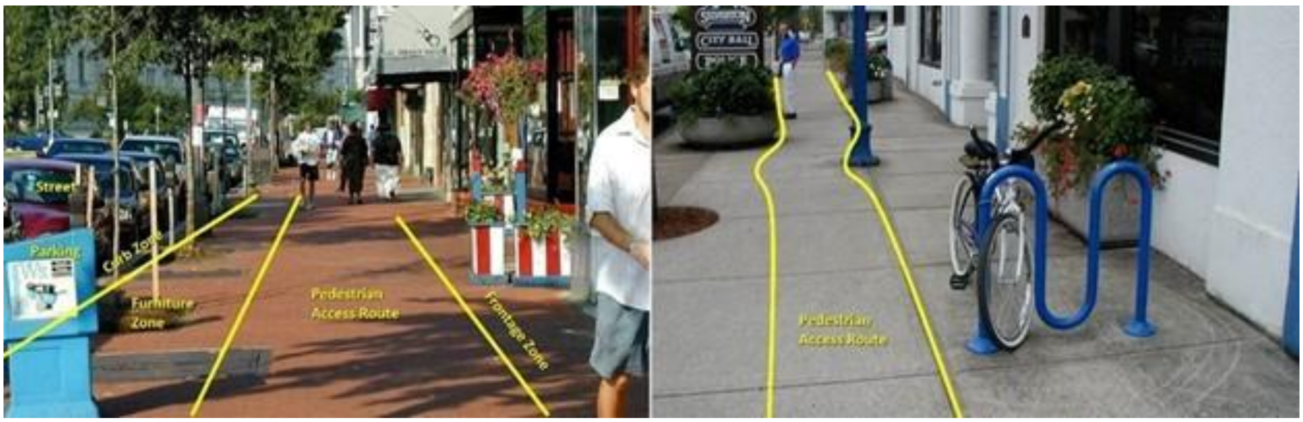
## Pedestrian Through Zone

The Pedestrian Through Zone, also known as the "walking zone" or Pedestrian Access Route (PAR), is the portion of the sidewalk, ~~shared use~~shared-use path, or shoulder used for pedestrian movement. For it to function, it must be kept clear of obstacles and be wide enough to comfortably accommodate expected pedestrian volumes, including those using mobility assistance devices, pushing strollers, or pulling carts.

**Width:** Refer to Table 4-1 and Table 4-2. In locations with very high pedestrian volumes, additional width should be considered. When intermittent existing obstacles reduce the PAR to less than the constrained 4' width, it is recommended that the clear width be as much as possible over the 32" needed to allow for the passage of a person in a mobility device. However, if right-of-way is being taken on the project at any location, then the 4' constrained width shall be provided.

**Special Considerations:** An accessible corridor is not necessarily an intuitive corridor. While sidewalks do not need to be perfectly straight, the Pedestrian Through Zone should not weave back and forth in the right of-way. Figure 4-4 below illustrates two accessible corridors. For pedestrians with vision disabilities, a straight, wide corridor free from obstacles (as shown in the photo on the left) is easier to navigate than one requiring maneuvers or adjustments to the travel path to avoid obstacles (as illustrated in the photo on the right).

**Figure 4-4: Photos showing an accessible and intuitive Pedestrian Through Zone versus a compliant but unintuitive Pedestrian Through Zone**




## Frontage Zone

The Frontage Zone is defined as the area between the back of the sidewalk and the property line which may coincide with the face of a building. In residential areas, the Frontage Zone may be occupied by front stairs, lawns, or other landscape elements that extend from the front door to the Pedestrian Through Zone edge. The Frontage Zone of commercial properties might include architectural features or projections, outdoor retailing displays, café seating, awnings, signage, and other intrusions into or use of the public right-of-way. Along some streets, the Frontage Zone is unimproved, but is present to accommodate sidewalk maintenance.

Width: Frontage Zone width will vary based on context, see Table 4-1. In general, a 2 ft. Frontage Zone is the minimum, and a 1 ft. Frontage Zone is acceptable in constrained conditions. People walking tend to shy away from a building, wall, fence, steps or railing by 1 ft. Where buildings or other continuous objects are located against the back of the sidewalk and constrained situations do not provide width for the Frontage Zone, the effective width of the Pedestrian Through Zone is reduced by 1 ft.

### Buffer Zone

The Buffer Zone, or “landscape zone,” lies between the curb or edge of pavement and the Pedestrian Through Zone. In commercial areas, this zone may include hardscape pavement, pavers, or tree grates. In residential, or lower intensity areas, it is commonly a planted strip. The slope of the buffer zone varies, with 4-8 percent being typical. While the defined Buffer Zone lies behind the curb, on-street parking or bike lanes within the curb-to-curb width can also act as a sidewalk buffer by increasing the separation between the pedestrians and moving motor vehicle traffic. On curbed roadways where there is no on-street parking or bicycle lane, there should be a sidewalk buffer.

When a roadway is uncurbed and surface runoff is collected in a roadside ditch or drainage swale, the swale may be between the Pedestrian Through Zone and traveled way as it eliminates the need for dedicated buffer space, limits the runoff and, reduces the chances of ice during winter months, and maximizes the space between pedestrians and motorized vehicles. However, the location of the drainage swale or ditch in relation to the Pedestrian Through Zone may vary depending on the context of the facility.

**Width:** Buffer Zone widths are described in Table 4-1 and Table 4-2[2]. When sidewalks are not present and pedestrians are using a roadway shoulder, a buffer may be inclusive of a rumble strip.

**Special Considerations:**

- The Buffer Zone can provide space for snow cleared from streets and sidewalks, although snow storage should not impede access to or use of important mobility fixtures such as parking meters, bus stops, and curb ramps.
- The Buffer Zone may extend into the parking lane by the use of curb extensions to provide additional space for trees, pedestrian ramps, bus shelters, bicycle parking, waiting areas, or other needs.

## 4.3.3 Walkway Surface Design

The accessible pedestrian facility design criteria are established by PROWAG and ODOT design requirements that meet the USDOJ and FHWA federal accessibility requirements. The design parameters in this chapter are intended to provide core criteria to be met on a project to satisfy federal accessibility requirements. There are several controlling criteria for a walkway to comply with the PROWAG and ODOT requirements for a pedestrian access route:

**Figure 4-6a: Potential Treatments for Mid-block Crossings with RRFB (3-Lane section with existing drives and 35 MPH or less posted speed) – Update warning sign colors to black on yellow**

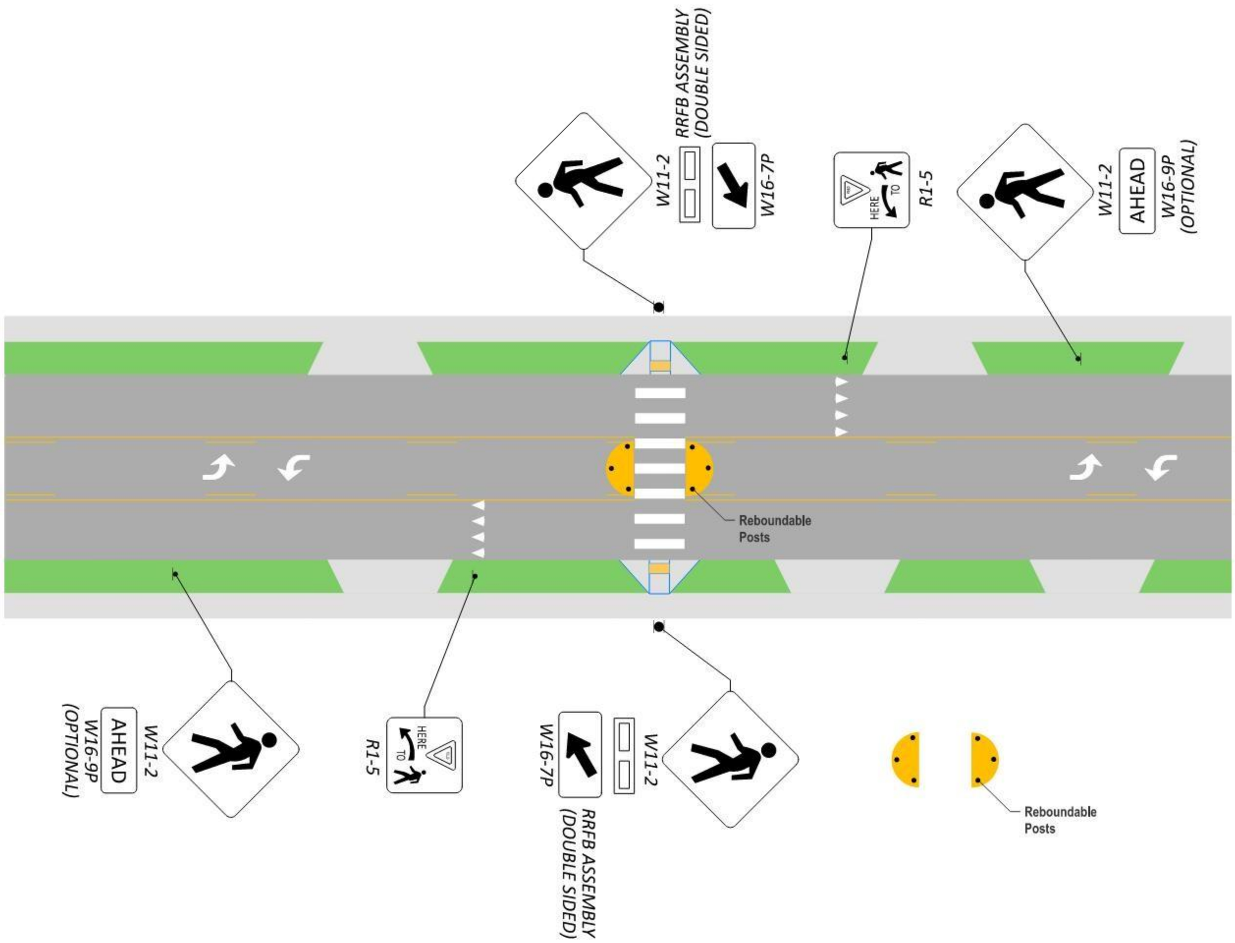



**Figure 4-6b: Potential Treatments for Mid-block Crossings with PHB (3-Lane section with existing drives and greater than 35 MPH posted speed) – Update warning sign colors to black on yellow**

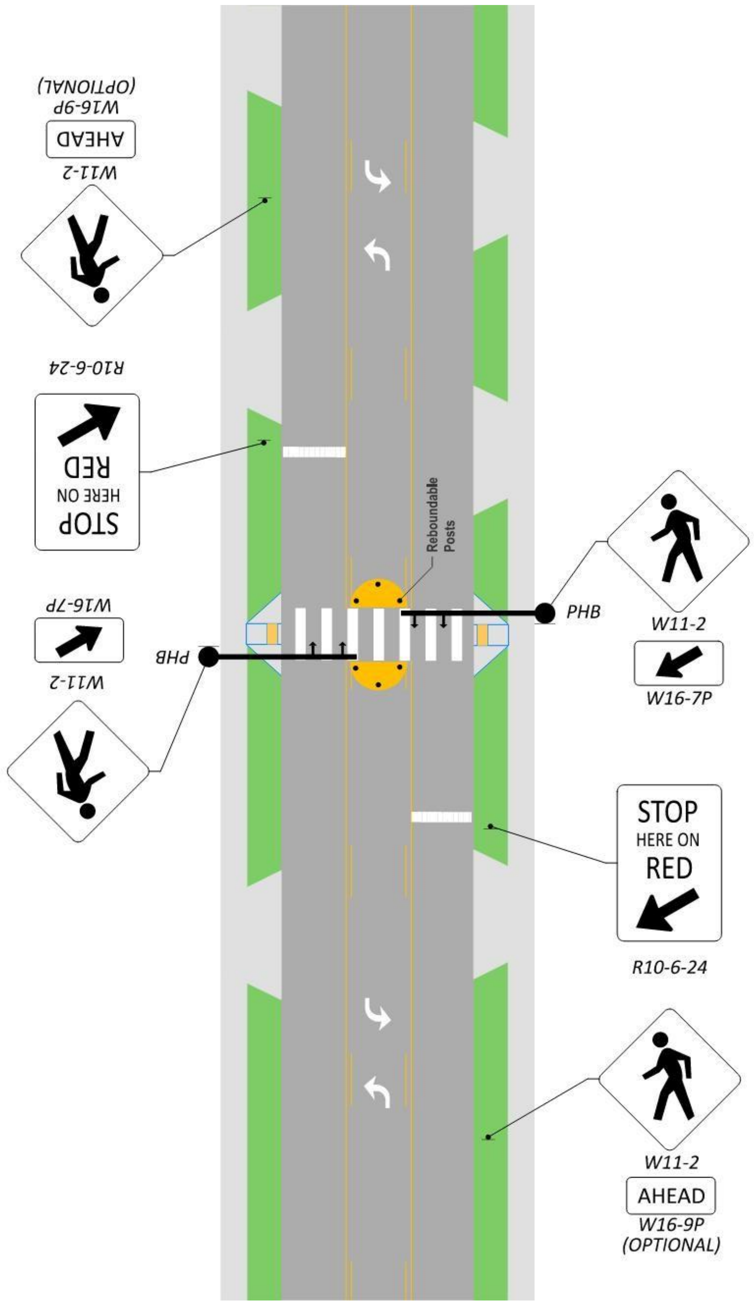

W11-2
AHEAD
W16-9P
(OPTIONAL)
STOP
HERE ON
RED
R10-6-24
W11-2
W16-7P
PHB
Rebounddable
Posts
PHB
W11-2
W16-7P
STOP
HERE ON
RED
R10-6-24
W11-2
AHEAD
W16-9P
(OPTIONAL)

**Figure 4-6c: Potential Treatments for Mid-block Crossings with RRFB (5-Lane section with existing drives and 35 MPH or less posted speed)** – Update warning sign colors to black on yellow

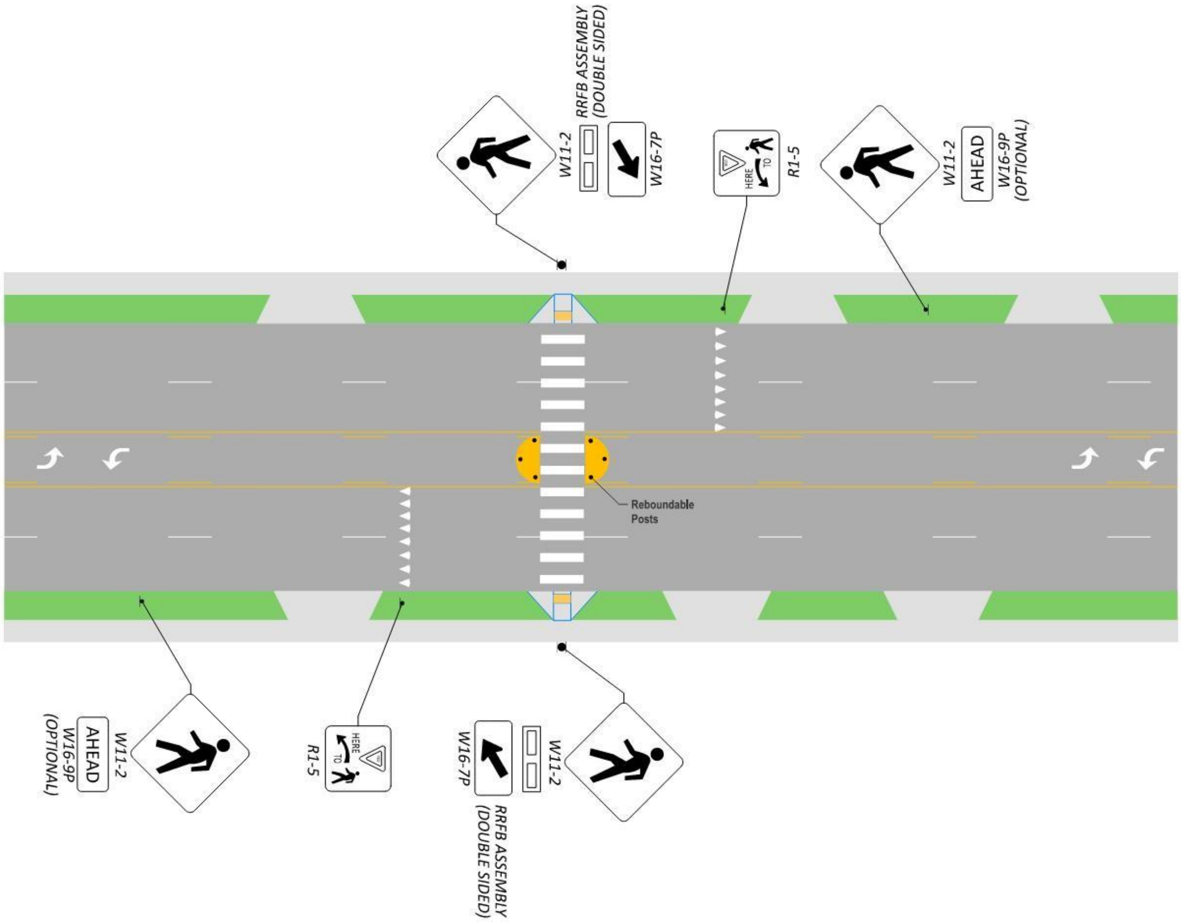
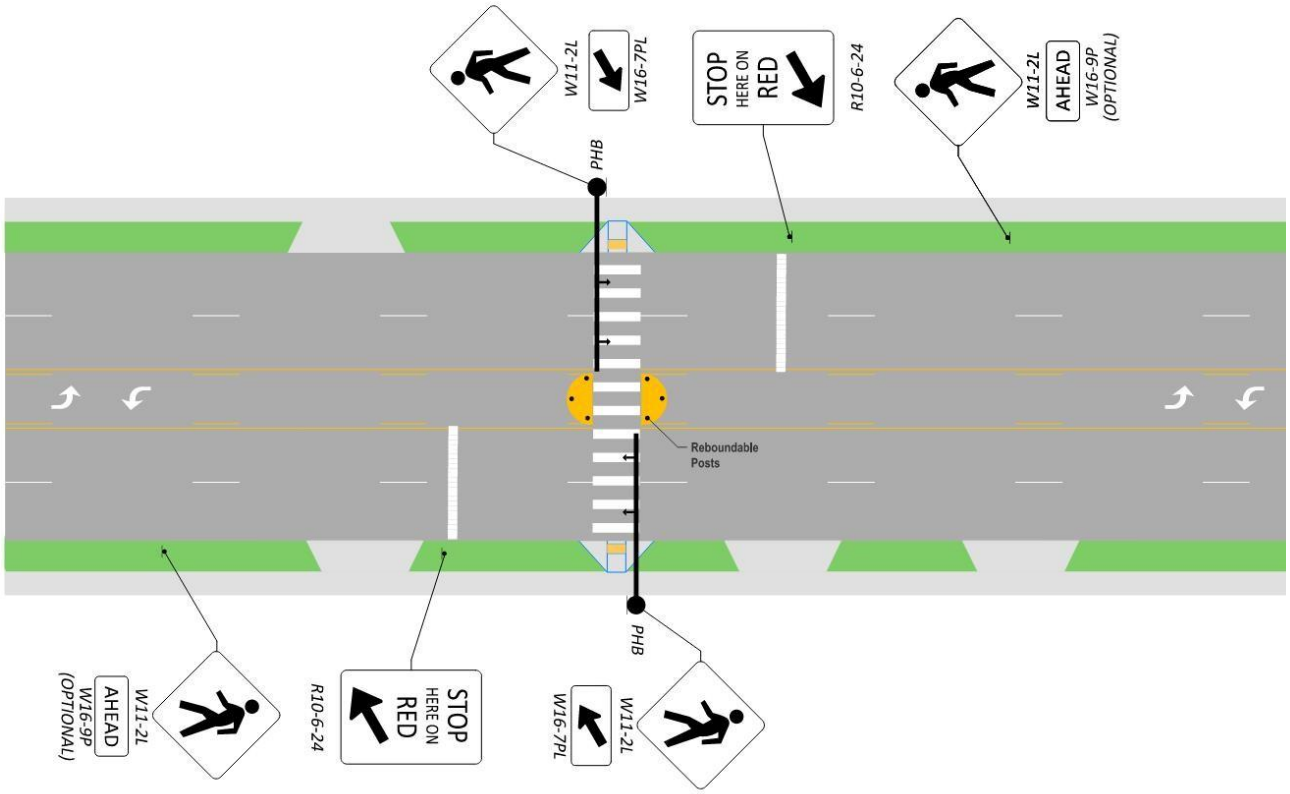


**Figure 4-6d: Potential Treatments for Mid-block Crossings with PHB (5-Lane section with existing drives and greater than 35 MPH posted speed)** – Update warning sign colors to black on yellow




## 4.5 Pedestrian Crossing Treatment Design

A safe and intuitive pedestrian crossing incorporates the proper layout of design elements such as curb ramps, traffic control devices, intersection corner radii, and sight distance that accommodates all users.

## 4.5.1 Markings

### 4.5.1.1 Crosswalk Markings

Crosswalk markings are a basic tool for directing pedestrians across the street and alerting motorists and bicyclists of crossing pedestrians. Engineering judgement in conjunction with guidance in the OMUTCD and TEM should be used to determine when to mark a crosswalk. In general, marked crosswalks and other safety treatments should be prioritized at locations where pedestrians are vulnerable to conflicts with vehicles due to:

- High pedestrian and vehicle volumes, typical in town centers, at major bus stops, or near universities
- V~~V~~ulnerable populations such as children, senior citizens, people with disabilities, or hospital areas
- Roadway conditions that make it difficult for pedestrians to cross, such as wide crossing distances, high traffic speeds, and/or complex intersection geometry

In some instances, crosswalk markings should be used in conjunction with other markings, signs, and warning beacons or signals. Refer to the OMUTCD and Table 4-6~~9~~ to determine when to supplement crosswalk markings with other traffic control devices. Refer to the OMUTCD, TEM, and Chapter 8 of the MDG for additional information on the design and layout of pedestrian crossing traffic control devices.

There are two types of standard crosswalks. See below and Standard Construction Drawing TC-74.10 for additional information:

- Standard (transverse) crosswalk markings – A standard crosswalk consists of two white transverse (parallel) lines, each a minimum of 12 inches in width.
- High-visibility (longitudinal) crosswalk markings – The 11th Edition MUTCD provides 3 types of high-visibility crosswalk markings: longitudinal bar, ladder, and bar pair. As per the TEM, Section 301-6.1, ~~high visibility ODOT Standard crosswalk consists of~~the longitudinal bar ~~lines~~ crosswalk is the default high-visibility pattern ~~only striped parallel to the direction of travel. Additionally,~~ for ODOT mai~~the OMUTCD allows lo~~n~~gi~~t~~udin~~ained~~l~~ ~~lines can~~~~to be used alone or in addition to the transverse lines, thus creating a ladderstyle crossing~~highways.

In general, longitudinal markings are more visible to drivers than the two transverse lines.[10] They are commonly used as a safety countermeasure to alert drivers to unexpected pedestrian crossings or particularly vulnerable pedestrian users (such as school zones or transit stops). Where the determination has been made to install crosswalk markings on ODOT-maintained highways, the longitudinal bar crosswalk should be used in the following situations:

1. At intersections where a minimum of one approach has a speed limit of 35 mph or higher
2. At all established mid-block pedestrian crossings and with appropriate signing accompaniment

Refer to the TEM, Section 301-6.1, and OMUTCD, Section 3C~~B~~.03~~18~~, for line widths and spacing criteria for both standard and high-visibility crosswalks. At any marked crosswalk, curb ramps and other sloped areas should be wholly contained within the crosswalk markings. The crosswalk lines should extend the full length of the crossing. The TEM, Section 301-6.2 discusses optional aesthetic treatments that may be used between the white crosswalk lines. See SCD TC 74.10 for spacing to avoid vehicle wheel paths.

### 4.5.1.2 Yield Markings

Yield lines may be used to indicate the point at which a bicyclist or motorist should yield in compliance with a yield sign, a Yield Here to Pedestrian (R1-5 or R1-5a) sign or a or Bicycle Yield to Peds (R9-6) sign. See OMUTCD, Section 3B.19~~6~~ for guidance on yield markings.

An advance yield line can greatly reduce the likelihood of a multiple-threat crash, which occurs when a motorist stopped in one lane blocks the view of a second motorist. Advanced yield lines should be considered for any uncontrolled multi-lane crosswalk.

Advance yield markings should be placed per OMUTCD Section 3B.19 in advance of a marked or mid-block crosswalk to indicate where the vehicles are required to stop or yield and shall be paired with a Yield Here to Pedestrians (R1-5) sign.

## 4.5.2 Signing

Signage for the design of pedestrian facilities falls into two primary categories:

- 
- Guide and wayfinding signs – see Section 5.7.1.

- Approaches to curb extensions can be created as a straight taper or using reverse curves, though reverse curves are easier for snowplow operators to guide along without catching the plow edge.

See DWG 4-1 for additional design details for curb extensions.

### 4.5.5 Raised Crossings

Raised crossings are an effective strategy for reducing crashes between motorists and crossing pedestrians and bicyclists because they provide a vertical change in the roadway to slow the speeds of motor vehicles, increase visibility of vulnerable street users, and increase yielding behavior of motorists.[11,12] Raised crossings should be considered where motorists are required to yield the right of way to the crossing user. This includes locations such as:

- Unsignalized collector and local street crossings with side paths;
- Separated bike lanes along arterials;
- Crossings of driveways and alleys;
- Crossings of channelized right turn lanes and roundabouts; and
- Intersections where a large corner radius is required to accommodate large vehicles and truck aprons are not possible or desired.

A target speed of less than 10 mph for the raised area should be used on roadways with a posted speed of 25 mph, but a target speed of 10 - 20 mph may be used where crossing volumes are low. Raised crossings are not appropriate across streets where posted speeds are over 35 mph or where roadway grades exceed 8 percent. Designers should also consider the effects of raised crossings on drainage and pedestrian accessibility and must coordinate designs with emergency services.

Raised crossings are similar to speed tables and should have the following design characteristics (See Figure 4-9):

- A width of 10 to 12 ft. for the flat portion of the crossing is preferred. At a minimum, the width of raised crossings should be as wide as the connecting sidewalk and bicyclist path of travel (if relevant).
- For raised street crossings and raised driveway crossings where the driveway functions like a street, detectable warning surfaces must be provided at edges of sidewalks to indicate to pedestrians that they are exiting the sidewalk and entering the street.

- 
- Designers should ensure that raised crossings meet accessible slope requirements.

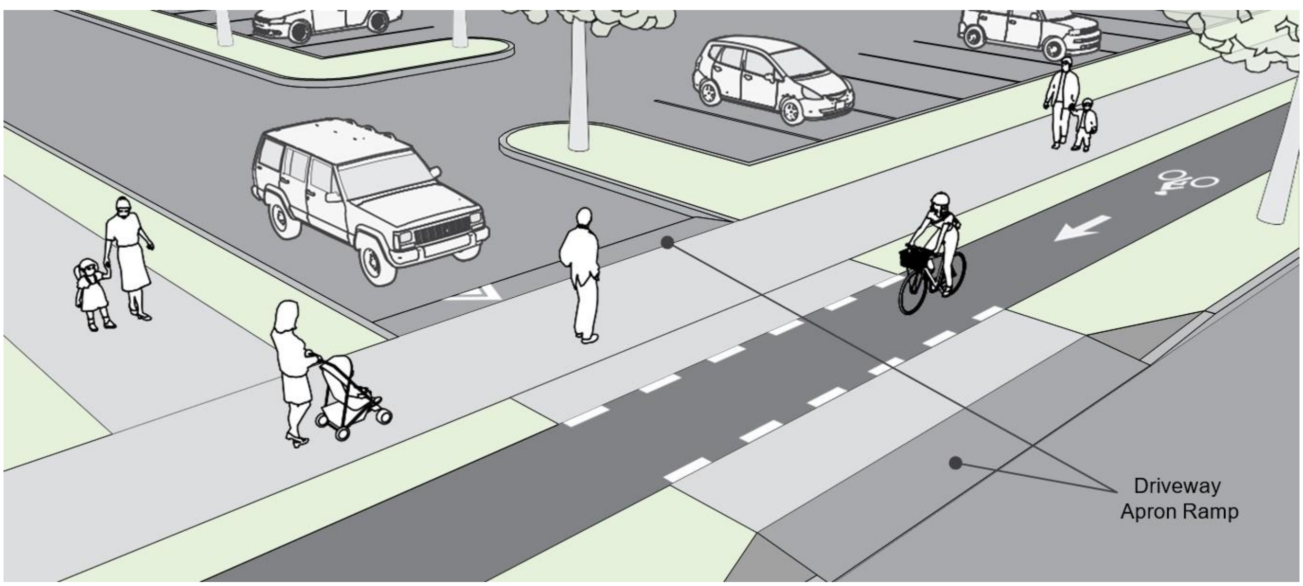
On-street parking and loading shall be restricted a minimum of 20 ft. before the marked crosswalk to provide adequate sight distance and visibility between people crossing and people driving, and to prevent drivers from having to pull forward onto the raised crossing to back into the first parking space. Designers should supplement parking restrictions with signage, pavement markings, and vertical elements such as flexible delineators or bollards where appropriate.

- Consider the use of raised crosswalks with curb extensions to maximize visibility and further slow traffic.
- On uncontrolled motor vehicle approaches, yield lines or speed hump markings should be used to indicate where motorists should yield to bicyclists and pedestrians.
- 
- Provide a ~~RAISED CROSSWALK~~SPEED HUMP sign.

For driveways, the surface materials, color, and texture of the sidewalk, ~~shared use~~shared-use path, and/ or separated bike lane should extend through the crossing, maintaining visual continuity to encourage motorists to yield at the crossing.

See DWG 4-2 for additional design details for raised crossings. See Section 7.8.3 to determine the appropriate target speed for the raised crossing.

**Figure 4-9: Raised Driveway Crossings**



conditions). A reconstructed bridge is any improvement to an existing bridge involving the replacement of the bridge deck or more.

Designers working on a pedestrian-only bridge should refer to Sections 303.2, 309.4/309.4.3.3, 309.5.3, 309.5.5.1, and 310.8 of the ODOT Bridge Design Manual and other national guidance17 for relevant information on pedestrian bridges, bicycle and pedestrian bridges, and railing/fencing guidance for pedestrian bridges or vehicle bridges with pedestrians present.

### 4.7.3 Barriers and Railings for Pedestrian Facilities

Railing requirements differ based on the expected design user, the type of facility, and the slope. To maintain minimum ADA requirements on sloped approaches to a grade-separated facility, handrails must be provided at a continuous height of 34 to 38 inches above the walk surface. A second set of handrails at a maximum height of 28 inches may be considered if children are expected to be regular users of the facility. If two handrails are provided, the minimum vertical clearance between the two is 9 inches to reduce the likelihood of entrapment.

If the primary purpose of a railing on an overpass is to separate users from a drop-off, the minimum barrier height is 42 inches above the walk surface. If bicyclists are also expected on the overpass, designers should refer to Chapter 5 for guidance on ~~shared use~~shared-use paths.

## 4.8 Work Zones

Accessible routes should be maintained through construction sites or pedestrian detour routes should be provided. These routes can be along the existing pedestrian route or an alternative temporary route. The requirements for pedestrian access route widths, grades, cross slopes, and surface treatments through or around work zones must all meet the requirements detailed in PROWAG Sections R300 and R400. Per Chapter 6 of the OMUTCD, agencies must provide reasonably safe and effective movement for all roadway users. If the existing pedestrian route cannot be maintained, information about alternate routes should be provided. This must include access to temporary bus stops, reasonably safe travel across intersections, and other routing issues. Barriers and channelizing devices that are detectable by people with visual disabilities must be provided. Curb ramps and detectable warnings shall be implemented where applicable. The following items should be considered to facilitate an accessible pedestrian route through or around work zones in addition to the features mentioned above:

- Advanced warning and guidance signs
- Illumination and reflectors
- Use of temporary walkways
- Channeling and barricading to separate pedestrians from traffic
- Barricading to prevent a person with vision disabilities from entering work zones
- Accommodation for pedestrian through work zones
- Temporary striping, detectable warning surfaces, and pedestrian signalization for crosswalks; adjusted pedestrian crossing times for modified crosswalk lengths

Guidance for providing pedestrian facilities through or around work zones is discussed in the TEM and the OMUTCD.

The TEM, Section 603 provides guidance on pedestrian and worker safety. This section notes that in work zones "where pedestrian traffic is present, pedestrian safety and needs must be addressed." OMUTCD, Sections 6C~~D~~.01 ~~and~~ 6C~~D~~.02 and 6C.03 provide additional details.

The TEM, Section 606-21 provides additional guidance on the types of temporary traffic control zones that are needed for work affecting pedestrian and bicycle facilities. OMUTCD, Sections 6N~~G~~.0~~5~~4~~, and~~ 6M.04~~F.74~~ and 6K.02 provide additional details.

ODOT SCD MT-110.10 and OMUTCD, Figures ~~6H~~6P-28 and ~~6H~~6P-29 show typical traffic control device uses and techniques for pedestrian movement through work areas.

OMUTCD, Figures 6P-47 through 6P-51 show typical traffic control techniques for bicycle paths and shared-use paths through work zones.

## 4.9 Additional Resources

The following resources provide information about the design of pedestrian facilities:

- Publications Gateway[18] – provides direct links to design guides, specifications and standard drawings.
- ODOT ADA Design Resources[19] – provides a summary of available resources, trainings, design guidelines, requirements, facility databases, and standard drawings specifically related to the ADA.

## Chapter 4 Endnotes

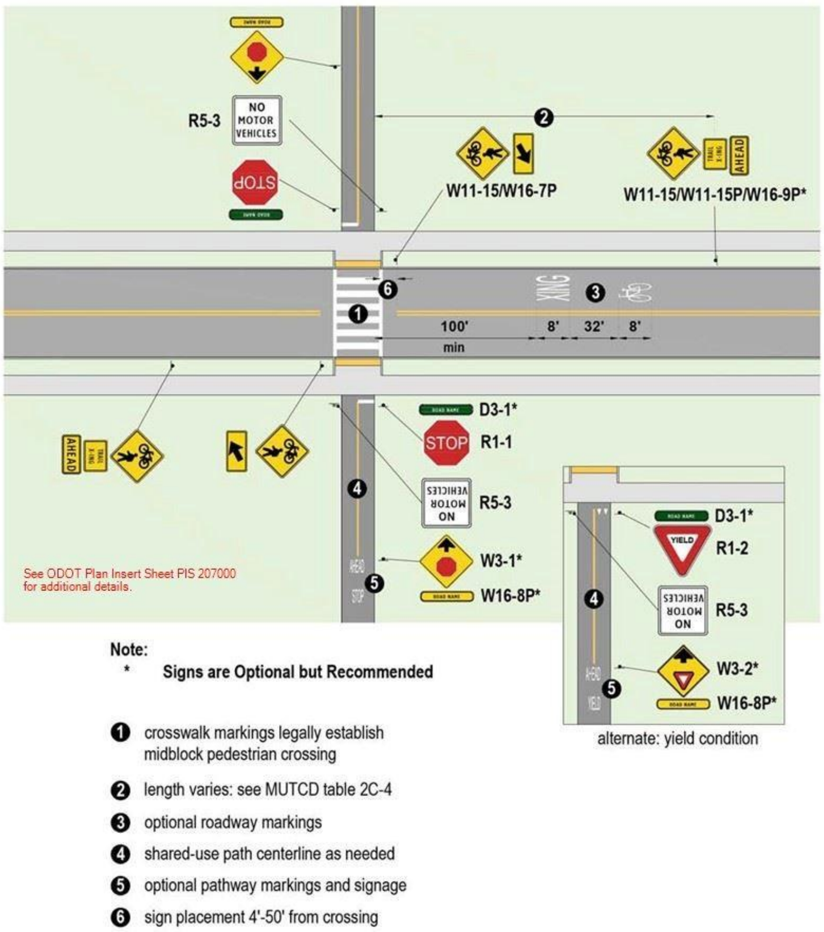

1. FHWA Small Town and Rural Design Guide
2. FHWA. Summary of Travel Trends, 2017 National Household Travel Survey. FHWA-PL-18-019. Federal Highway Administration, U.S. Department of Transportation, Washington, DC, 2011.
3. FHWA Achieving Multimodal Networks
4. NACTO Urban Street Design Guide
5. Bertullis, T. and D. Dulaski. Driver Approach Speed and its Impact on Driver Yielding to Pedestrian Behavior at Unsignalized Crosswalks. *In Transportation Research Record 2464*. TRB, National Research Council, Washington, DC, 2014.
6. Fitzpatrick, K., S. Turner, M. Brewer, P. Carlson, B. Ullman, N. Trout, E. S. Park, J. Whitacre, N. Lalani, and D. Lord. *National Cooperative Highway Research Program Report 562: Improving Pedestrian Safety at Unsignalized Crossings*. NCHRP, Transportation Research Board, Washington, DC, 2006. 7. Goddard, T., K. B. Kahn, and A. Adkins. Racial Bias in Driver Yielding Behavior at Crosswalks. *Transportation Research Part F: Traffic Psychology and Behavior.* Transportation Research Board, Washington, DC, 2015.

8. Coughenour, C., S. Clark, A. Singh, E. Claw, J. Abelar, and J. Huebner. Examining Racial Bias as a Potential Factor in Pedestrian Crashes. *Accident Analysis & Prevention*. 2017

9. FHWA *Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations*
10. Guide for the Planning, Design, and Operation of Pedestrian Facilities, AASHTO
11. Huang, H.F. and M.J. Cynecki. The Effects of Traffic Calming Measures on Pedestrian and Motorist Behavior. FHWA-RD-00-104. Federal Highway Administration. U.S. Department of Transportation, Washington, DC, 2001.
12. Candappa, N., K., S. N. Fotheringham, M.G. Lenne, and B. Corben. Raised Crosswalks on Entrance to the Roundabout -- A Case Study on Effectiveness of Treatment on Pedestrian Safety and Convenience. Traffic Injury Prevention, Vol. 15, No. 6, 2014, pp. 631-639.
13. The Department of Justice, United States Access Board's ADA Standards
14. FHWA's Designing Sidewalks and Trails for Access, Part 2, Best Practices Design Guide 15. The Department of Justice, United States Access Board's ADA Standards
16. FHWA's Designing Sidewalks and Trails for Access, Part 2, Best Practices Design Guide
17. *AASHTO LRFD Guide Specifications for the Design of Pedestrian Bridges*

18. Publications Gateway
19. ADA Design Resources
20. FHWA *Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations*

**Figure 5-9: ~~Shared Use~~Shared-use Path Stops or Yields**




**Commented [TK1]:** Point 2 - Please update to table 2C-3 of the OMUTCD

**Figure 5-10: ~~Shared Use~~Shared-use Path Stops or Yields near Railroad Crossing**

**Commented [TK2]:** Point 2 - Please update to table 2C-3 of the OMUTCD

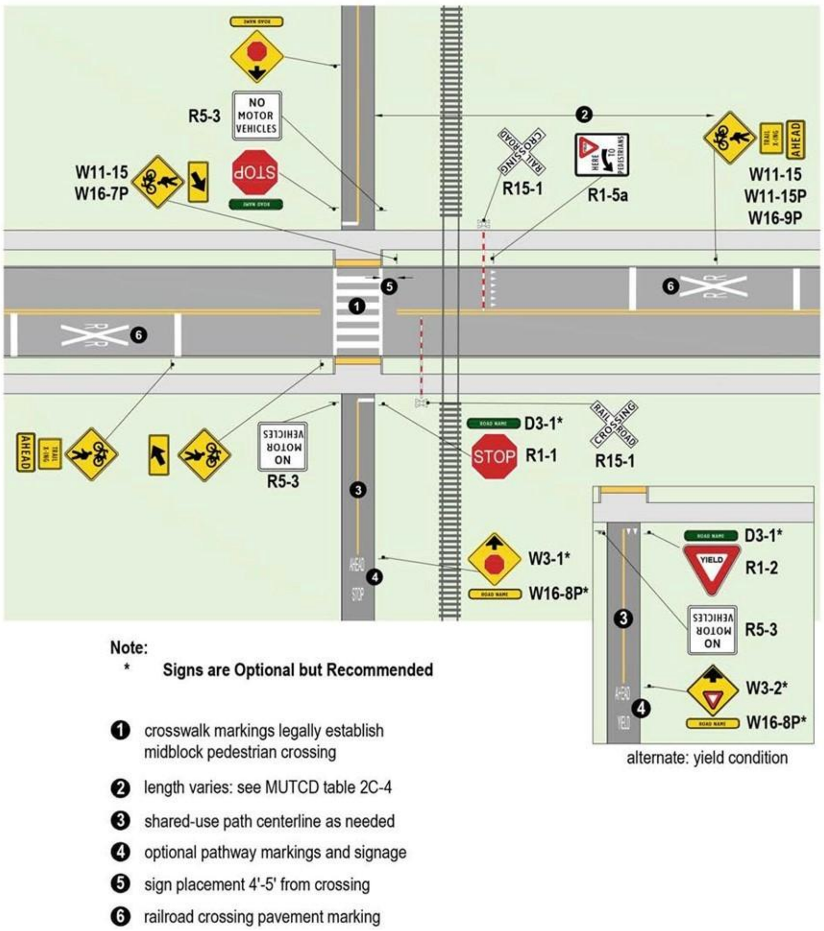
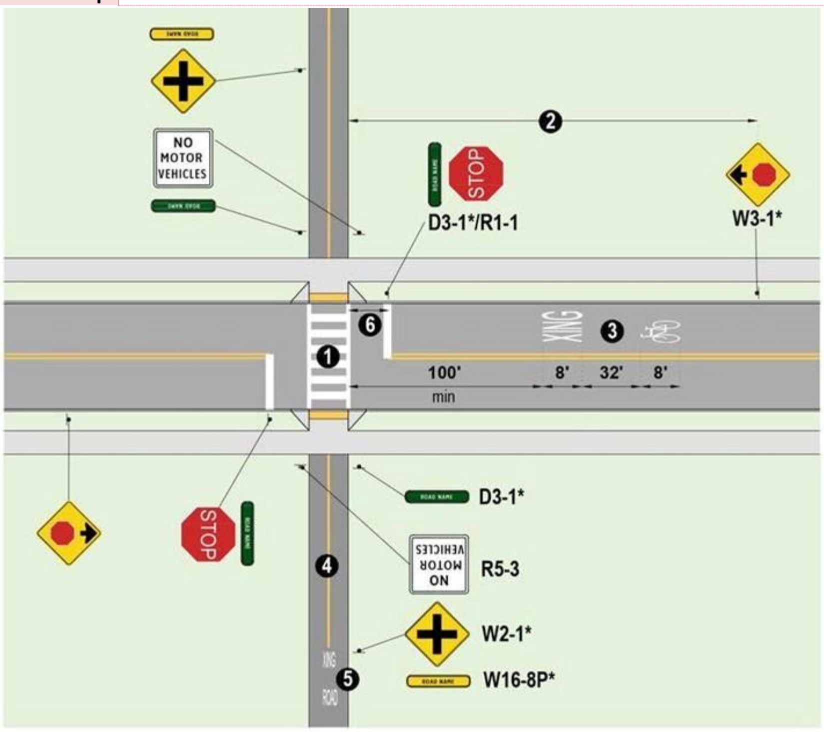


**Figure 5-11: Road Stops**

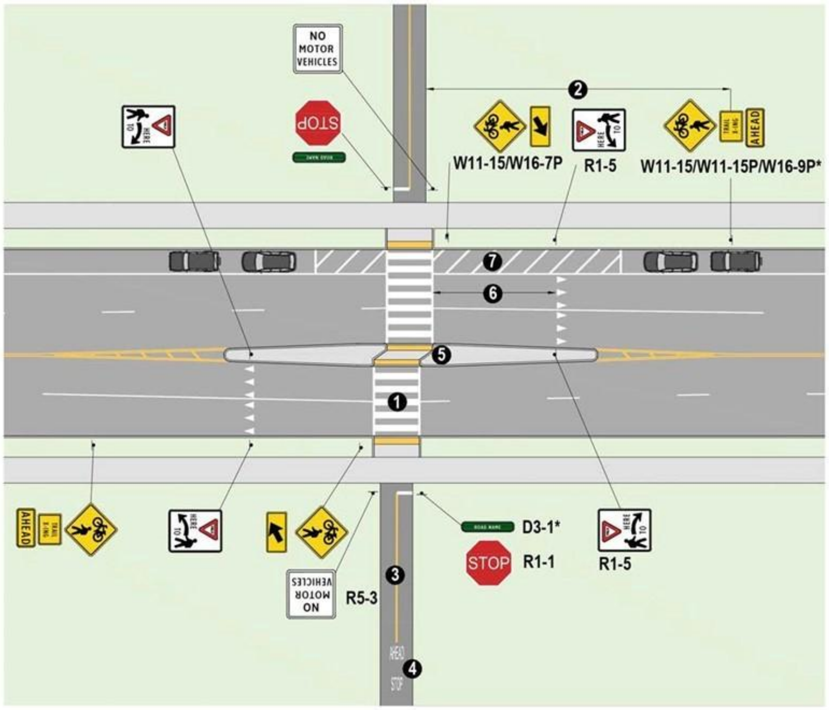



Note:
* Signs are Optional but Recommended

1. crosswalk markings legally establish midblock pedestrian crossing
2. length varies: see MUTCD table 2C-4
3. optional roadway markings
4. shared-use path centerline as needed
5. optional pathway markings and signage
6. sign placement 4'-50' from crossing

**Commented [TK3]:** Point 2 - Please update to table 2C-3 of the OMUTCD

**Figure 5-12: Multi-lane Road Uncontrolled with Advance Yield Line**




Note:

* Signs are Optional but Recommended

1. crosswalk markings legally establish midblock pedestrian crossing
2. length varies: see mutcd table 2C-4
3. shared-use path centerline as needed
4. optional pathway markings and signage
5. refuge median
6. yield bar placement 20'-50'
7. parking restricted

**Commented [TK4]:** Point 2 - Please update to table 2C-3 of the OMUTCD

## 5.7 Signing and Marking

### 5.7.1 Signs and Traffic Control

Primary guidance for traffic control signs can be found in chapters 2B and 9B through 9D of the OMUTCD; the information presented in this section is supplemental to that guidance and is specific to ~~shared use~~shared-use paths.

For advance warning sign placements on ~~shared use~~shared-use paths, the sign should be placed to allow adequate perception-response time. A minimum of 2.5 seconds of perception reaction time should be used for all path users. The location of the sign should be based on the stopping sight distance needed by the fastest expected path user; however, the sign should not be located closer than 50 ft. from the location warranting the advance warning.

Sign post reflectors should not be installed on ~~Shared Use~~Shared-use Paths running parallel to roadways.

#### ~~Shared Use~~Shared-use Path Crossing Assembly

Roadway users may be warned of a ~~shared use~~shared-use path crossing by using a Combined Bicycle/ Pedestrian Warning (W11-15) sign. On a roadway approach to a ~~shared use~~shared-use path crossing, placement of an intersection or advance traffic control warning sign should be at the minimum distance for the approach speed in Table 2C-3~~4~~ of the OMUTCD.

The assembly consists of a W11-15 accompanied by a Downward Arrow (W16-7P) plaque mounted below the warning sign. The Advance ~~Shared Use~~Shared-use Path Name (W16-8P) plaque may be mounted on the sign assembly (below the W11-15 sign) to notify approaching roadway users of the name of the ~~shared use~~shared-use path being crossed.

At ~~shared use~~shared-use path crossings that experience frequent conflicts between motorists and path users, or on multi-lane roadways where a sign on the right-hand side of the roadway may not be visible to all travel lanes, an additional ~~shared use~~shared-use path crossing warning sign assembly should be installed on the left-hand side of the road, or on the crossing island, if present.

The W11-15 may be placed on the roadway in advance of a ~~shared use~~shared-use path crossing. Again, this warning sign should not be used in advance of locations where the roadway is stop-, yield-, or signal-controlled. Advance warning sign assemblies may be supplemented with an AHEAD (W16- 9P) plaque located below the TRAIL XING W11-15P plaque.

### Traffic Control Regulatory Signs

YIELD and STOP signs are used to assign priority at controlled but unsignalized ~~shared use~~shared-use path–roadway intersections. The choice of traffic control (if any) should be made with reference to the priority assignment guidance provided in Section 6.4, but YIELD signs are preferred over STOP signs where sight distances accommodate yield operation. The design and use of the signs are described in sections 2B and 9B of the

OMUTCD.

When these signs are co-located with others on or near the same post, placement should not obstruct the shape of the STOP or YIELD signs.

### Intersection and Advance Traffic Control Warning Signs

Advance traffic control warning signs announce the presence of a traffic control of the indicated type (YIELD, STOP, or signal) where the control itself is not visible for a sufficient distance on an approach for users to respond to the device. An intersection warning sign may be used in advance of an intersection to indicate the presence of the intersection and the possibility of turning or entering traffic.

On a ~~shared use~~shared-use path approach to a roadway intersection, placement of an advance warning sign should be at a minimum distance that is equal to the stopping sight distance of the fastest expected path user in advance of the location to which the sign applies. The advance placement distance should not be less than 50 ft.

An intersection or advance traffic control warning sign may carry a Advanced Street/~~Shared Use~~Shared-use Path Name (W16-8P) plaque to identify the intersecting road or path, as appropriate for the approach.

### Guide Signs

The purpose of guide and wayfinding signs on ~~shared use~~shared-use paths is to inform users of intersecting routes, direct them to important destinations, and generally to give information that will help them proceed along their way in a simple and direct manner. Road Name (D3-1) and ~~Shared Use~~Shared-use Path Name (W16-8P) plaque should be placed at all ~~shared use~~shared-use path–roadway crossings and considered at other path access points. This helps path users track their locations and can enhance personal security of users. They should also be used at junctions where one major ~~shared use~~shared-use path crosses another. At mid- block crossings, the D3-1 sign may be installed on the same post with a regulatory sign.

Guide signs to indicate directions, destinations, distances, route numbers, and names of crossing streets should be used in the same manner as described in section 2D.55~~0~~ of the OMUTCD.

### Warning Signs

The OMUTCD provides guidance for the application of warning signs on ~~shared use~~shared-use paths. In general, the use of warning signs should be limited to locations where sight distance to the condition is limited or the condition is otherwise unexpected. Where pavement markings are not included around fixed objects or other physical features which could represent a crash hazard, the application of reflective materials on the object (e.g., bollard) or Type 3 Object Marker plaques in front of the obstruction should be considered where night time operation is allowed on the path.

## 5.7.2 Pavement Markings

Pavement markings can provide important guidance and information for path and roadway users. Pavement markings should be retroreflective.

### Center Lines

A yellow center line stripe may be used to separate opposite directions of travel where passing is inadvisable. The use of a center line stripe can be applied to the entire length of a facility, or only at specific locations. On ~~shared use~~shared-use paths, the use of a center line stripe may be particularly beneficial in the following circumstances:

- For ~~shared use~~shared-use paths with high user volumes (continuous stripe)
- On curves with restricted sight distance, or design speeds less than 14 mph (localized stripe)
- On unlit ~~shared use~~shared-use paths where night-time riding is permitted (continuous stripe)
- Approaching intersections (localized stripe)
- Approaching obstructions within the center of the ~~shared use~~shared-use path, such as bollards (localized stripe)

The use of the center line stripe may not be desired in parks or natural settings. However, on ~~shared use~~shared-use paths where a center line is not provided along the entire length of the path, appropriate locations for a solid center line stripe should still be considered where described above.

A solid yellow center line stripe may be used on the approach to intersections to discourage passing on the approach and departure of an intersection. If used, the center line should be striped solid the length of the stopping sight distance from the edge of the sidewalk (or roadway, if no sidewalk is present). A consistent approach to intersection striping can help to increase awareness of intersections.

### Stop and Yield Lines

Use and design of stop and yield lines is described in sections 3B and 9~~C~~E of the OMUTCD. For ~~shared use~~shared-use paths, stop or yield lines should be placed across the half-width of the path corresponding to the stop or yield-controlled approach. If used, the stop or yield line should be placed a minimum of 2 ft. behind the nearest sidewalk or edge of roadway if a sidewalk is not present.

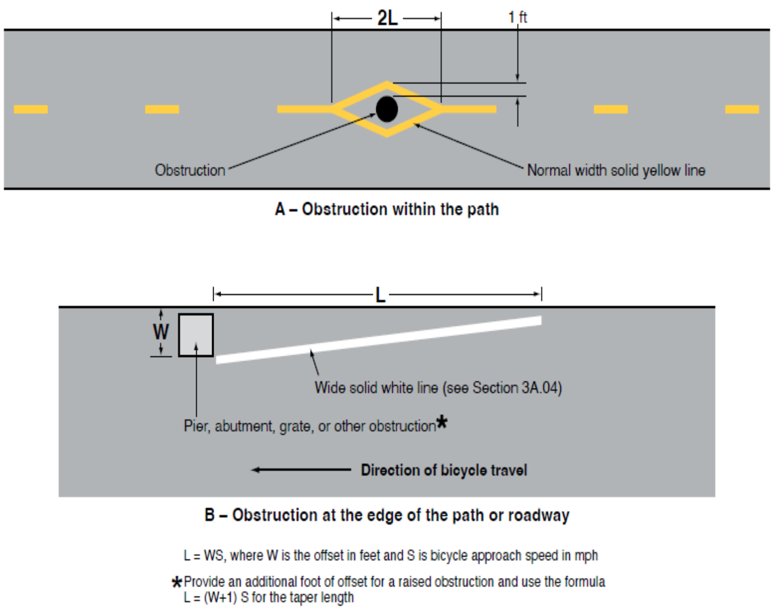
### Obstruction Markings

Obstructions should not be located within the clear width of a ~~shared use~~shared-use path because they present a crash hazard to bicyclists and other ~~shared use~~shared-use path users. Where an obstruction on the traveled portion cannot be avoided (for example, in situations where bollards are used, see Section 5.6.1, or where a ~~shared use~~shared-use path splits abuts a natural feature), channelizing lines of appropriate color (yellow for center line, otherwise white) should be used to guide bicyclists around it with sufficient advance warning of the presence of the obstruction by signs if the obstruction is not otherwise visible.

For obstructions located on the edge of the ~~shared use~~shared-use path, an obstruction marking should be used as shown in Figure 5-14. The edge line or center line obstruction markings may be supplemented with buffer markings or colored pavement to further emphasize the hazard. At locations where a center line is present, the center line should shift as well to maintain relatively equal lane widths on either side of the path center line.

The markings should be located per the guidance for shy distance from obstructions in Section 3.6.2.

**Figure 5-14: Obstruction Marking at Edge of ~~Shared Use~~Shared-use Path**

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## Edge Lines

White edge line markings should be considered for use on ~~shared use~~shared-use paths under the following situations:

- Where night-time use is permitted or routinely occurs
- Approaches to intersections to alert path users of changing conditions
- To separate pedestrians from bicyclists where the ~~shared use~~shared-use path design includes a separate area for pedestrian travel
-
- When the ~~shared use~~shared-use path width is changing significantly over a relatively short distance Approaches to marked constraints on the outside edge of the ~~shared use~~shared-use path, such as entrances to tunnels or when passing bridge abutments
- To establish a shy distance from an obstruction that may otherwise not be noticeable, such as a short stretch of curbing or the foot of an adjacent retaining wall

Refer to Section 3.3.2 for more information on separation of ~~shared use~~shared-use path traffic.

### Marked Crosswalks

Marked crosswalks should be used for all crossings of ~~shared use~~shared-use paths at roadways; they are required at mid-block locations to create a legal crossing. At congested crossings, the ~~shared use~~shared-use path can be widened on the approach (see Section 5.3.1) to provide a separate bicycle crossing (see Section 6.5.1) and pedestrian crosswalks to reduce conflicts and allow faster moving bicyclists to bypass pedestrians increasing the person crossing-capacity of the crossing.

### Advance Word or Symbol Markings

Advance pavement markings may be used on ~~shared use~~shared-use path approaches at crossings where the crossing is unexpected or where there is a history of crashes, conflicts, or complaints. If a supplemental word marking (such as HWY XING) is used, its leading edge should be located at or near the point where the approaching user passes the intersection warning sign or advance traffic control warning sign that the marking supplements. Additional markings may be placed closer to the crossing if needed but should be a minimum of 50 ft. from the crossing. Advance pavement markings may be placed across the entire width of the path or within the approach lane. Pavement markings should not replace the appropriate signs. Pavement markings may be words or symbols as described in Part 3 of the OMUTCD.

### Narrow Path Conditions

At locations where paths with higher volumes of users must narrow below the minimum widths described in Section 5.3.1 consideration should be given to warning of the narrowed path condition. Fixed objects or natural features adjacent to the path that present potential hazards to path users should be properly marked following the Obstruction Markings guidance. Advance warning signs should be considered where sight distance is restricted to the object or feature including the use of the PATH NARROWS (W5-4a) sign. Appropriate channelization tapers should also be included to effect any changes in ~~shared use~~shared-use path width ahead of the location. When narrower ~~shared use~~shared-use path widths occur at discrete locations, consider including a marked center line to help organize opposing directions of travel.

**5.8 Use of Limited Access Right of Way**

When considering the use of limited access right of way (LA/RW) for a potential shared-use path it is important to work closely with the District Real Estate Administrator. Refer to the State Highway Access Management Manual, Section 3.1 for further information regarding the procedure to request an access permit for a new or revised opening in the LA/RW. If considered, the following requirements should be met:

- The shared-use path must be available for public use and includes a fence or wall to prevent access to the LA facility travel lanes.
- The shared-use path location should be located as far away from the existing facility as possible to reduce possible impacts from future projects.
- The shared-use path should be outside of the clear zone or provide a crash worthy barrier to protect path users.

## Chapter 5 Endnotes

1. FHWA Shared-Use Path Level Of Service Calculator – A User's Guide

## 6.2 Bicycle Routes

As discussed in Section 2.5.2, people bicycling are best accommodated when a connected and intuitive network of bicycle facilities is provided. Signed bicycle routes can help to identify streets and paths designated for bicycling and can provide bicyclists with wayfinding cues.

The network of bicycle routes consists of local and regional routes established by cities and local agencies, State Bike Routes established by ODOT, and U.S. Bike Routes established by the American Association of State Highway and Transportation Officials (AASHTO). Bicycle routes are typically established based on well-defined origins and destinations, which could include schools and other community resources, residential neighborhoods, business districts and employment centers, or connections to other bicycle routes.

Bicycle routes may be designed for different design user profiles. When planning and designing for Interested but Concerned Bicyclists, existing signed bicycle routes should be assessed to understand if they meet the needs of this design user.

### Signing and Markings

The bicycle network should include route identification and wayfinding signs to help bicyclists navigate each bike route. In ~~additional~~ addition to the bicycle facility pavement markings and signing discussed in Chapter 5 and Section 6.3, bicycle route signage should be used to help provide a visual identity to the bike network and differentiate those streets and paths from others that are not part of the defined bicycle network.

**Commented [JW3]:** Replace with "addition" per July ORE markup

- Bicycle Route Guide signs (D11-1) and corresponding destination plaques (D1-1 through D1-3) serve as wayfinding signs that can help bicyclists identify and follow designated bicycle routes more easily and can provide directions to other bicycle routes or key community destinations. Bicycle Route Guide signs should be installed at appropriate intervals along the network, at locations where changes in route direction occur, and where bike routes intersect.
- Local and State Bicycle Route Signs (M1-8 and M1-8a) may be used to establish a unique identification for a specific local or State bicycle route. An M1-8a sign with "OH" at the top of the sign may only be used on routes designated as State Bicycle Routes.
- Owners of non-numbered bicycle routes should use the Non-Numbered Bicycle Route signs as described in OMUTCD 9D.06 if providing signing on the route.
- U.S. Bike Route Signs (M1-9 and M1-9 (Alternate)) are reserved for use on designated U.S. bike routes. These types of bicycle route signs should be supplemented by other bicycle guide signs and wayfinding

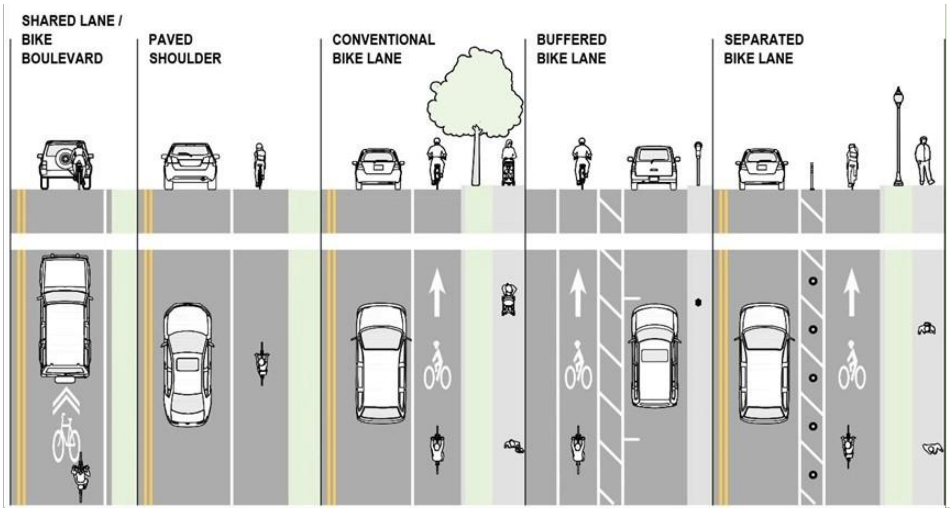
signs where appropriate to inform bicyclists of changes in direction or key destinations along the route. Where two or more bike routes overlap, the routes should be signed with two or more separate signs instead of multiple routes on the same sign.

On ODOT-maintained roadways, sign locations should be approved by District Bicycle and Pedestrian Coordinators. Refer to ODOT's State and U.S. Bike Route System Overview and Implementation Guide for additional information including maintenance responsibilities.

## 6.3 On-Road Bicycle Facilities

The following section provides design guidance for various bikeways. Although this section refers to these as bikeways, designers should understand that these facilities are also used by people on scooters, skateboards, and other micromobility devices, all of which should be considered in the planning and design process. For general design considerations including lighting, drainage, and utilities in relation to bikeways, see Chapter 3. Bicycle travel should be safely accommodated at bridges, viaducts, tunnels (Sections 4.7 and 5.4); traffic signals (Chapter 8); interchanges and roundabouts (Chapter 9); transit stops (Chapter 10); and railroad crossings (Chapter 11).

**Figure 6-1: On-Road Bikeway Types**




**Commented [BS4]:** Figure needs to be updated with the new bike lane symbol marking

### 6.3.1 Shared-Lanes

Shared-lanes are the most common bicycle accommodations since bicycles may operate on all roadways except where prohibited by ORC Section 4511.051. Shared-lanes may be identified with signage and markings or be left unmarked. Sometimes marked shared-lanes are provided as an interim strategy to enhance awareness of bicyclists' presence on the road where physical separation is desired but not currently feasible. Shared-lanes should not be used roadways with speed~~s~~ limits of 40 mph or greater ~~over 35mph~~ (OMUTCD ~~9C~~9E.~~07~~09.~~02~~03).

The designs and dimensions for shared-lanes differ by location, but attention to the following design features can make shared-lanes more comfortable for bicyclists.

- Along the roadway, provide good pavement quality, adequate sight distances, roadway design that encourages slower motor vehicle operating speeds and lower traffic volumes, bicycle- compatible drainage grates and bridge expansion joints, and safe railroad crossings.
- At signalized intersections, provide appropriate signal timing and detection systems that respond to the presence of bicycles. See Chapter 8.
- At uncontrolled crossings, provide treatments that ensure bicyclists have opportunities to safely cross the intersecting roadway. If such features or conditions are not present, improvements should be implemented. See Low-stress Intersection Crossings in Section 6.5.6 for design guidance for more information.

Where bicyclists are operating in shared-lanes, travel lane widths should generally be the minimum widths appropriate for the context of the roadway. In the past, it was common practice to provide wider outside lanes (14 ft. or greater) under the assumptions that motorists in such a lane could pass a person riding a bicycle without encroaching into the adjacent lane and that this practice would improve operating conditions and safety for both bicyclists and motorists. However, this is inconsistent with Ohio passing laws, and experience and research finds that this configuration does not adequately provide safe passing distance and that motorists generally do not recognize that this additional space is intended for bicyclists. Wider travel lanes are also associated with increases in motor vehicle speeds, which reduce comfort and safety for bicyclists. Wide lanes should not be used as a strategy to accommodate bicycling. Where wide lanes exist, roadways should at a minimum be restriped to reduce wide lanes to minimum lane widths. Additional space may be reallocated to other purposes such as bike lanes, wider sidewalks, etc.

**Commented [JW5]:** MUTCD Section 9E.09 P 03... It states shared lane markings should not be placed on roadways with speeds of 40 mph or greater. This is in effect the same since speed limits are in multiples of 5 mph.

**Commented [JW6R5]:** Updated

The use of constrained width bike lanes (see Section 6.3.4) is preferable to a wide outside lane. However, the use of constrained width bike lanes should be limited to constrained roadways where minimum bike lane widths cannot be achieved after all other travel lanes have been narrowed to minimum widths appropriate for the context of the roadway. For bicycle lanes adjacent to on-street parking, designers must follow the guidance in Section 6.3.4.

## Shared-~~-~~Lane Signs

On urban roadways with posted speed limits of 35 mph and below, the roadway lane may be marked as a shared-~~-~~lane with signage and ~~shared lane~~shared-lane bicycle markings. Signage options include:

- "BICYCLES ALLOWED USE OF FULL LANE" sign (R9-20) may be used in situations where motorists must either change lanes in order to pass a bicycle at a safe distance when overtaking or operate at reduced speed behind bicyclists until an opportunity for safe passing is presented. Lanes less than 14.5 ft. are too narrow for a motorist to pass a bicyclist at a safe distance. Most general purpose lanes are 12 ft. wide or less, and wider lanes are discouraged due to safety. Given this, on most roadways the lane widths are insufficient to allow for a bicyclist and an overtaking vehicle to travel safely side by side within the lane.
- ORC Section 4511.27 states, in part, "When a motor vehicle.... passes a bicycle, three ft. or greater is considered a safe passing distance." The ~~PASS [BICYCLE] MIN 3 FT~~Bicycle Passing Clearance sign (~~R3~~R4-~~H16~~19) should be used at locations where a problem or crash history between motor vehicles and bicyclists exists. It may also be used at other locations based on engineering judgment.
- BICYCLE warning sign (W11-1) may be supplemented with an "IN ROAD~~,~~," (W16-1P) or "ON BRIDGE," plaque. The use of this sign assembly should be used in unique situations where bicyclists may appear to motorists to be unexpectedly operating within the travel lane.

The BICYCLE warning sign (W11-1) supplemented with a "SHARE THE ROAD" plaque ~~(W16-1P) should~~ shall not be used to communicate a shared-~~-~~lane condition. While it was previously common practice to use this combination of signs to communicate a shared-~~-~~lane condition, research has shown that the "SHARE THE ROAD" message is unclear to both motorists and bicyclists.[1] Existing applications of the "SHARE THE ROAD" plaque shall~~ould~~ be replaced with the "IN ROAD" (W16-1P) plaque.

## Shared-~~-~~Lane Markings

Shared-~~-~~lane markings are intended to let bicyclists know where to position themselves in the lane and to communicate to motorists that bicyclists are likely to occupy the travel lane. When using ~~shared lane~~shared-

**Commented [JW7]:** This appears to be a custom ODOT sign from the Traffic Engineering Manual (TEM) but we don't see it in the 2012 OMUTCD. The MUTCD has a dedicated sign for this (R4-19). Consider simply using this now.

**Commented [DS8R7]:** There is a new R4-19 sign in the SHS that is not covered in the 11th Edition of the MUTCD. ODOT will most likely adopt the R4-19 and retire the R3-H16.

**Commented [JW9R7]:** Updated

**Commented [DH10]:** official MUTCD warning sign (W16-1P) may be used now

**Commented [PB11R10]:** Just noting that there is not a sign code for an "ON BRIDGE" plaque

**Commented [DS12R10]:** SDMM does have "ON BRIDGE WHEN FLASHING" (W16-H13aP)

**Commented [JW13R10]:** Updated

**Commented [JW14]:** Consider removing this paragraph entirely since the W16-1P sign is no longer in the Manual.

**Commented [DS15R14]:** W16-1P changed from "SHARE THE ROAD" to "IN ROAD". The paragraph could be reworded to inform the reader that previous versions of W16-1P (SHARE THE ROAD) should be replaced with the new version (IN ROAD).

MUTCD Section 9C.08 covers this.

**Commented [JW16R14]:** Updated

**Commented [JW17]:** Shared-lane is hyphenated in the MUTCD when referring to the signs or markings used to designate the facility

**Commented [JW18R17]:** Updated

lane markings, there are three considerations: lateral placement, longitudinal placement, and intersection approaches/navigation.

1. Lateral placement: Shared--lane markings should be marked on an alignment that represents a practical path of bicycle travel under typical conditions. For most streets, such as where on-street parking is present or where lane widths are less than 14.5 ft., this lateral placement should be the center of a shared travel lane. The lateral placement of a shared laneshared-lane marking is measured from the center of the chevron marking to the face of the curb, gutter seam, edge of the pavement, or edge of on-street parking (see Figure 6-2).

Where shared laneshared-lane markings are not placed in the center of the lane, they should be placed a minimum of 4 ft. from the face of curb, gutter seam, or edge of the travel waypavement, or edge of on-street parking. This minimum distance should be increased at locations where:

- Existing drainage inlets or gutters create potential safety issues;
- There is an inconsistent or rough roadway edge or gutter; or
- Guardrails, rock outcroppings, walls, or other physical objects are located immediately adjacent to the travel lane.

On a street with shared--lanes designated as a bicycle route, if the bicycle route makes a left turn it may be appropriate to place shared laneshared-lane markings within both the right and left lanes of the street.

**Figure 6-2: Shared-Lane Markings Lateral Placement**

**Commented [JW19]:** This is more restrictive than the MUTCD (12 feet from face of curb, which would be 4-5 feet into the travel lane with an 8-foot parking lane) - confirm that that is the intent.

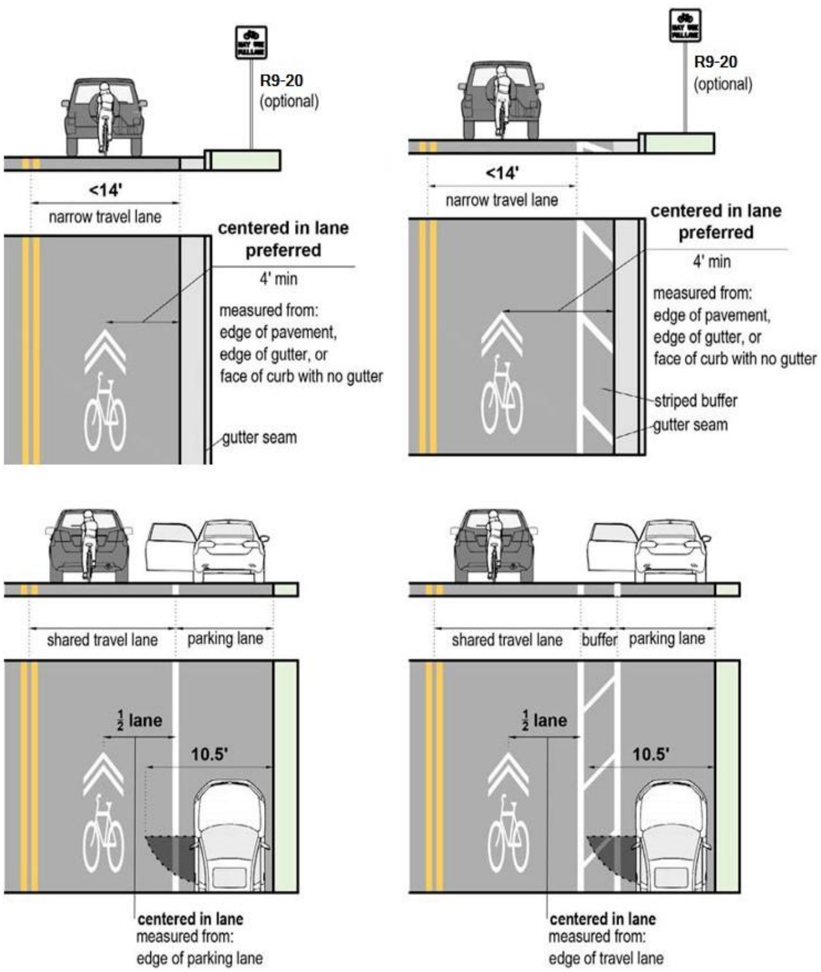
**Commented [DS20R19]:** MUTCD 9E.09 P07 suggests a minimum of 12 feet from the face of curb on roads with on-street parallel parking.
As described in this paragraph and In Figure 6-2 example with parallel parking indirectly shows a distance of at least 12 feet. This could be improved by adding a 3rd dimension from center of marking to face of curb.

**Commented [JW21R19]:** No change recommended, just wanted to clarify/confirm that ODOT intended to be more strict than the MUTCD. (ODOT's placement of shared-lane markings would be 13-14' from face of curb with an 8' parking lane and 10-12' travel lanes, which is greater than the minimum of 12' specified in the MUTCD).

**Commented [JW22]:** This language is different than the paragraph above, which references the edge of pavement or edge of on-street parking

**Commented [DS23R22]:** This should be "edge of pavement"
See MUTCD Section 9E.09 P08

**Commented [KF24]:** Update R9-20 sign image for clarity and consistency with MUTCD




2. Longitudinal spacing: Shared-lane markings should be placed a maximum of 50 ft. downstream from an intersection and spaced at intervals at a maximum of 250 ft. thereafter (see Figure 6-3). If possible, the first marking after an intersection or driveway should be placed outside of the wheel path of turning vehicles to reduce wear.

Unlike bike lanes, which provide a continuous visual presence, ~~shared lane~~shared-lane markings are intermittent. To compensate for this, consider placing ~~shared lane~~shared-lane markings at closer intervals than 250 ft. to increase motorist awareness of bicyclists and to provide additional guidance for bicyclists. This closer spacing may be used in the following situations:

- On streets with higher volumes of bicyclists where the shared-lane condition fills a gap between bikeways;
- To guide bicyclists through intersections, weaving areas, or turn lanes where there is higher potential for conflicts with motorists;
- 
- At locations with a history of conflicts or crashes between bicyclists and motorists;
  In locations with limited sight distance including approaches to horizontal and vertical curves; or
- In shared-lane conditions within tunnels and across bridges.

3. Intersection navigation: Shared-lane markings can also be used to provide guidance to a bicyclist to change lanes on approaches to intersections or to help them traverse an intersection. The markings should be located in a line of travel that allows the bicyclist time to merge while minimizing conflicts and unsafe motorists passing maneuvers. In these locations, the markings may be placed as close as necessary, less than the 50 ft. described above, to clearly identify the preferred travel path and maneuver. Example applications include:

- Turns through intersections;
- ~~Navigation of lane shifts through intersections (see Figure 6-3);~~
- Approaches to intersections where bicyclists must merge across one or more travel lanes; and
- Approaches and crossings of railroad tracks (Chapter 11).

While the OMUTCD does not require marking parking lane lines, it may be considered to mark the edge of on-street parking when bicyclists are expected. The parking lane line can provide a continuous point of reference to help bicyclists maintain their line of travel between ~~shared lane~~shared-lane markings. This can be further encouraged by adding optional door zone buffer markings (see Markings in Section 6.3.4) or the parking lane line. The placement of a ~~shared lane~~shared-lane marking in the travel lane in these cases may cause confusion for bicyclists and motorists. In situations with low parking demand, it is preferable to provide bike lanes and consolidate parking to one side of the street or remove parking altogether.

**Commented [JW25]:** The use of shared lane markings are prohibited to guide bicyclists through intersections (Section 9E.09 P 04 line B).

**Commented [JA26R25]:** I don't read this as having markings in the intersection. To me, this reads as happening at the approach.

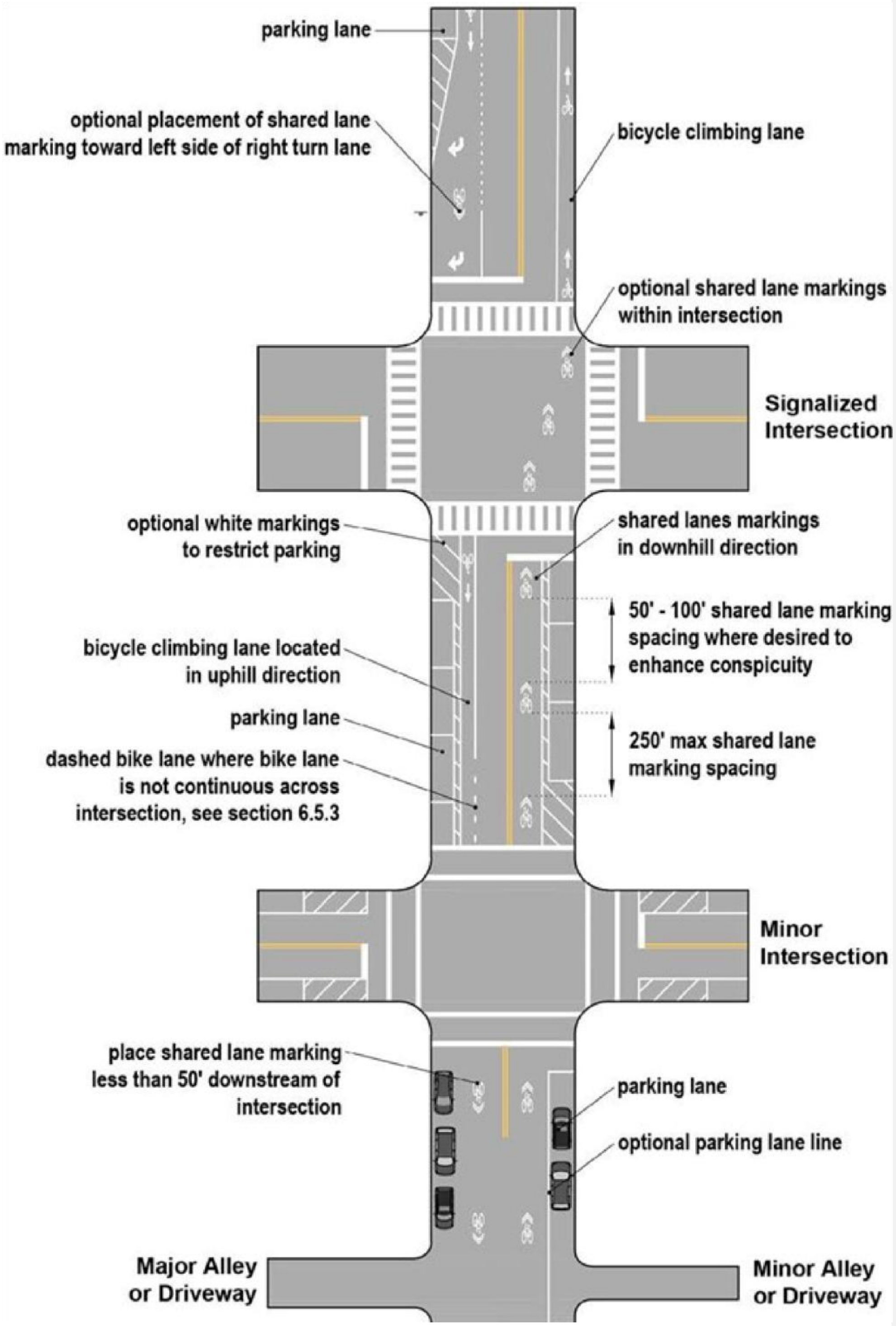
**Commented [DS27R25]:** I agree that some of this could be interpreted that shared lane markings can be used through intersections. (i.e., "Navigation of lane shifts through intersections (see Figure 6-3)")

**Commented [JW28R25]:** Updated (removed the second bullet point)

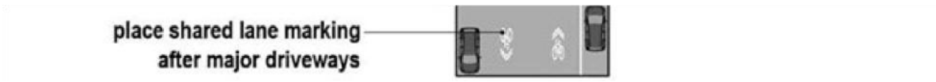
**Figure 6-3: Longitudinal Placement and Intersection Navigation Examples of ~~Shared Lane~~Shared-Lane Markings along a Roadway**

**Commented [JW29]:** Update figure to remove shared lane intersection guide markings per Section 9E.09 P 04 line B.

**Commented [JA30R29]:** Agree.



parking lane
optional placement of shared lane marking toward left side of right turn lane
bicycle climbing lane
optional shared lane markings within intersection
Signalized Intersection
optional white markings to restrict parking
shared lanes markings in downhill direction
50' - 100' shared lane marking spacing where desired to enhance conspicuity
bicycle climbing lane located in uphill direction
parking lane
250' max shared lane marking spacing
dashed bike lane where bike lane is not continuous across intersection, see section 6.5.3
Minor Intersection
place shared lane marking less than 50' downstream of intersection
parking lane
optional parking lane line
Major Alley or Driveway
Minor Alley or Driveway




## 6.3.2 Bicycle Boulevard

Bicycle boulevards, also commonly referred to as neighborhood bikeways or greenways, are low- volume and low-speed streets that enhance bicyclist safety and comfort through design treatments such as speed and/or volume reduction features, pavement markings, signage, and street crossing treatments. These treatments generally support through bicycle movements while discouraging non-local motorists from using them for through trips. Although bicycle boulevards operate as shared-lanes, the following guiding principles define bicycle boulevards and set them apart from other local streets or shared-lane roadways.

1. Managed motorized traffic volumes and speeds.
2. Prioritize bicyclist right of way at local street crossings.
3. Provide safe and convenient crossings at major streets.

Bicycle boulevards are intended to function as part of a low-stress bicycle network. The following summarizes the typical characteristics of a Bicycle Boulevard:

- Volumes and speeds: Motorist speeds and volumes should not exceed the criteria in Table 6-1.
- Traffic calming and diversion strategies should strive to achieve the preferred values in the table.
- Connections to local destinations: Routes should be parallel with and near major thoroughfares connected to major destinations (1/4 mile or less).
- Route directness: There is no excessive zigzag or circuitous routing.
- Topography: Longer, more gentle slopes are preferable to shorter, steep segments. Topography should be balanced with route directness.
- Feasibility of major street crossings: Major street crossings on routes should be designed to provide low-stress crossings as defined in Section 6.5.6.

**Table 6-1: Bicycle Boulevard Motorized Traffic Volume and Speed Performance Criteria**

| Minimize Motorized Through Traffic Volumes and Speed | | |
| --- | --- | --- |
| **Peak Hourly Traffic Volume*** | **Average Daily Traffic Volume** | **Operating Speed** |

### Bicyclist Right of Way Considerations at Intersections

ORC 4511.44 notes that “[t]he operator of a vehicle, streetcar or trackless trolley about to enter or cross a highway from any place other than another roadway shall yield the right of way to all traffic approaching on the roadway to be entered or crossed.” As such, a bicyclist operating on a shoulder must always yield the right of way to motorists. Bicyclists operating on the paved shoulder may not be aware of these requirements. In order to accommodate bicyclists along a paved shoulder and clearly communicate the right of way to all roadway users, designers may consider the following:

- The paved shoulder may be converted to a bike lane as it approaches intersections or driveways. By designating the area as a bike lane instead of a paved shoulder, the bike lane will constitute part of the roadway, bicyclists would have the right of way at intersections, and turning vehicles would be required to merge into the bike lane to make right turns. Designers may provide a regulatory sign identifying “Turning Vehicles Yield to Bikes” on state and local roads. This may better accommodate bicyclists of all ages and abilities and should always be considered if speeds are greater than 35 mph.

This is further discussed in Section 6.5.7.

## 6.3.4 Bicycle Lanes

Bicycle lanes (bike lanes) are one-way bikeways designated for preferential use by bicyclists that typically carry bicycle traffic in the same direction as adjacent motor vehicle traffic and are distinguished from traffic lanes by striping, signing, and pavement markings. Buffered bike lanes are striped on-street bike lanes paired with a painted buffer space separating the bike lane from the adjacent motor vehicle travel lane and/or parking lane to increase the comfort of bicyclists.

Figure 3-3 identifies the roadway conditions suitable for bike lanes to accommodate the comfort of an Interested but Concerned Bicyclist, but bike lanes can be provided to accommodate bicyclists on any roadway that legally permits bicyclist use.

In most cases, bike lanes should be provided on both sides of two-way streets. A bike lane provided on only one side may invite wrong-way use. The following scenarios note when it may be acceptable to provide a bike lane on one side and how to select which side:

- On streets where downhill grades are long enough to result in bicycle speeds similar to typical motor vehicle speeds, a bike lane may be provided only in the uphill direction, with ~~shared lane~~shared-lane markings in the downhill direction. This design can be especially advantageous on streets where fast downhill bicycle speeds have the potential to increase the likelihood of crashes with fixed objects, particularly in locations with on-street parking.

- Where a roadway narrows on one side of the roadway for a short segment with an otherwise continuous bike lane.
- Where an adjacent parallel roadway of similar width provides a bike lane in the opposing direction.

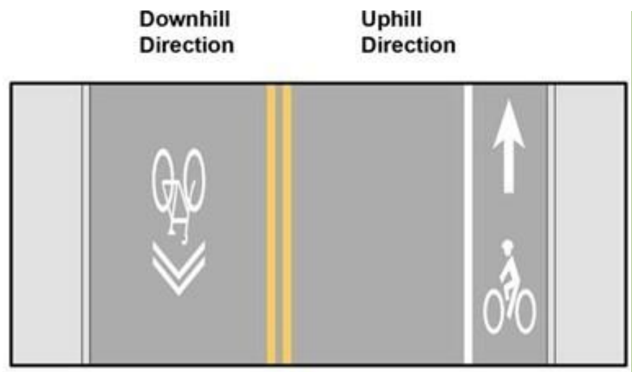
When a bike lane is only provided in one direction, ~~shared lane~~shared-lane markings should be added in the opposing direction if the roadway speed is 35mph or below. See Section 6.3.1 for shared-lane design.

## Width

The widths prescribed in Table 6-3 accommodate a person's operating space, occasional passing, and shy distances to vertical elements as discussed in Chapter 3. Chapter 7 provides guidance on when narrowing travel lane widths or reducing the number of travel lanes to achieve desired bike lane widths may be appropriate.

The width of a bicycle lane does not include the gutter adjacent to a curb. Where a bicycle lane is adjacent to a gutter, the width of the bicycle lane should be measured from the edge of the gutter to the center of the bike lane line. Where a bicycle lane is adjacent to a curb with no gutter, the bicycle lane width should be measured from the face of curb to the center of bike lane line. On streets with on-street parking, the bike lane width should be measured from the center of the parking line or buffer line to the center of the bike lane line.

**Figure 6-5: ~~Shared Lane~~Shared-Lane Marking and Bike Lane on Steep Street**




**Commented [BS31]:** Bike lane marking to be updated.

In addition to the design values presented in Table 6-3, consider the following when designing bike lane widths:

- Bike lanes wider than the shown minimum should be considered:
  - in locations with high parking turnover;
  - where side-by-side bicycle travel is desired;
  - where roadways have irregular edges or sharp drop-offs;
  - where bicycle lanes are positioned between two moving travel lanes, such as a turn lane and through lane;
  - or on roadways that have more than 5 percent heavy vehicles, posted speeds over 30mph or AADT over 6,000.
- On low-speed roadways with curbs but no gutter, where the minimum bike lane width cannot be achieved despite narrowing all other travel lanes to their minimum widths, a constrained 4 ft. wide bike lane can be used.
- Where wider bike lanes are feasible, a buffer may reduce incidences of motorist attempting to use the bike lane as a travel lane or parking lane. See Section 6.3.5. Alternatively, a wide bike lane may include green colored pavement to discourage motorist use.

**Table 6-3: Bike Lane Zone Widths**

**One-Way Standard Bike Lane Width Criteria**

| Bike Lane Description | Minimum Width (ft) | Constrained Width (ft) |
|---|---|---|
| Adjacent to curb[1] or edge of pavement | 5 | 4 |
| Between travel lanes or buffers | 5 | 4 |

[1] Exclusive of the gutter unless the gutter is integrated into the full width of the bike lane

| | | |
|---|---|---|
| Adjacent to parking[1] | 6 | 5 |
| Intermediate or sidewalk level raised bike lane[1] | 5.5 | 5 |
| To allow side-by-side bicycling or passing | 8 | 7 |

Bike lanes should typically be provided on both streets of a one-way couplet. If a one-way roadway pair in the opposite direction does not exist or would significantly increase a bicyclist travel time due to out of direction travel, there may be an increase in wrong way riding. If sufficient width exists, a counter flow bike lane can also be added to provide for two-way bicycle travel on a one-way street. For a bike lane to function as intended when built against the dominant flow of traffic on a one-way street, the following features should be incorporated into the design:

- The counter flow bike lane should be placed on the correct side of the roadway consistent with the ORC (i.e., on the left-hand side from the motorist's perspective).
- A bike lane should be provided for bicyclists traveling in the same direction as motor vehicle traffic. If there is insufficient room to provide a bike lane in the dominant flow direction of the street, ~~shared lane~~shared-lane markings should be considered to emphasize that bicyclists must share the travel lane on this side of the street.
- Where parking is present along a counter flow bike lane, motorists leaving a parking space may have difficulty seeing oncoming bicyclists in the counter flow bike lane, as sight lines may be blocked by other parked vehicles. For this reason, the provision of counter flow bike lanes should be discouraged where high-turnover parking is present on the same side of street.

---

[1] Raised bike lanes adjacent to parking should have a minimum width of 7 feet

## Bicycle Lanes on One-Way Streets

On one-way streets, bike lanes should normally be on the right-hand side of the roadway. A bike lane may be placed on the left side if there are a significant number of left turning bicyclists or if a left-side bike lane would decrease conflicts, such as those caused by bus stops, heavy right-turn movements, deliveries, or onstreet parking.

- Bike lane symbols and directional arrows should be used on both the approach and departure of each intersection, to remind bicyclists to use the bike lane in the appropriate direction, and to remind motorists to expect two-way bicycle traffic.
- Centerline markings, medians, or traffic separators shall be provided between motorists and bicyclists traveling in the opposing direction where the speed limit is 30 mph or less. Where the posted speed limit is 35 mph or greater, medians, traffic separators, or some form of physical separation shall be required to separate motorists and bicyclists traveling in the opposing direction. See OMUTCD 9E.08.
- ~~Centerline markings along the left side of the counter flow bike lane should be provided where passing is prohibited in both directions.~~
- ~~Medians or traffic separators should be considered to provide more separation between motorists and bicyclists traveling in the opposing direction, particularly at intersections. This treatment is required when posted speeds exceed 35 mph.~~
- At intersecting streets, alleys, and major driveways, DO NOT ENTER (R5-1) signs and turn restriction signs should include a supplemental EXCEPT BICYCLES (R3-7bP) plaque to establish that the street is two- way for bicyclists.
- At traffic signals, bicycle signal heads ~~should~~ shall be provided for counter-flow bicyclists, as well as suitable bicycle detection measures (OMUTCD 9E.08.12). A ~~supplemental plaque~~Bicycle Signal sign (R10-40 or R10-41 series) ~~that says BICYCLE SIGNAL may be needed beneath~~ shall be installed immediately adjacent to (including above or below) the signal face to clarify its purpose (OMUTCD 4H.03.02).

## Signage

The following describes common signs needed where bicycle lanes are present. ~~Section~~ Chapters 9B through 9D of the OMUTCD provides additional guidance on bike lane signage.

BIKE LANE (R3-17) signs may be placed as needed or at periodic intervals along a bike lane (see Figure 6-6). Spacing of the sign should be determined by engineering judgment based on the prevailing speed of bicycle and other traffic, block length, and distances from adjacent intersections, but should not be installed in a manner that creates sign clutter. Bike lane markings are typically used more frequently than BIKE LANE signs, but where the BIKE LANE sign is used it should generally be placed adjacent to a bike lane pavement marking. The sign may be located on an existing post/utility pole when present.

**Commented [DH32]:** Added clarifying language for counter-flow bike lane per ODOT staff

**Commented [JW33]:** Consider adding the MUTCD sign designations

**Commented [JW34R33]:** Updated

**Commented [JW35]:** Consider adding the MUTCD sign designations

**Commented [JW36R35]:** Updated

**Commented [JW37]:** Is it intended for this to be a bike signal, vehicle signal, or ped signal? Section 9E.08 P12 implies that a bike signal is required. May require clarification with FHWA.

Also what is the intent of the BICYCLE SIGNAL sign? If the intent is for bike signals to be used, the bike signal signs have changed and we'd recommend including the MUTCD sign designation. If the intent is to use vehicle signals in these applications, we can no longer add a bike signal sign to a non-bike signal (Section 4H.06 P 01)

**Commented [PB38R37]:** Bicycle signal. Update sign codes as well

**Commented [JW39R37]:** Updated

**Commented [JW40]:** Chapters 9B through 9D of the 11th Edition of the MUTCD

**Commented [JW41R40]:** Updated

The standard BIKE LANE (R3-17) sign with the AHEAD (R3-17aP) plaque may be placed in advance of the start (upstream end) of a bike lane. These signs are often considered at locations where the bike lane may be unexpected or there are sight distance restrictions to the bike lane.

The BIKE LANE sign with the ENDS (R3-17bP) plaque may be used in advance of the end of a bike lane to warn that a bike lane is ending. The BIKE LANE ENDS sign should always be used where a bike lane changes to an unmarked paved shoulder, for example at the urban or suburban fringe, but should not be used at temporary interruptions in a bike lane, such as where a bike lane is dropped on the approach to an intersection and resumes immediately after the intersection.

A BIKE LANE ENDS warning (W9-5) sign may be used in advance of a BIKE LANE ENDS regulatory sign, to warn bicyclists and motorists of the upcoming condition. A "BICYCLES ALLOWED USE OF FULL LANE" sign (R9-20), BICYCLE warning sign (W11-1), and/or ~~shared lane~~shared-lane markings may be installed downstream of the merge area.

If motorists stopping, or parking in a bike lane is a known problem, then, local jurisdictions shall install NO PARKING BIKE LANE signs (R7-9 or R7-9a) restricting parking.

For locations where wrong-way riding by bicyclists is frequently observed in bike lanes, the WRONG WAY and RIDE WITH TRAFFIC plaque (R5-1b and R9-3cP) may be used.

For locations where warning or regulatory signs are not applicable to bicyclists, an EXCEPT BICYCLES plaque should be used to supplement the warning or regulatory sign. These plaques may be applicable to supplement a variety of signs, such as DO NOT ENTER, NO OUTLET, ONE WAY, ALL TRAFFIC MUST TURN RIGHT, etc. The EXCEPT BICYCLES plaque shall not be used to exempt bicycles from STOP, YIELD, Yield Here to Pedestrians, or Stop Here for Pedestrians signs, nor from traffic signal indications. The regulatory (R3-7bP) version of the sign ~~should~~ shall only be used with other regulatory signs; the warning (W16-20P) version ~~with black letters on a warning~~of the sign ~~panel should~~shall only be used with other warning signs.

**Commented [JW42]:** Consider adding the MUTCD sign designations

**Commented [JW43R42]:** Updated

**Commented [JW44]:** Consider also noting that it cannot be used with STOP or YIELD signs

**Commented [JW45R44]:** Updated

## Markings

As detailed in ~~Section 9C~~Chapter 9E of the OMUTCD, a bike lane is designated for preferential use by bicyclists with a white line and bike lane symbol markings or word markings. The markings should be supplemented with the directional arrow marking indicating the correct direction of travel in the bike lane. Although the

**Commented [JW46]:** Section 9E of the 11th Edition of the MUTCD

**Commented [JW47R46]:** Updated, but left reference to OMUTCD based on previous correspondence white line may be a normal width (4 to 6 inch wide), a wider width should be considered where additional emphasis is appropriate, such as roadways with higher motorist speeds and volumes. Wider markings can have the added benefit of improving the longevity of the markings.

Bike lane symbol markings should be placed a maximum of 50 ft. downstream from an intersection and spaced at intervals based on engineering judgement thereafter (see Figure 6-6). Spacing at or below 250 ft. may provide additional flexibility in urban areas. The first marking after an intersection or driveway should be placed outside of the wheel path of turning vehicles, to reduce wear. Additional bike lane symbols may be placed at closer intervals.

Bike lane symbols may be closer than 250 ft. where potential conflicts between bicyclists and motorists are higher, such as approaches to areas with significant parking turnover, at the near- and far-side of intersections and driveways, and adjacent to turn lanes. In suburban and rural areas, with long distances between intersections and little roadside activity, bike lane symbols may be as far apart as 1,000 ft. or more.

Designers should also consider conflict markings at intersections and driveways as discussed in Section 6.5.1.

### Green-Colored Pavement

Green-colored pavement is beneficial to supplement other bikeway pavement markings to communicate to road users where portions of the roadway have been designated for exclusive or preferential use by bicyclists, and to enhance the conspicuity of a bicycle lane, bike lane symbol, bicycle lane extension, bicycle crossing, bicycle box, or two-stage bicycle turn box. Green-colored pavement is an optional treatment that may be used per OMUTCD Section 3H.06.

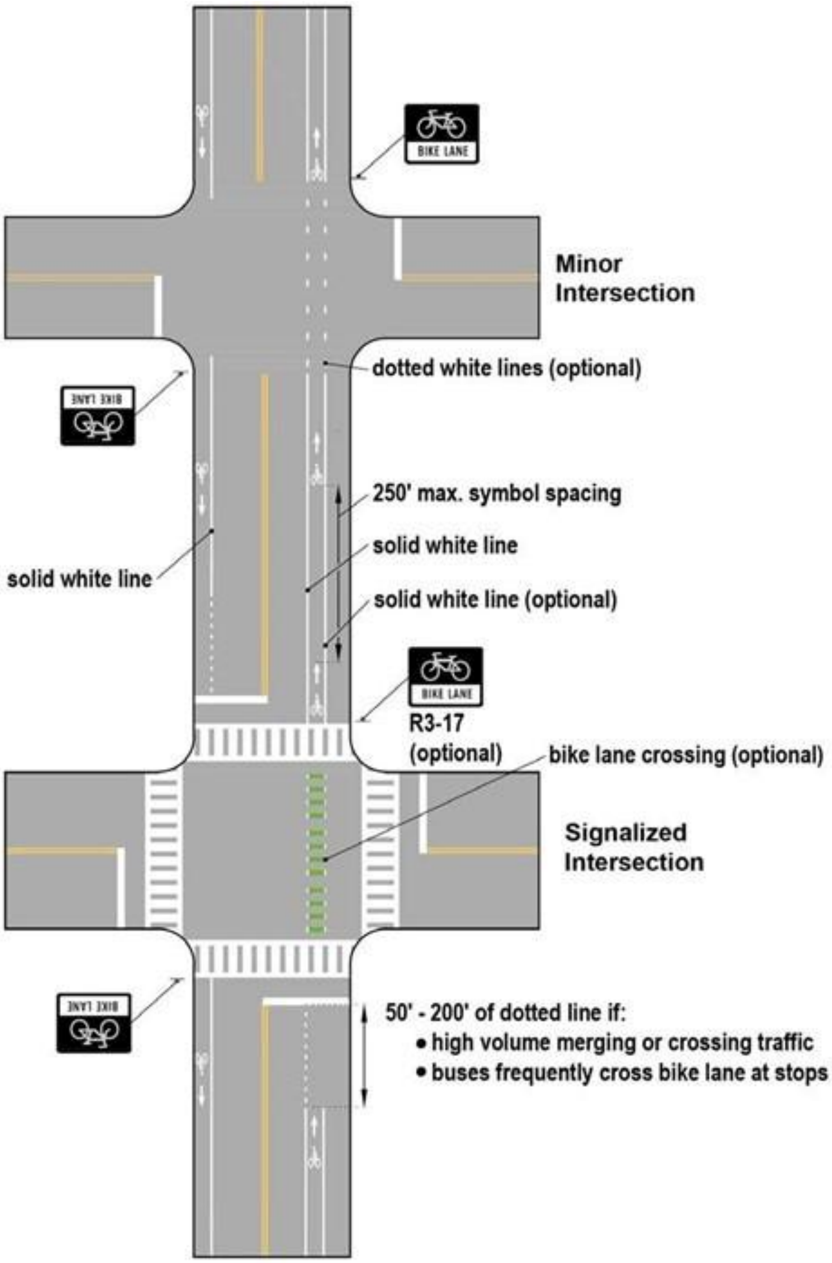
If green-colored pavement is used, designers should consider the longevity of the marking materials, the installation methods, and the expected motorist wheel paths to reduce long- term maintenance. For example, thermoplastic green markings may be appropriate for lane extension markings, two-stage bicycle turn boxes, and approaches to intersections where vehicles are expected to traverse the markings, whereas epoxy or methyl methacrylate (MMA) green markings may be appropriate where few vehicles would traverse the markings or where long areas of green are desired (such as within bike boxes or along areas with on-street parking). Thermoplastic pavement markings may also be ground-in to reduce the likelihood of a plow catching the edge of the markings to improve their longevity.

The use of green-colored pavement to supplement other bikeway pavement markings, such as a shared lane marking, requires experimental approval from FHWA.

**Commented [JW48]:** Green paint cannot be used with a shared lane marking now. This experiment was not incorporated into the 11th Edition.

**Commented [JW49R48]:** Updated

**Figure 6-6: Typical Bike Lane Pavement Markings and Traffic Control Signs**




**Commented [JW50]:** Update bike lane markings per MUTCD

## Bicycle Lanes Adjacent to On-Street Parking

Where on-street parking is permitted along a bike lane, the bike lane should be located between the parking lane and the travel lane, unless designed as a separated bike lane following guidance in Section 6.3.7 for separated bike lanes. Delineating the bike lane with two stripes, one along the street side and one along the parking side, is preferable to a single stripe.

When parallel parking lanes are narrow (7 ft.) with high turnover it is preferable to provide a separated bike lane to eliminate conflicts with the vehicles, see Section 6.3.7. When a separated bike lane is not feasible or an interim solution is needed, a buffered bike lane should be provided, see Section 6.3.5. If a striped buffer is not desired, the bike lane width may be increased to provide bicyclists with more operating space to ride out of the area of opening vehicle doors; however, as bike lane widths increase they may appear more like travel lanes and may result in instances of double parking. Designers may consider the use of green pavement to discourage motorists from using the bikeway.

If a buffered bike lane is not feasible, designers should consider the following options in the order stated:

1. Evaluate the reduction of travel lane widths and parking lane widths to accommodate the design widths for buffered bicycle lanes.
2. Evaluate if parking can be consolidated to one side of the street or removed to provide the additional space necessary to accommodate the design widths for buffered bicycle lanes
3. On constrained streets where it is not feasible to eliminate parking or to narrow or remove a travel lane to achieve the minimum dimensions, research indicates there is a slightly reduced risk of dooring in bike lanes as compared to shared-lanes.[2] The bicycle lane may be narrowed to a minimum width of 4 ft. to provide a buffer within the door zone area. The door zone buffer may vary from 2 ft. to 4 ft. (3 ft. minimum where parking lanes are 7 ft.). The buffer markings will encourage bicyclists to ride farther from parked vehicles and encourage motorists to park closer to the curb.
4. Provide ~~shared lane~~shared-lane markings in accordance with Section 6.3.1. This design is unlikely to accommodate the Interested but Concerned Bicyclist, but could accommodate the Highly Confident Bicyclist.
5. The minimum combined bicycle lane and parking lane width is 12 ft. All other travel lanes should be narrowed to the allowable constrained width before the minimum combined bicycle and parking lane width is considered. Pavement markings may be used within the bike lane to identify the potential door zone area by extending parking tees or diagonal pavement markings into the bike lane up to 3.5 ft. from the parking lane line. See Figure 6-7.

For the scenarios listed above, to improve the visibility of the bike lane adjacent to parking or loading areas, green-colored pavement, may be used within the bicycle lane.

Bike lanes should not be placed adjacent to head-in angled parking, since drivers backing out of parking spaces have poor visibility of bicyclists in the bike lane. The use of back-in angled parking can help mitigate the conflicts normally associated with bike lanes adjacent to head-in angled parking. Figure 6-8 provides guidance on the angle, width, and depth of back-in angled parking.

**Figure 6-7: Example of Door Zone Markings in Constrained Bike Lane Conditions**

Commented [JW51]: Update bike symbol per MUTCD

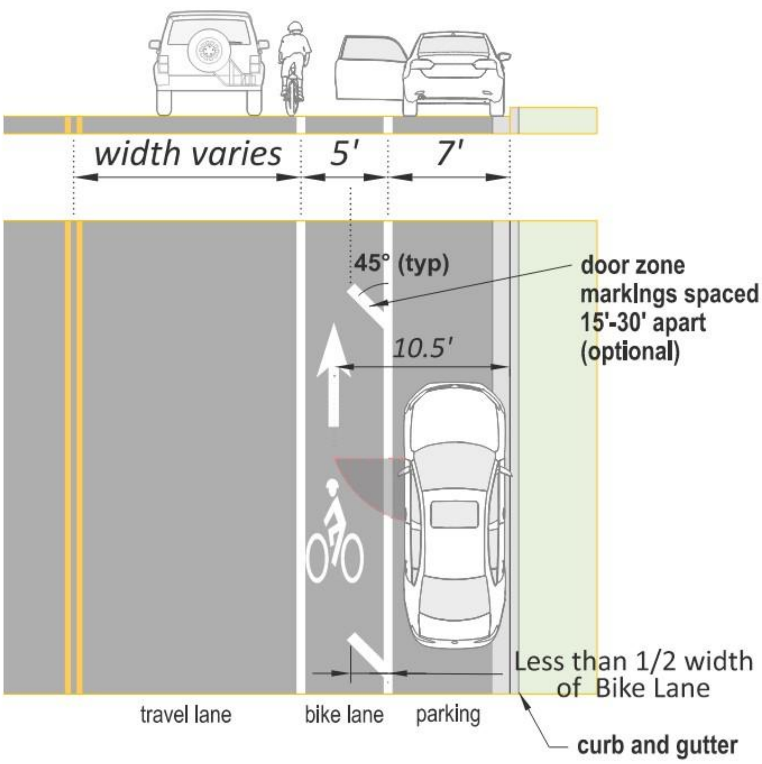
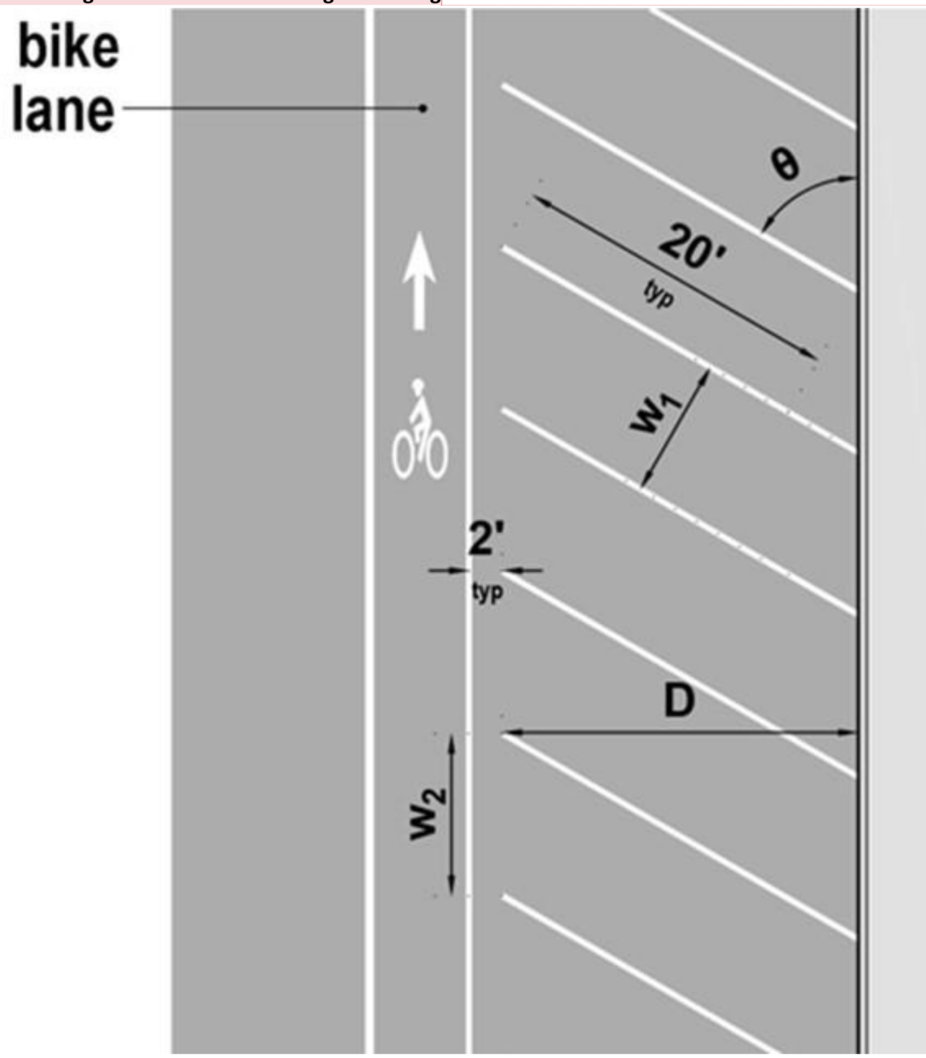


**Figure 6-8: Design Criteria for Back-in Angled Parking**




**Back in Angle Parking**

Commented [JW52]: Update bike symbol per MUTCD

| θ (Degrees) | W1 (feet) | W2 (feet) | D (feet) |
|---|---|---|---|
| 0° | 7-10 | 20 | 7-10 |
| 30° | 8-9 | 16-18 | 16.9-17.8 |
| 45° | 8-9 | 11.3-12.7 | 19.8-20.5 |
| 60° | 8-9 | 9.2-10.4 | 21.3-21.8 |

W1 = stall width

W2 = striping width D =

depth to face of curb

θ = angle

## Curbside Management

At locations where vehicles frequently stop or stand in the bike lane, in addition to the signing strategies noted above, it may be beneficial to implement curbside management strategies to result in increased parking and loading space availability during peak periods and to address various curbside uses. Curbside management strategies may include implementation of loading zones, metered parking with performance pricing to promote parking turnover, evening freight delivery, paratransit loading areas, or passenger drop off areas. These strategies may be implemented on a corridor with a bike lane or on adjacent streets. Where on-street parking is present, loading zones may be delineated within the parking lane, and the bike lane may be preserved alongside them. See the ITE Curbside Management Practitioners Guide for more information.

### 6.3.5 Buffered Bicycle Lanes

Buffered Bicycle lanes (buffered bike lanes) are one-way bikeways designated for preferential use by bicyclists that are striped with a buffer space separating the bike lane from the adjacent motor vehicle travel lane and/or on-street parking lane to increase the comfort of bicyclists. Where space is available, existing bike lanes can be improved through the provision of the painted buffer. Buffered bike lanes may be provided on any roadway to increase the comfort of bicyclists and are beneficial for the Interested but Concerned Bicyclist as traffic volumes and speeds increase (see Figure 3-3). Buffered bike lanes follow the same design guidance as bike lanes for widths and other design elements with the following additions:

### Width

The width of the bike lane should generally follow the guidance for Bicycle Lanes (see Section 6.3.4). However, where a buffered bike lane is provided the bicycle lane may be narrowed to a minimum of 4 ft. to maximize the width of the buffer. While the buffer is not a part of the bicycle lane width, it should be anticipated to be used by bicyclists to pass other bicyclists or to merge into the adjacent travel lane; as such, the buffer surface should be traversable.

### Striped Buffer Markings

The striped buffer of a buffered bike lane may include chevrons, diagonal lines, or wide pavement marking stripes depending on the conditions and widths available~~.~~ (~~S~~see Figure 6-9). Where the width of a buffer is less than 2 ft., chevron or diagonal line markings may be omitted within the buffer space. Where the width of a buffer is between 2 and 3 ft., chevron or diagonal line markings should be provided within the buffer space. Where the width of a buffer is greater than 3 ft., chevron or diagonal line markings shall be provided within the buffer space. Where diagonal lines are used in lieu of chevron markings, diagonal line markings shall slant away from the adjacent vehicular travel lane.

Where provided, ~~crosshatching or chevron~~chevron or diagonal line markings should be provided at a regular interval. A typical spacing is 15 ft. with some locations reduced to as frequent as ~~5~~ 10 ft. spacing where engineering judgment determines a more frequent spacing should be used to discourage motorists encroachment or parking. The maximum spacing should not exceed the equivalent of the speed limit of the roadway (e.g., 45 mph posted speed equals a 45 ft. maximum spacing between markings). There is no maximum buffer width; however, when it is feasible to provide buffers totaling 6 ft. or more in width, consideration should be given to installing separated bike lanes, see Section 6.3.7 for evaluating if a separated bicycle lane may be appropriate.

Where parking is permitted, a buffer located between the bike lane and parking can increase the comfort and safety of bicyclists operating adjacent to parked vehicles by reducing the potential for a dooring type crash. See also Bicycle Lanes Adjacent to On-Street Parking.

**Commented [JW53]:** Consider stating that diagonal lines should slant away from traffic in the adjacent travel lane? MUTCD Section 9E.06 P 11

**Commented [DH54R53]:** Could also refer to Figure 6-9 for line positioning

**Commented [JW55R53]:** Updated

**Commented [JW56]:** Consider clarifying that when the buffer is <2' diagonal lines/chevrons can be omitted, between 2'-3' they should be included, and over 3' they shall be included. This isn't super clear in the MDG and the figure dimensions don't align with the MUTCD

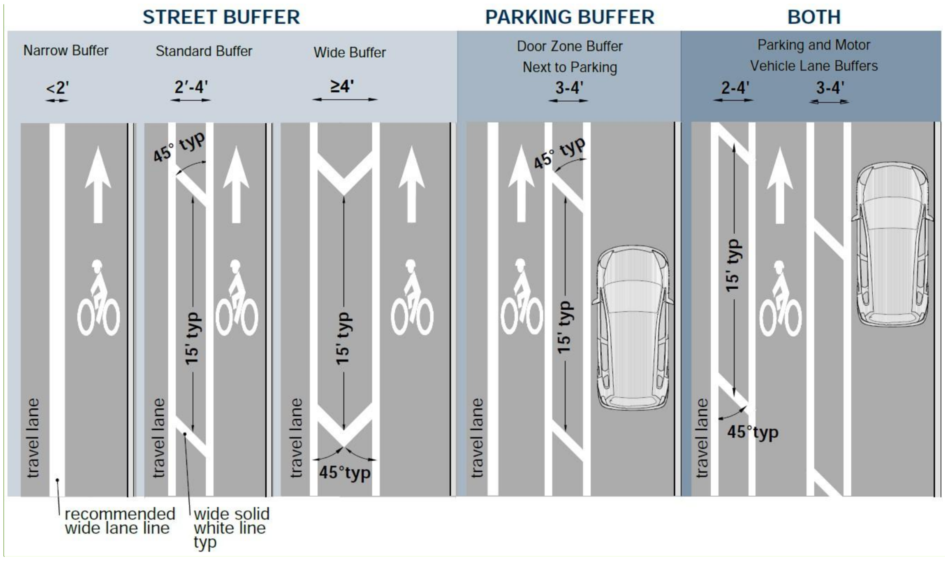
**Commented [JA57R56]:** I agree that this would make sense to include.

**Commented [JW58R56]:** Updated

**Commented [JW59]:** MUTCD has a "should" minimum of 10 feet (Section 9E.06 P 12)

**Commented [JW60R59]:** Updated

**Figure 6-9: Typical Striped Buffer Treatments**




Commented [BS61]: To be updated with new bike lane markings.

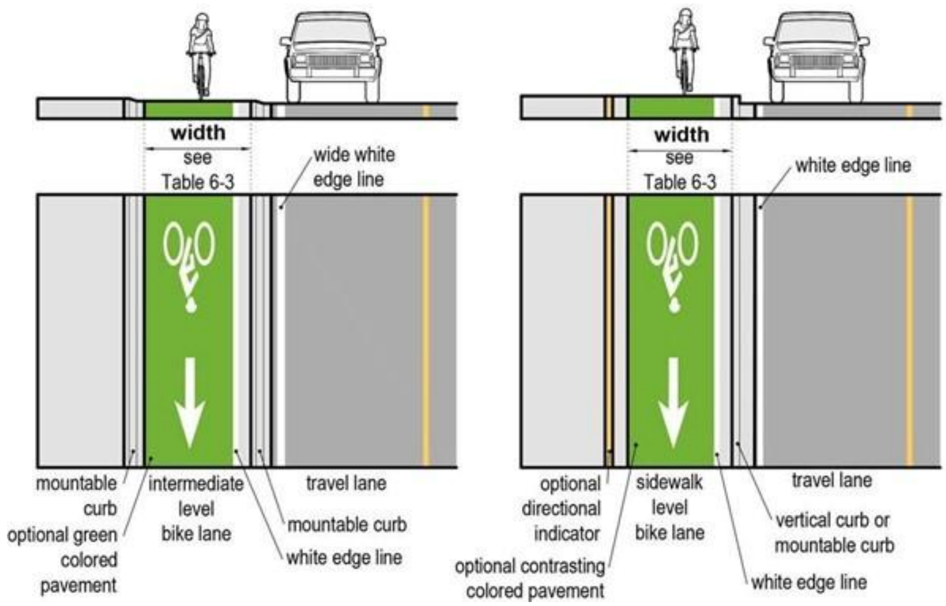
## 6.3.6 Raised Bicycle Lanes

A conventional bicycle lane can be raised above the street grade to create a new bikeway type that provides more separation from vehicles when a separated bike lane (see Section 6.3.7) with horizontal separation is not feasible. In general, a separated bike lane is preferable to a raised bike lane to prevent motor vehicle encroachment and to reduce the potential for a bicyclist to crash while transitioning from the raised bike lane to the roadway at intersections. While a mountable curb between the raised bike lane and travel lane can reduce crash risk for bicyclists, it may not discourage motorists from encroaching into the raised bike lane. Raised bike lanes should not be installed adjacent to on-street parking due to the greater risk of dooring.

Raised bike lanes can be raised between street level and sidewalk height (intermediate level) or can be located at sidewalk height (sidewalk level). Specific information on the curb types adjacent to raised bike lanes are discussed in Section 6.3.7. The width of raised bike lanes should accommodate the anticipated bicyclist demand and reduce the likelihood that a bicyclist will have to transition to an adjacent travel lane or sidewalk to pass other bicyclists or to avoid hazards such as debris, surface defects, or objects in the bike lane.

The width should also consider the elevation of the bike lane. Table 6-3 provides minimum and constrained widths for both raised bike lane scenarios. A white edge line should be provided near the top of the curb to provide a buffer between bicyclists and the curb; however, the width of the bike lane is still measured from curb to curb.

**Figure 6-10: Raised Bike Lane Examples**




To prevent motor vehicle encroachment into the bike lane, a sidewalk-level raised bike lane built with a vertical curb between the bike lane and travel lane is preferred. Where sidewalks are adjacent to the raised bike lane, a detectable edge should be provided to reduce the likelihood people with vision disabilities will enter the bike lane. This consideration may lead to the design of an intermediate-level bike lane. Section 6.3.7 provides additional guidance for sidewalk buffer designs.

At locations where an intermediate-level raised bike lane is less than 7 ft. in width, the bike lane should have a continuous mountable curb on both sides, between the bike lane and travel lane and the bike lane and the sidewalk, allowing bicyclists to traverse the curb if necessary (see Figure 6-10). While the provision of a vertical curb along the travel lane is more likely to discourage motorists from entering the raised bike lane, it may also decrease the comfort and safety of bicyclist if the bike lane is not sufficiently wide or if it is necessary for the bicyclist to exit the bike lane.

**Commented [JW62]:** Figure needs updating with new bike symbol

The bike lane elevation may vary within a single corridor via bicycle transition ramps which raise or lower the bike lane as needed at pedestrian crossings, transit stops, driveways, and intersections. Additional details on the design of intersections are discussed in Section 6.4. Frequent elevation changes along a corridor should be avoided because they reduce the comfort of the bicycling environment and can create maintenance challenges.

Raised bike lanes will require special considerations for maintenance activities as it may be difficult to maintain a debris free surface with standard street maintenance practices. For example, street sweepers cleaning an adjacent travel lane may push additional debris onto an intermediate level bike lane.

### Markings and Signing

A wide white edge line may be used along a raised bike lane, but should be used at locations with an intermediate height bike lane to provide additional emphasis of the mountable curb or the lower height vertical curb. When the sidewalk is attached, directional indicators along the sidewalk should be used to differentiate the bike lane from the sidewalk to pedestrians with low or no vision.

Paving material, green-colored pavement, and signage can all help to differentiate the bike lane from an adjacent travel lane or to increase awareness of the elevation change. Designers may supplement the BIKE LANE (R3~~2~~-17) sign with a plaque with the message RAISED in black letters.

**Commented [BS63]:** R3-17

**Commented [JW64R63]:** Updated

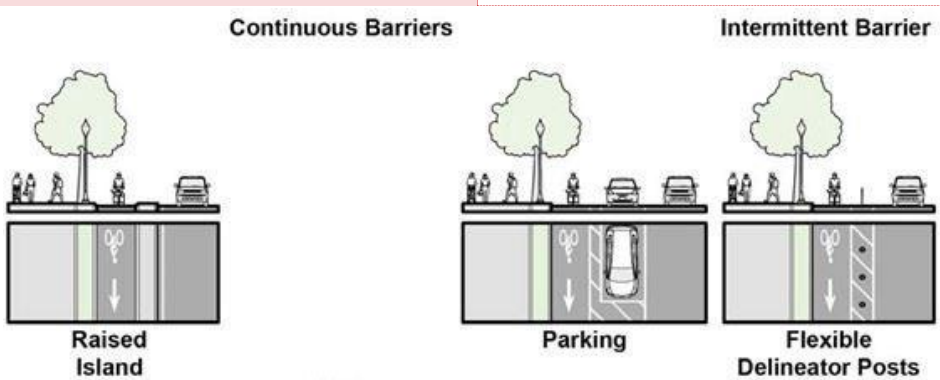
## 6.3.7 Separated Bicycle Lanes

Separated bicycle lanes are exclusive bikeways that are physically separated from motor vehicle traffic. While buffered bike lanes provide a horizontal separation from motor vehicle traffic, separated bike lanes also provide vertical separation such as flexible delineators or a curbed median. Separated bike lanes may be located at street elevation, sidewalk elevation, or at an intermediate elevation in between the sidewalk and street. When built at sidewalk level, care must be taken to ensure they are distinct from the sidewalk to discourage pedestrian encroachment. Separated bike lanes may be installed in one-way and two- way configurations, each of which present opportunities and challenges that must be considered during the design process.

vertical elements (see Figure 6-12) can be used. On higher speed roads, vertical elements must be crashworthy. Vertical objects may be struck by motor vehicles and require regular replacement. Maintenance and operation crews should plan on replacing vertical objects placed in the buffer zone and refreshing pavement markings, on a regular basis. If vertical objects are struck with significant regularity, adjustments to the design should be considered. The placement of vertical elements within the street buffer should consider the need for shy distances to the bikeway and to the travel lane, access to and from onstreet parking, drainage, and maintenance. Vertical element spacing should consider the alignment with corresponding pavement markings in the buffer and the necessary effectiveness of the vertical elements to keep vehicles from encroaching into the separated bike lane. For example, on a higher-speed suburban road where motorists are less likely to cross into the bike lane (i.e., fewer driveways or loading and unloading needs), a wider spacing of the vertical elements may be acceptable, but on lower-speed urban streets, a spacing of 15 ft. or closer may be appropriate to prevent vehicles from attempting to stop or park in the bike lane, similar to the minimum distance for buffered bike lane markings. Vertical elements may also be more closely spaced approaching intersections or driveways to better see where the gaps in the vertical elements are provided for driveway access points while preventing vehicle encroachment too early at these conflict points.

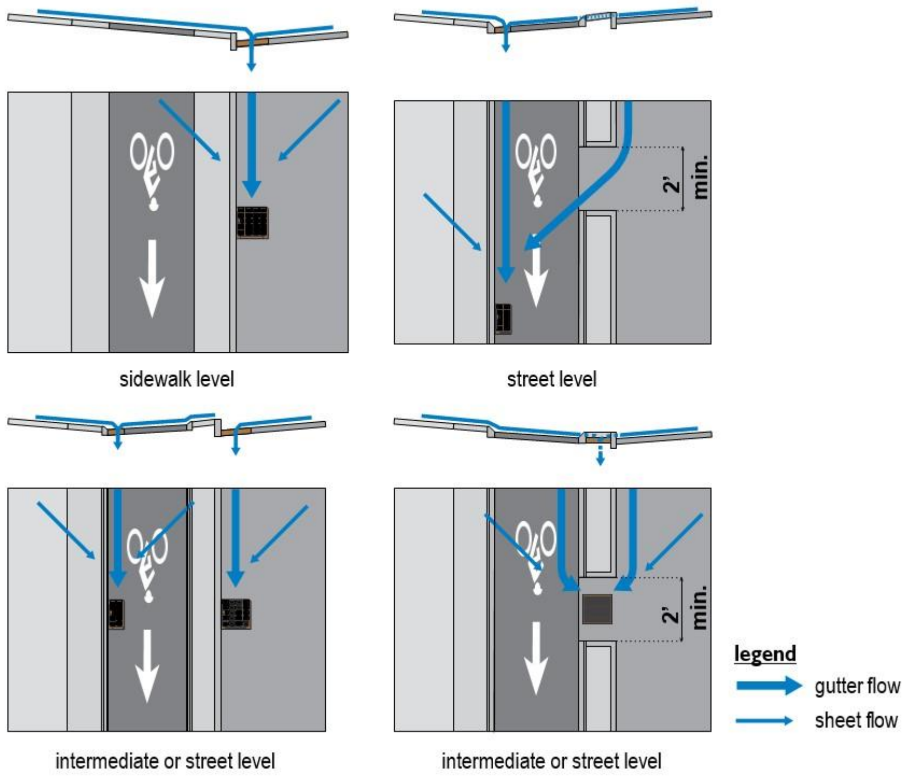
On-street parking may be used as a street buffer without other vertical elements if the parking always has high occupancy throughout the day and night, but vertical objects are typically provided to prevent vehicles from parking within the street buffer or bike lane. Additional pedestrian accessibility considerations for onstreet parking are identified in the sections below.

**Figure 6-12: Vertical Elements in the Street Buffer Zone**




**Commented [JW65]:** Update with latest bike symbol per MUTCD

**Figure 6-13: Examples of Separated Bike Lane Drainage Configurations**



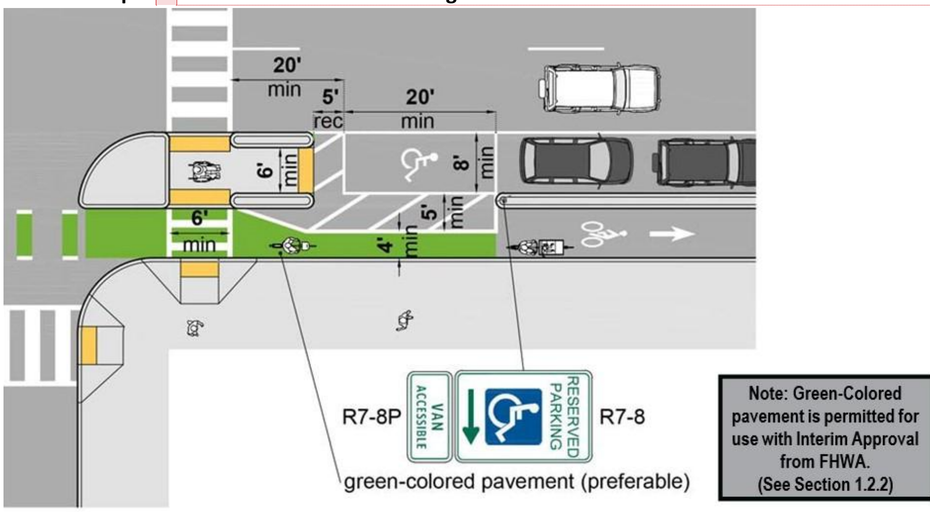

Commented [JW66]: Update with latest bike symbol per MUTCD

## Maintenance

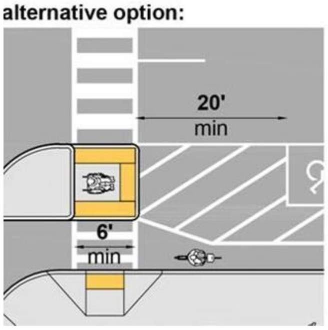
Maintenance of separated bike lanes should be discussed early in the design process to ensure that the bike lane will be maintained to provide safe operation for bicyclists. This often requires a discussion of existing street cleaning equipment and snow clearing equipment to understand the width needed to accommodate maintenance operations. Although a city or district may not have a typical plow or street sweeper narrow enough to get into a separated bike lane, there may be other existing equipment that can be used, such as a loader, tractor, or utility vehicle. The purchase of new equipment may also be appropriate, particularly as a bike network expands, to ensure that the equipment is appropriate for maintaining the bikeway type(s).

The consideration of maintenance may be the justification for providing a wider bike lane or locating vertical elements closer to the travel lanes to allow equipment to pass behind the vertical elements to sweep or plow

**Figure 6-14: Example of Accessible On-Street Parking at Intersection**



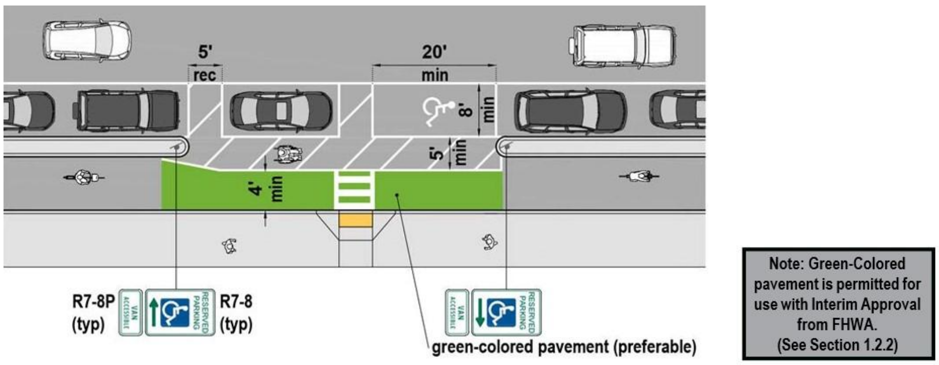

alternative option:




**Commented [JW67]:** Remove reference to IA per July ORE markup.

**Commented [JW68R67]:** Update bike symbol per MUTCD

**Figure 6-15: Example of Accessible Mid-block On-Street Parking**




At locations where there is a higher volume of pedestrians crossing between the separated bike lane such as valets or designated rideshare pick up and drop off, the following treatments should be used:

- Add a PED XING pavement marking across the bike lane where the approach grade is 3 percent or greater, or where the location is within 100 ft. of an intersection.
- 
- Use a raised street buffer and sidewalk or intermediate-level separated bicycle lane.
  Increase the street buffer width. This may result in narrowing the bike lane width to constrained bike lane widths along this short segment.
- 
- Mark pedestrian crossings and use BIKES YIELD TO PEDS (R9-6) signs.
  Pedestrian railings may be used along the bikeway to direct pedestrians to marked crossings of the bike lane at loading zones where pedestrian activity is anticipated to be high. When present, these should be placed at an appropriate offset so that they do not present a hazard to bicyclists (see discussion on Shy Spaces in Section 3.6.2).

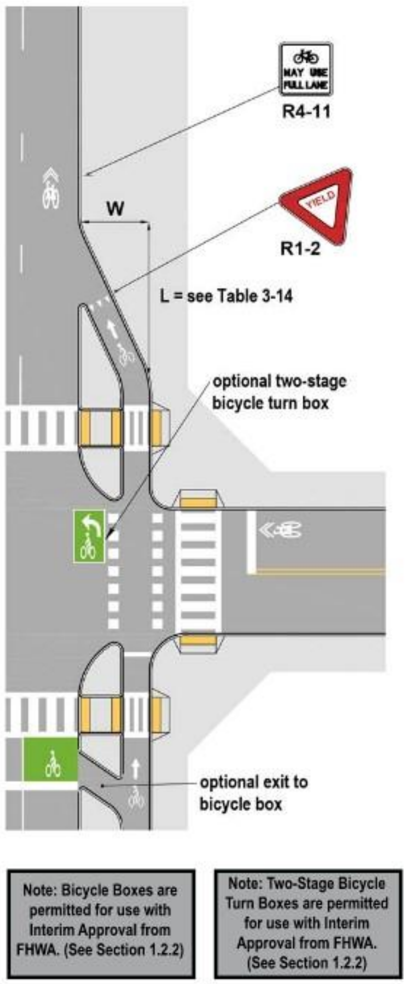
## Transitions between Separated Bicycle Lanes and other Bikeway Types

Transitions between separated bike lanes and other bikeway types is essential for all projects that include a separated bike lane. The actual transition design can vary greatly from location to location depending on many of the contextual factors discussed throughout this guide. The selected transition design should clearly communicate how bicyclists should enter and exit the separated bike lane in order to minimize conflicts with other users.

**Commented [JW69]:** Remove reference to IA per July ORE markup

**Commented [JW70R69]:** Consider adding bike symbol

**Figure 6-16: Transition to Shared-Lane**



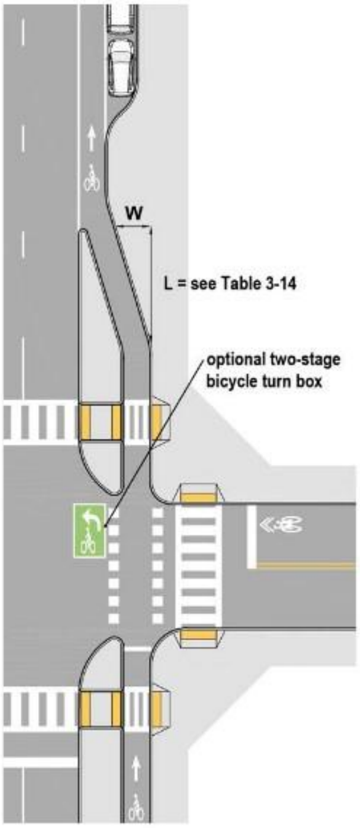

**Commented [JW71]:** Remove references to IA per July ORE markup.

**Commented [JW72R71]:** The bike box on the bottom of the image does not comply. There should be a stop bar for bikes before the crosswalk. Section 9E.12 P 05 Bike Box should not be contiguous with a crosswalk.

**Commented [JW73R71]:** Update the bike symbol per the MUTCD

**Commented [JY74R71]:** R4-11 update to R9-20

**Figure 6-17: Transition to Conventional Bike Lane**




Note: Two-Stage Bicycle Turn Boxes are permitted for use with Interim Approval from FHWA. (See Section 1.2.2)

**Commented [JW75]:** Remove reference to IA per July ORE markup.

**Commented [JW76R75]:** Update bike lane symbol per MUTCD.

**Figure 6-18: Transition to Conventional Bike Lane on Intersecting Street**

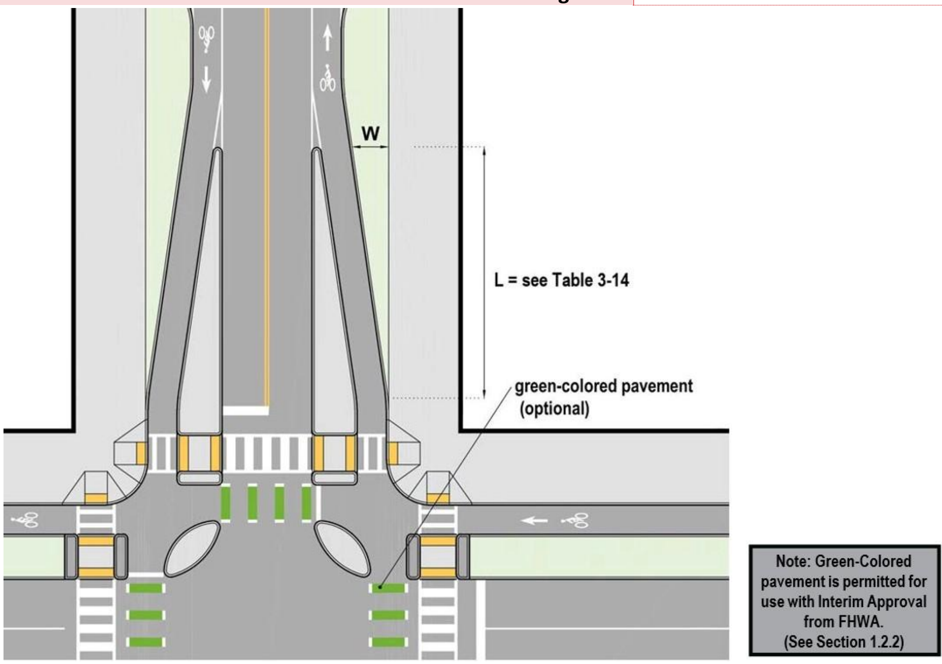
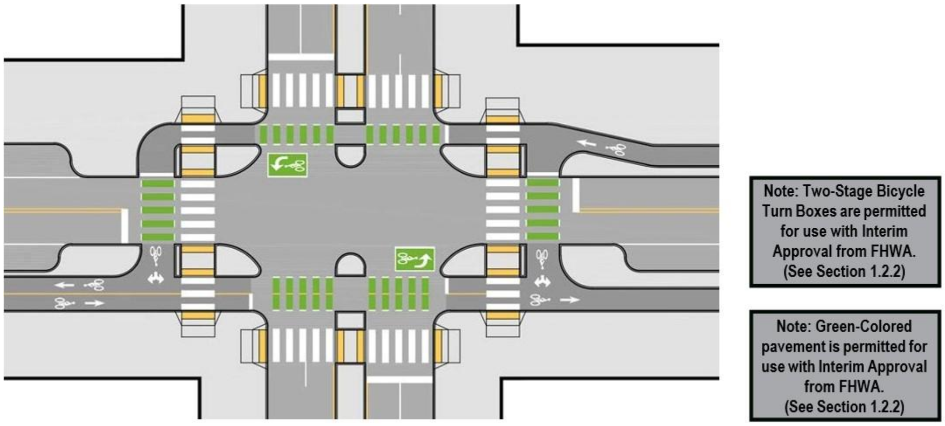



**Figure 6-19: Transition from One-Way to Two-Way Separated Bike Lanes at Protected Intersection**




**Commented [JW77]:** Remove reference to IA per July ORE markup.

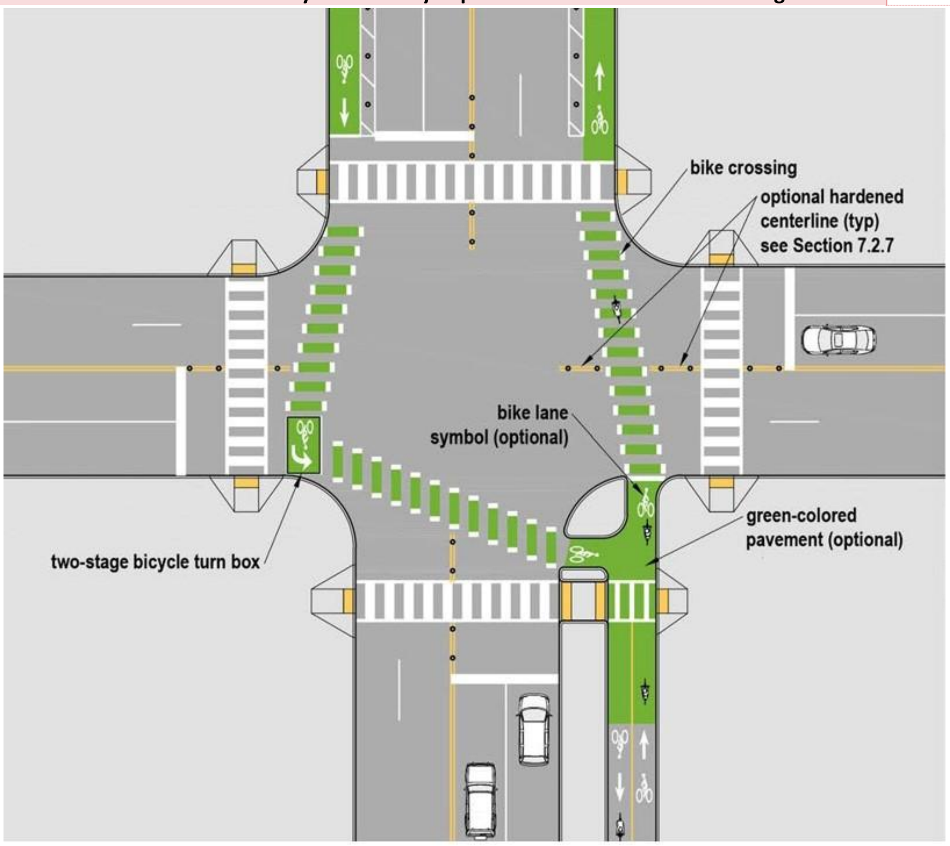
**Commented [JW78R77]:** Bike lane symbols need to be updated per MUTCD

**Commented [JW79]:** Remove references to IA per July ORE markup.

**Commented [JW80R79]:** Update bike lane symbols per MUTCD.

Also, the two-stage turn box for the south side two-way cycle track is not MUTCD compliant. It should have a single through arrow for the two bicycle directions. (Note this is not what most agencies do, but is what is what the MUTCD specifies) Section 9E.11 P 06 and Figure 9E-11

**Figure 6-20: Transition from One-Way to Two-Way Separated Bike Lanes with Two-Stage Turn Box**




Note: Two-Stage Bicycle Turn Boxes are permitted for use with Interim Approval from FHWA. (See Section 1.2.2)

Note: Green-Colored pavement is permitted for use with Interim Approval from FHWA. (See Section 1.2.2)

**Figure 6-21: Transitions between Offset Intersections with Two-Way Separated Bike Lanes**

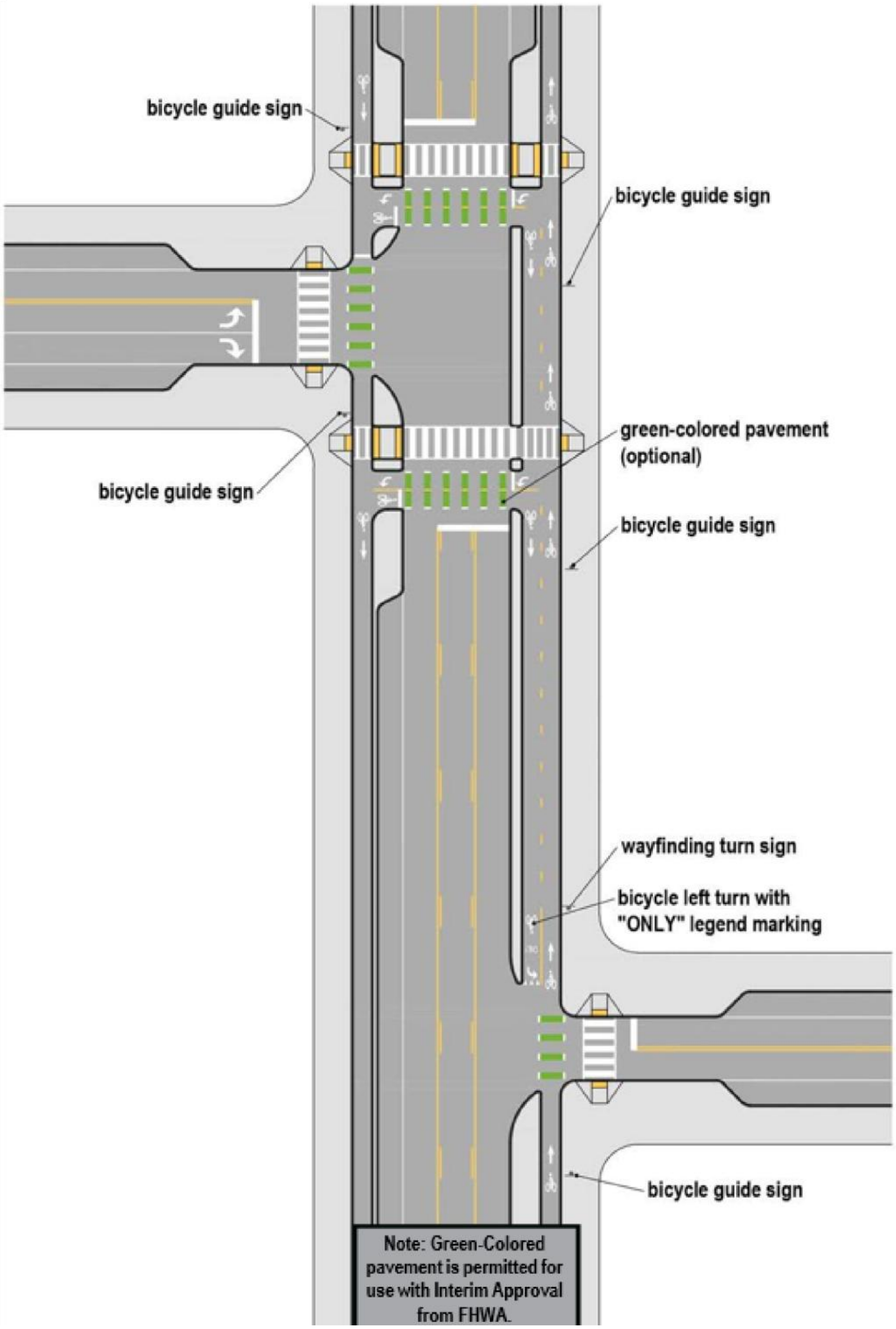
**Commented [JW81]:** Remove references to IA per July ORE markup.

**Commented [JW82]:** Remove reference to IA per July ORE markup.

**Commented [JW83R82]:** Update bike symbol markings per MUTCD

**Commented [JW84R82]:** TWLTL markings should not continue to intersections (Section 3B.05 P 06)

**Commented [JA85R82]:** Transverse markings for the sb direction would make sense there. The nb direction could be a left turn lane.


bicycle guide sign
bicycle guide sign
green-colored pavement (optional)
bicycle guide sign
bicycle guide sign
wayfinding turn sign
bicycle left turn with "ONLY" legend marking
bicycle guide sign
Note: Green-Colored pavement is permitted for use with Interim Approval from FHWA.

(See Section 1.2.2)

### 6.3.8 Bicycle Ramps

Bike ramps are used to improve bicyclist safety or comfort, to shift the elevation of a bikeway to a different elevation (e.g., from street-level to sidewalk-level), or to change the bicycle facility type (e.g., from a conventional bike lane to side path).

It is common to use bike ramps when approaching roundabouts, at interchange ramp crossings, or at high-conflict zones (such as heavy weaving areas or high turning volume intersections). In these situations, the bike ramp serves the purpose of allowing bicyclists to avoid sharing travel lanes with motorists. In some instances, it may be appropriate to provide a bike ramp that would be used by most bicyclists, but also provide an on-street option for Highly Confident and Somewhat Confident Bicyclists to allow them to ride in the shared-lane environment.

The other situation to use a bike ramp is approaching pedestrian conflict areas or raised crossings across a separated bike lane, where a change in elevation is desired to meet pedestrian accessibility guidelines, to slow bicyclists at conflicts, or to transition the bikeway elevation.

In either situation, the overall facility geometry, the extent of construction or type of project, or the types of bikeways being connected can affect the alignment of the bike ramp. Figure 6-22 identifies two options for bike ramps that transition to a shared-use path. Detail 1 is preferable to provide a bicyclist with a comfortable change in alignment and ensure grade breaks are parallel to the path of travel. Detail 2 should be used where there is insufficient space to provide the straight taper shown in Detail 1. Designers may encounter the following challenges with the design shown in Detail 2:

- Narrow bike ramp widths can force bicyclists to encroach on adjacent motorist travel lanes, pedestrian zones, or on-coming bicycle traffic on two-way facilities in order to access the ramp.
- If grade breaks at the top and bottom of the bike ramp are not perpendicular to the bicyclist path of travel, bicyclists with more than two wheels (e.g., adult tricycles or bikes with trailers) can experience instability or overturning.

**Figure 6-24: Typical Bike Parking Spacing for Parallel, Diagonal, and Longitudinally Oriented Inverted U Racks**

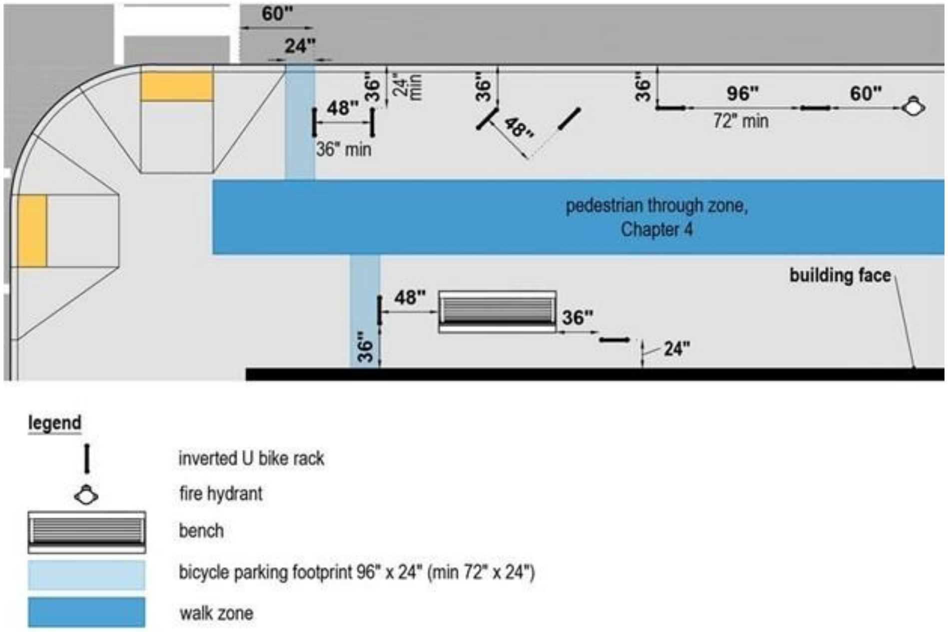
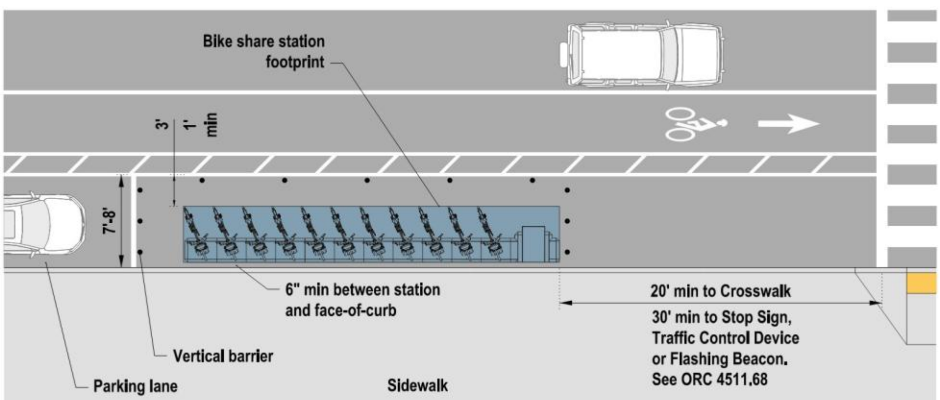



**Figure 6-25: Example of Bikeshare Stations Installed Within a Roadway**




**Commented [JW86]:** Bike lane symbol to be updated per MUTCD

- Minimize exposure to conflicts
- Reduce speeds at conflict points
- Provide adequate sight distance
- Communicate right of way priority
- Provide clear transition between bikeway types
- Accommodate people with disabilities

### 6.5.1 General Bikeway Design at Intersections & Crossings

#### Separation of Modes

It is preferred that a bikeway and any physical separation provided along a bikeway be maintained up to intersections. Sections 6.5.2, 6.5.3, and 6.5.6 discuss when additional physical separation may be appropriate based on speeds, volumes, and contexts. In some instances, it may not be feasible to maintain a bikeway and separation to an intersection, which will necessitate specific design considerations and may not maintain the desired level of comfort and safety for the selected bikeway. Chapter 8 provides guidance for separating users through signalization strategies and Chapter 9 provides additional design treatments at complex intersections and roundabouts.

#### Visibility of All Users

Adequate sight lines are needed between all roadway users as they approach an intersection. Section 3.5 defines sight distance requirements for different intersection scenarios. Due to the mixed nature of traffic at intersections (pedestrians, bicyclists, and motorists), the designer should keep in mind the speed of each travel mode and its resulting effect on design values when considering design treatments. The fastest vehicle should be considered for approach speeds (typically the motor vehicle and bicycle) because these modes require the greatest stopping distance. By contrast, for departures from a stopped condition, the characteristics of slower users (typically pedestrians and bicyclists) should be considered due to their greater exposure to cross traffic.

When a separated bike lane or side path is located behind a parking lane, it is typically necessary to restrict parking and other vertical obstructions near a crossing to ensure adequate sight distances are provided. At intersections and driveways with permissive turning movements where bicyclists and motorists are traveling in the same direction, parking restrictions (and the resulting sight distances) are a key consideration. See Section 3.5. At intersections and driveways with stop signs, where motorists must stop before turning across the separated bike lane or side path, the standard parking restricted area adjacent to the intersection (20 ft.

minimum from a crosswalk and 30 ft. prior to a traffic control device at per ORC 4511.68 (6), (7)) may be adequate. More discussion of driveways is provided in Section 6.5.8.

### Speed Minimization

If conflict points cannot be eliminated, intersection designs should minimize the speed differential between users at the points where travel movements intersect. Reducing speeds, particularly of motor vehicles, at conflict points may allow all users more time to react to avoid a crash and can reduce the severity of a potential injury if a crash does occur. Intersections where bicyclists operate should be designed to prioritize slower-speed turning movements and weaving movements across the path of bicyclists. Treatments for reducing speed and improving safety at conflict points are provided in subsequent sections based on the bikeway type and roadway configuration and Chapter 7 provides design guidance for the various traffic calming treatments as well as a discussion of design and check vehicles for evaluating corner radii.

### Communicate Right of Way Priority

Intersection design should provide bicyclists, pedestrians, and motorists with cues that both clearly establish which user(s) have the right of way and consistently communicate expected yielding behavior. Traffic control devices should communicate right of way priority through the provision of:

- Marked pedestrian crossings of bikeways;
- Marked bicycle crossings (lane extensions) at driveways and intersections;
- Regulatory or warning signs for motorists and/or bicyclists who are crossing, merging, or turning where appropriate;
- Signalization where provided.

Regulatory and warning signs will depend on the bikeway type and lane configuration and is discussed for each treatment type. At signalized intersections, bicyclists may be controlled by motor vehicle signals, pedestrian signals, or bicycle signals. A bicycle signal provides a separate indication for the exclusive use of bicyclists. See Chapter 8 for bicycle signalization design considerations.

### Intersection Pavement Markings

Intersection pavement markings are used to highlight conflict areas and aid bicyclist navigation. Table 6-10 summarizes the pavement markings selection guidelines based on the intersection and bikeway type.

**Bicycle Crossing Markings (Lane Extension Lines)**

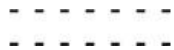
Where a bikeway crosses an intersection separate from a crosswalk, bikeway lane markings may be extended through the intersection to delineate the bicycle crossing and raise awareness of the presence of bicyclists. Bike lane crossings can be used to:

- Delineate a preferred path for people bicycling through the intersection, especially crossings of wide or complex intersections,
- Improve the legibility of the bike crossing to roadway users, and
- Encourage motorist yielding behavior, where motorists must merge or turn across the path of a bicyclist.

Figure 6-26 provides design details for bicycle crossing markings. Bicycle crossings should consist of dotted extensions lines, which should match the width of the line it is extending. 6 inches is a typical width for a bicycle dotted extension line, but wider extension lines should be considered to further emphasize the crossing and improve the longevity of the markings. Bicycle lane symbols may be added within lane extension lines to communicate the directionality of the bike lane, which may be beneficial in areas where two-way separated bike lanes or counter flow bike lanes are present.

**Table 6-10: Bicycle Crossing and Intersection Markings Selection Guidelines**

| Intersection Type | Condition | Separated Bicycle Lane | Conventional/Buffered Bike Lane | Bicycle Boulevard |
|---|---|---|---|---|
| Signalized | Turn Conflict |  |  | No Markings |
| | No Turn Conflict |  |  | No Markings |
| | Bikeway Corridor Turns Left |  |  |  |

| | | | | |
|---|---|---|---|---|
| Unsignalized | High Turning Volume |  |  | No Markings* |
| | All other conditions |  |  | No Markings |
| | Bikeway Corridor Turns Left |  |  | No Markings |

*Additional treatment may be needed

Bicycle crossings may also be supplemented with green-colored pavement. If used, the green- colored pavement ~~should~~ shall align with the dotted extension line pattern of the dotted edge lines. If the green-colored bike crossings are proposed parallel to pedestrian crosswalks comprised of wide longitudinal lines (i.e., high visibility crosswalks) the dotted extension lines and green- colored pavement should align with the crosswalk markings. See Figure 6-26. This placement will reduce pavement marking clutter and ensure that the green-colored markings are spaced to avoid motorist wheel paths and improve the longevity of the markings.

At locations where the bicycle crossing is contiguous to ~~less than 1 ft. from~~ the pedestrian crossing, the dotted extension line nearest the pedestrian crossing shall be retained. ~~can be removed, allowing~~ T~~t~~he edge of the crosswalk shall not ~~to~~ serve as the edge of the bicycle crossing.

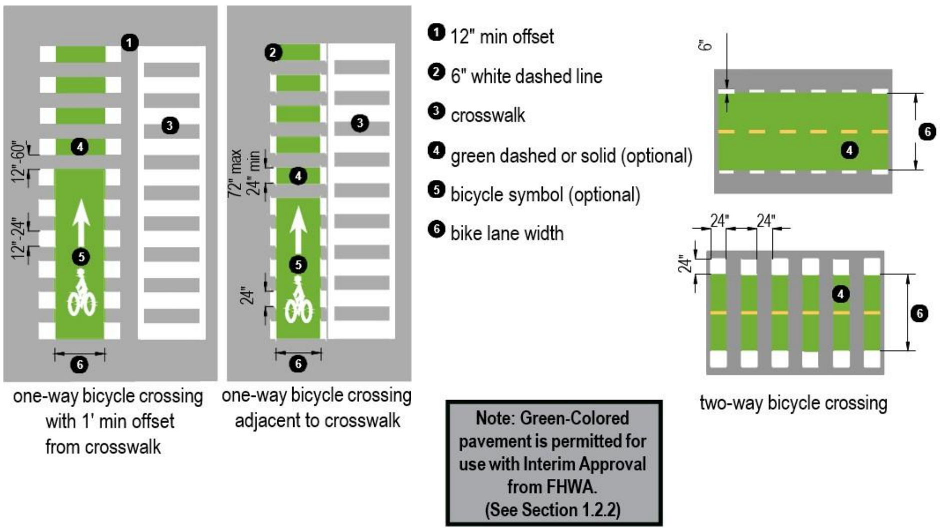
**Commented [JW87]:** This is a shall in the new MUTCD. Section 3H.06 P 04

**Commented [JW88R87]:** Updated

**Commented [JW89]:** This is not permitted per the new MUTCD. Section 9E.03 P 11

**Commented [JW90R89]:** Updated

**Figure 6-26: Bicycle Crossing Pavement Markings**




**Commented [JW91]:** Remove reference to IA per July ORE markup.

**Commented [JW92R91]:** Update bike symbol per MUTCD.

**Commented [JW93R91]:** Use of green paint is not compliant - dotted bike crossing cannot have solid green paint (Section 3H.06 P 04)

## Two-Stage Bike Turn Box

Figure 6-27 designates an area at an intersection intended to provide bicyclists a place to wait for traffic to clear before proceeding in a different direction of travel. To use the two-stage bike turn box, bicyclists traverse the intersection within the bike lane, stop within the turn box, reorient themselves to the cross street, and wait for the signal for the cross street to proceed, eliminating the need to merge across travel lanes.

Two-stage bicycle turn boxes may be used for left or right turns, and its use is preferred for making turns instead of a bike box (see Section below), particularly on higher-volume or multi-lane roads. A two-stage bike turn box may be used at any intersection regardless of the type of traffic control. ~~The use of a two-stage turn box at an unsignalized intersection is not an approved use of this treatment and would require an experimental approval from FHWA.~~

Two-stage turn boxes should be installed where a bikeway intersects with another designated bikeway or where it would connect to a major destination, such as a school, community center, grocery store, etc. When designing a buffered or separated bike lane, designers should plan on installing two-stage turn boxes at most intersections to discourage merging with traffic to make a left turn before reaching intersections. When designing a conventional bike lane, if the volume or speed of the adjacent roadway is more than 6,000 ADT or 30 mph, designers should consider installing two-stage turn boxes at intersections.

**Figure 6-27: Two-Stage Bike Turn Box Pavement Markings**

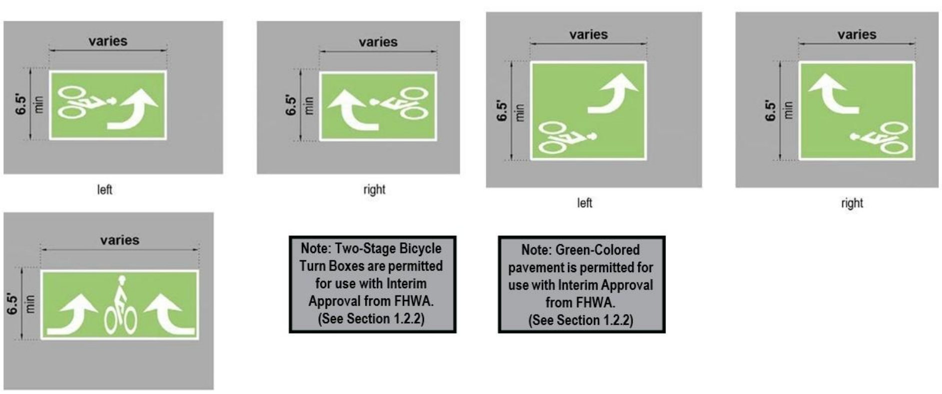



**Figure 6-28: Two-Stage Left Turn Box Placement**

**Commented [JW94]:** This distinction is not there in the MUTCD - can be used at all intersections.

**Commented [JA95R94]:** Revise to state that the two-stage bike box can be used at any intersection.

**Commented [JW96R94]:** Updated

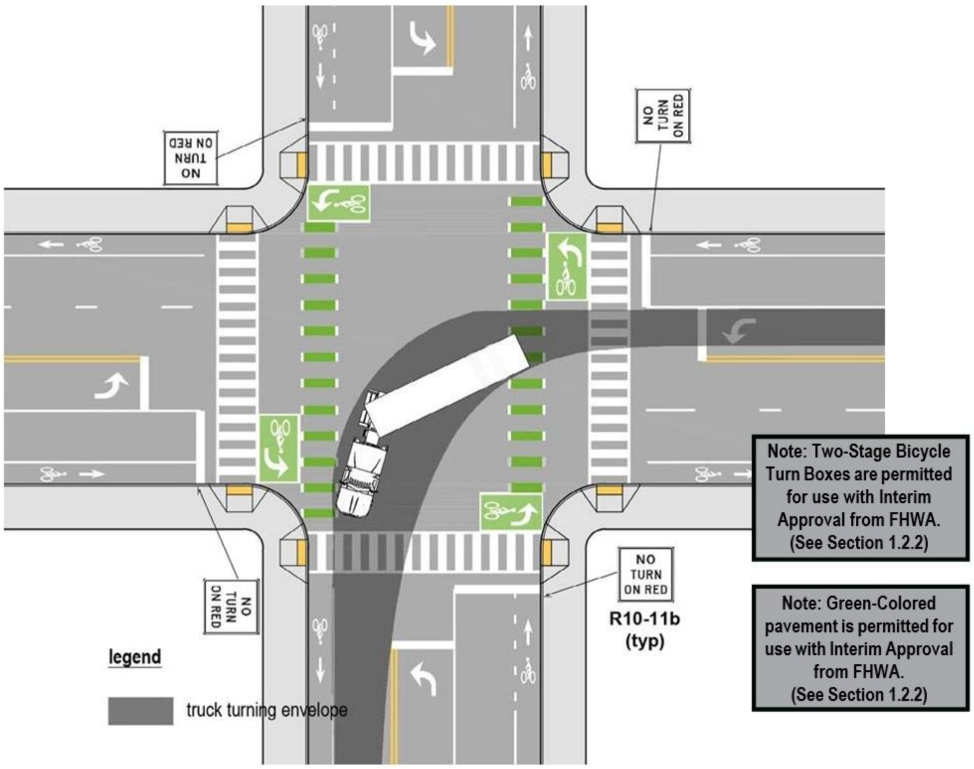
**Commented [JW97]:** Remove references to IA per July ORE markup.

**Commented [JW98R97]:** Update bike symbols per MUTCD

**Commented [JW99R97]:** Bottom left example should have a single thru arrow per Section 9E.11 P 06 and Fig. 9E-11.

**Commented [JW100]:** Remove references to IAs per July ORE markup.

Update bike lane symbol


NO TURN ON RED
NO TURN ON RED
NO TURN ON RED
NO TURN ON RED
R10-11b (typ)
legend
truck turning envelope
Note: Two-Stage Bicycle Turn Boxes are permitted for use with Interim Approval from FHWA. (See Section 1.2.2)
Note: Green-Colored pavement is permitted for use with Interim Approval from FHWA. (See Section 1.2.2)

A two-stage bike turn box:

- Must be located outside of the path of through and turning traffic;
- Should be located adjacent to the direct path of bicyclist travel;
- Should be located downstream of the crosswalk and downstream of the stop line;
- Should be located in an area clearly visible to motorists and adequately illuminated;
- Must include a bicycle symbol, preferably oriented in the direction in which the bicyclists enter the box, along with an arrow showing the direction of the turn; and
- May include green-colored pavement or pavement markings to enhance the conspicuity of the box (Note: if used, green-colored pavement or pavement markings shall encompass the entire box).

**Commented [JW101]:** If used, green paint shall encompass the entire box (Section 9E.11 P 12)

**Commented [JW102R101]:** Updated

A NO TURN ON RED (R10-11) sign shall be installed where a two-stage bike turn box is not located outside the path of right-turning traffic to prevent motorists from entering the bicycle queuing area. The placement must also consider left- turning traffic that may otherwise overlap with the two-stage bike turn box. Passive detection of bicycles in the two-stage bike turn box must be provided if detection is required to actuate a traffic signal. Additionally, installation of the appropriate regulatory or guide signs should be considered in conjunction with two-stage bike turn boxes. Where use of the box is required, Two-Stage Bicycle Turn Box regulatory (R9-23 series) signs shall be used. Where use of the box is optional, Two-Stage Bicycle Turn Box guide (D11-20 series) signs may be used.

**Commented [JW103]:** Consider adding MUTCD language regarding the use of R9-23 series signs for use of the turn boxes.

**Commented [JW104R103]:** Updated

Two-stage bicycle turn box dimensions vary based on the street operating conditions, the presence or absence of a parking lane, traffic volumes and speeds, and available street space. The queuing area should be a minimum of 6.5 ft. deep measured in the longitudinal direction of bicycles sitting in the box. The box must be outlined with solid white lines.

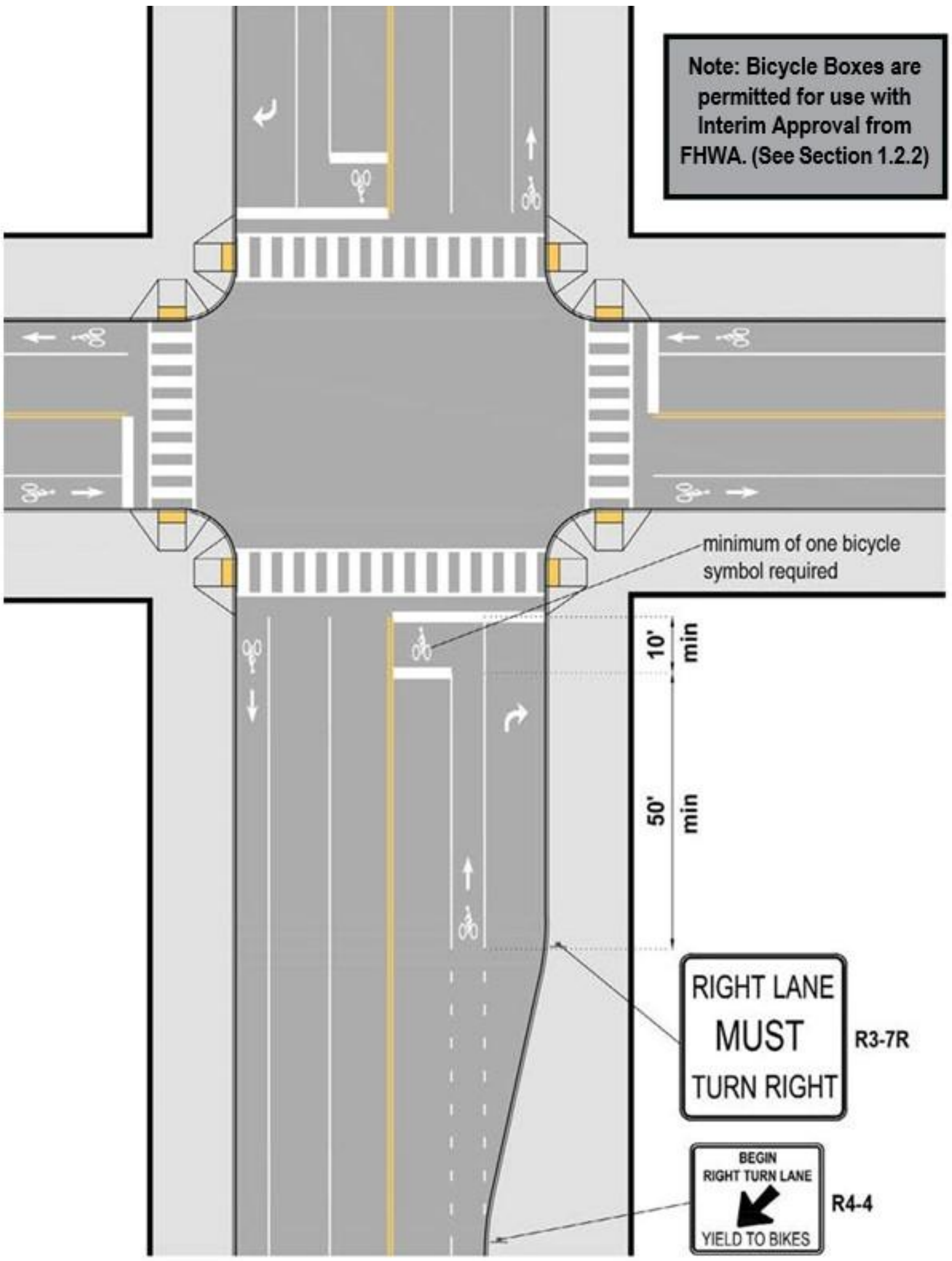
**Figure 6-29: Bicycle Box Configuration Across One Lane of Through Traffic**

**Commented [JW105]:** Remove reference to IA per July ORE markup.

**Commented [JW106R105]:** Update bike lane symbol

**Commented [JW107R105]:** Consider adding optional green paint

**Commented [JA108R105]:** Agree that the green paint would be a good addition that is optional


Note: Bicycle Boxes are permitted for use with Interim Approval from FHWA. (See Section 1.2.2)
minimum of one bicycle symbol required
10' min
50' min
RIGHT LANE MUST TURN RIGHT
R3-7R
BEGIN RIGHT TURN LANE
YIELD TO BIKES
R4-4

### Bike Boxes

A bicycle box is a designated area on the approach to a signalized intersection consisting of an advanced stop line and bicycle symbol. Bike boxes mitigate conflicts between through bicyclists and right-turning motorists, reduce conflicts between motorists and bicyclists at the beginning of the green signal phase, and provide additional queuing space for bicyclists. ~~. A two-stage bicycle turn box should instead be used to accommodate bicyclist turns.~~ The use of bike boxes is limited to signalized intersections and should not be used in other locations.

One bicycle symbol ~~should~~ shall be placed in the box to indicate it is for bicycle use. Bike boxes ~~should~~ shall be a minimum of 10 ft. in depth and may be larger depending on anticipated bicyclist volumes. A minimum of 50 ft. of bike lane should be provided on the approach to a bike box so bicyclists will not need to ride between lanes to enter the box. The approaching bike lane, and the bike box, may be colored green. If used, the green-colored pavement or pavement markings shall cover the entire box.

The stop line for motorists should be set back to coincide with the beginning of the bike box. The sign STOP HERE ON RED (R10-6 or R10-6A), aligned with the motorist stop line, should be installed to indicate the correct stopping location for motorists, with an EXCEPT BICYCLES (R3-7bP) word legend plaque. The sign STOP HERE ON RED (R10-6 or R10-6A) should not be used in locations with a separate turn lane where motorists are stopping in two different locations (see Figure 6-29).

Turns on red ~~should~~ shall be prohibited on the approach where a bike box is placed in front of traffic that has potential to turn on red, using a NO TURN ON RED sign (R10-11 series). At intersections where a high number of collisions occur between through bicyclists and turning vehicles, alternative treatments should be considered such as a protected intersection (see Section 6.5.2), leading or exclusive bicycle signal phases (see Chapter 8), separate lanes for through and turning traffic, or a combination of these and other treatments.

**Commented [JW109]:** This is not enumerated in the MUTCD; in fact, it shows a bike box across two lanes (one of which is a left turn lane)

**Commented [DH110R109]:** See MUTCD Figure 9E-12

**Commented [JW111R109]:** Updated

**Commented [JW112]:** This is a shall condition per MUTCD Section 9E.12 P 08

**Commented [JW113R112]:** Updated

**Commented [JW114]:** This is a shall condition per MUTCD Section 9E.12 P 08

**Commented [JW115R114]:** Updated

**Commented [JW116]:** If used the green paint shall cover the entire box (Section 9E.12 P 13)

**Commented [JA117R116]:** Add this after that final sentence.

**Commented [JW118R116]:** Updated

**Commented [JW119]:** This is a shall condition per MUTCD Section 9E.12 P 09

**Commented [JW120R119]:** Updated

## 6.5.2 Separated Bike Lanes at Intersection Design

A protected intersection (discussed below) is the preferred intersection treatment for separated bike lanes and side paths. When intersections are constrained, designers should consider the following in the order listed:

1. Reduce each roadway element (motor vehicle lanes, buffers, separated bike lanes, and sidewalk) to its minimum dimensions or minimum number of travel lanes necessary.

2. Eliminate the sidewalk buffer while still providing a detectable edge adjacent to the road for pedestrians with disabilities (see Chapter 4).
3. Provide a conventional bike lane or mixing zone (not appropriate for side paths or two-way separated bike lanes) by transitioning the separated bike lane to:
    - A conventional bike lane with an optional bicycle ramp to the sidewalk for roadways with operating speeds of 35mph or greater. If local jurisdictions prohibit bicycle use on sidewalks, this option is limited to when the ramp leads to a side path or shared-use path or requires a sign to indicate that a bicyclist must dismount and walk their bike.
    - A conventional bike lane or shared-lane for roadways with operating speeds of less than 35 mph.
4. These options are further discussed below and in Section 6.5.3 for conventional bike lane designs.

## General Intersection Design

The principles and basic pavement marking treatments of intersection design are covered in Section 6.5.1. This section covers only issues that are unique to separated bike lane and side path intersection designs.

## Reducing Speed at Conflict Points

Where motorists are permitted to turn across the path of bicyclists, intersections should be designed to reduce motorist turning speeds. Designers should apply the following treatments for reducing motorist turning speeds when feasible based on the roadway context:

- At protected intersections, the effective radius of the intersection corner plays a significant role in determining the speed at which turning motorists may negotiate the corner. See the Protected Intersection section below and Chapter 7 for design information regarding reducing turning speed through the use of corner islands, truck apron treatments, and design and check vehicles.
- The speed of left-turning motorists crossing a bikeway should also be considered. Channelizing devices such as median islands and hardened centerlines (see Chapter 7) can be used to establish a smaller turning radius, reducing the speed of motorists, which can improve yielding and reduce the severity of crashes.
- Raised crossings can also be an effective treatment for reducing both left and right turning vehicle speeds, increase visibility of bicyclists, and increase yielding behavior of motorists. See Chapter 7 and the bike ramp discussion in Section 6.3.8.

It may also be necessary to slow the speed of bicyclists approaching an intersection, especially where the grade of the roadway will frequently result in a higher speed of travel.

- Bending the bike lane away from the adjacent motor vehicle lane is preferred, as this creates a larger offset at the intersection from turning vehicles, while also introducing horizontal deflection in the bike lane. The offset may also allow for the provision of a corner island or protected intersection. The horizontal deflection should follow the bicycle taper rate design criteria specified in Chapter 3 using the desired operating speed.
- Where horizontal deflection is not feasible due to geometric constraints, designers may consider vertical deflection for bicyclists, raising the elevation of the bikeway to reduce their speed as they approach an intersection. See the following Transitions between Elevations section for vertical deflection design parameters.

### Transitioning Bikeways between Elevations

Separated bike lanes may transition from one elevation to another in order to accommodate:

- Raised crossings at intersections,
- A vertical deflection to slow bicyclists as they approach an intersection, and
- At loading/unloading areas that prioritize pedestrians such as accessible parking, valet parking, transit stops, or ridesharing pick-up/drop-off

The ramp for the bicyclist should provide a smooth vertical transition with a maximum slope of 8 percent; however, a 5 percent slope is preferred. For side paths, any transitions must be consistent with pedestrian accessibility guidelines. Speed hump markings should be used on bicycle ramps to allow the ramp to be more visible to bicyclists. Transition ramps should typically not be located within a lateral shift or curve in the bike lane alignment near an intersection. Transition ramps may impact drainage flow and require additional storm sewer infrastructure.

### Restricting Motor Vehicles

Separated bike lane and side paths should be marked with bicycle crossings (Figure 6-26) and crosswalks (Section 4.5.1), respectively, at intersections and driveways. These marked crossing treatments are often sufficient to communicate that motor vehicles are not the intended user of the bikeway. Bicycle lane symbol markings (Section 6.3.4) located close to an intersection or driveway can further reinforce the intended user.

Green-colored pavement or markings in the bicycle crossing and/or close to an intersection or driveway can further enhance the conspicuity and reinforce that vehicles are not authorized.

KEEP RIGHT or KEEP LEFT signs (R4-7, R4-8), supplemented with an optional EXCEPT BIKES plaque (Section 6.3.4), can be installed in the street buffer to reinforce that motorists should not enter the bikeway.

If the above-mentioned treatments have been implemented and found to be ineffective, changes to the width of the separated bike lane or side path may be considered. Visually narrowing the width of the bikeway using white edge lines should first be considered. For one-way separated bike lanes, the use of flexible delineators or other vertical elements (Section 6.3.7) may be used to narrow the physical width of a one-way separated bike lane to a maximum of 6 ft. at intersections and driveways, but these treatments should not be placed in the middle of a one-way separated bike lane. For two-way separated bike lanes or side paths, if the above treatments are found to be ineffective, the treatments from Section 5.6.1 may be considered. A two-way separated bike lane may include a flexible delineator post on the centerline at intersections as a temporary measure to acclimate drivers to the lane configuration and then the flexible delineator can be removed once driver education has occurred.

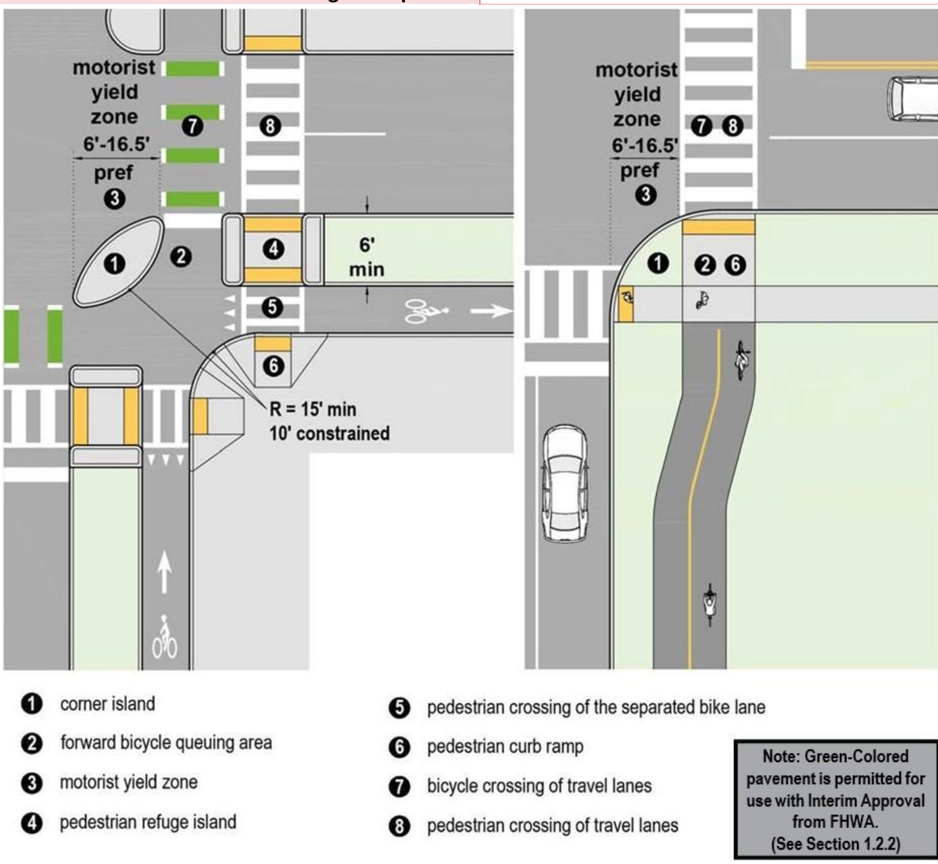
## Protected Intersection

Protected intersections maintain bicyclist separation in a separated bike lane or side path up to the intersection using corner islands (vertical elements or curbing) to separate bicyclists from traffic. The design principle may be used at signalized and unsignalized intersections and driveways.

At uncontrolled approaches of intersections and at signalized intersections where turning vehicles and bicycle through movements are expected, designers should offset the bicycle crossing between 6 and 16.5 ft. from the adjacent motor vehicle lane. This treatment creates a yielding space for motorists and has been shown to reduce crashes at uncontrolled and permissive conflict locations. Figure 6-30 shows the design components for a protected intersection.

Designers should consider using a text-only TURNING VEHICLES YIELD TO PEDESTRIANS AND BICYCLES sign to communicate when turning motorists need to yield to these street users.

**Figure 6-30: Protected Intersection Design Components**




## Corner Island

Figure 6-30 shows the corner islands in a protected intersection. The corner island is a key component of a protected intersection, which provides the following benefits:

- Helps establish the horizontal offset between the adjacent motor vehicle lane and the bike crossing, creating a motorist yield zone,
- 
- Provides a defined intersection corner to slow turning vehicles,

  Positions bicyclists waiting to cross ahead of the adjacent motor vehicle lane via an advanced bicycle stop line, allowing bicyclists to be more visible,

**Commented [JW121]:** Remove reference to IA per July ORE markup

**Commented [JW122R121]:** Update bike symbol

- Creates queuing space for bicyclists making a two-stage turn, outside of the path of through bicyclists, thus eliminating the need for some two-stage bicycle turn boxes, and
- Allows for a pedestrian crossing island, shortening the crossing length and reducing exposure.

Corner islands may be constructed of concrete and curbing, or may be constructed with low-cost materials, such as paint and flexible delineator posts or engineered rubber curbs and/or rubber speed cushion (see Figure 6-31). If a corner island is constructed of mountable materials, such as rubber speed cushions, designers should understand that the forward queuing area for bicyclists and pedestrian crossing islands may no longer be protected from turning motorists and should therefore be removed. Where flex posts or other vertical elements are used, they should be placed a minimum of 1 ft. offset from the turning radius of design vehicles at all intersection and driveways, See Chapter 7 for determining intersection curb radii.

**Figure 6-31: Protected Corner Treatment Examples: Concrete Corner Island (left) and Flexible Delineators and Rubber Parking Stops (right)**

## Pedestrian Considerations

When the street buffer is 6 ft. ~~in width~~wide, it may be used as a pedestrian crossing island, which can shorten the pedestrian crossing distance. In this case, pedestrians would cross the separated bike lane as an uncontrolled crossing, then cross the motor vehicle lanes as a separate crossing.

When the pedestrian crossing is located at a signalized intersection, the designer can consider reducing the signal timing for the pedestrian crossing to reflect this shorter crossing distance only if the pedestrian pushbuttons are located within the pedestrian crossing island. Yield markings, BIKES YIELD TO PEDS (R9-6) signs, and crosswalk markings should indicate the right of way between bicyclists and pedestrians at these locations.

When the street buffer is less than 6 ft. in width and there is not space for a pedestrian crossing island, the crossing distance cannot be shortened, and any associated signal timing must be calculated for the entire street width.

When on-street parking is located along a corridor, normal parking restrictions at intersections will allow space for a wider street buffer as the separated bike lane approaches the intersection. When there is no parking along the corridor, an offset can be created by narrowing or removing the sidewalk buffer and increasing the width of the street buffer as the separated bike lane approaches the intersection (i.e., bending the bikeway out, away from the adjacent travel lanes).

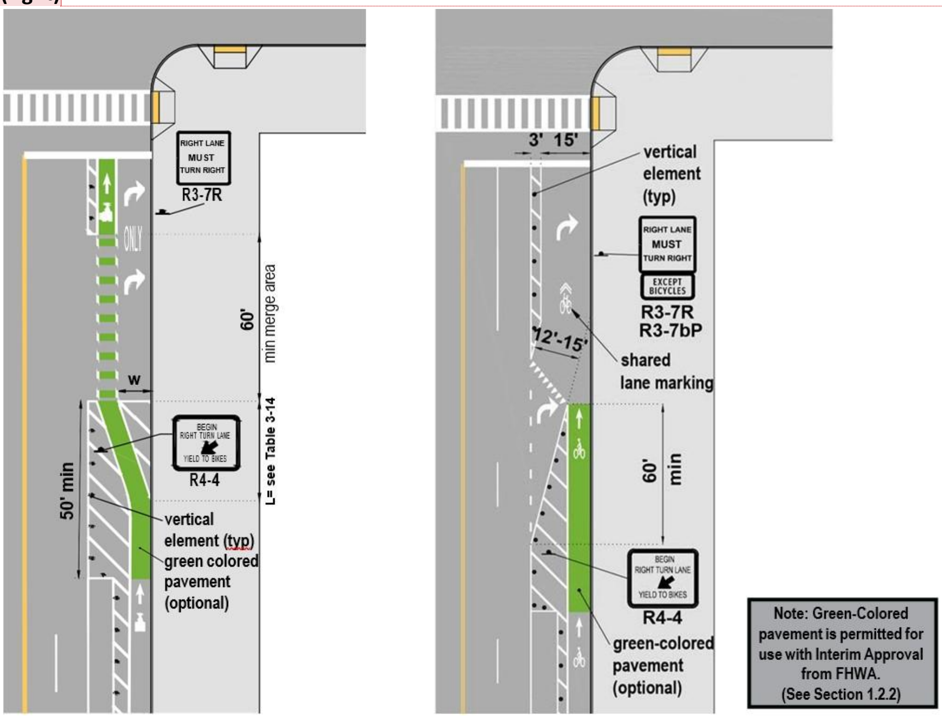
### Separated Bike Lanes with Mixing Zones at Intersections

Where protected intersections are not viable, or where separate signal phasing cannot be provided between right-turning motor vehicles and bicycles, the following mixing zone options may be considered for separated bike lanes at intersections. Mixing zones create a defined merge point for a motorist to yield and cross paths with a bicyclist in advance of an intersection. They require removal of the physical separation between the separated bike lane and the motor vehicle travel lane, and are therefore generally appropriate as an interim/retrofit solution or in situations where right-of-way constraints make it infeasible to provide a protected intersection.

The speed of motor vehicles at the merge point is a critical factor for the safety and comfort of bicyclists in mixing zones to accommodate the Interested but Concerned Bicyclist profile. The following strategies can be used to reduce speeds of motor vehicles entering the merge point:

- Minimize the length of the merge area to slow motorists prior to the conflict area.
- Locate the merge point as close as practical to the intersection.
- Minimize the length of the storage portion of the turn lane based on anticipated vehicle queue length (see L&D Manual Volume 1, Section 401.6.3).
- Provide a buffer and physical separation (e.g., flexible delineator posts) from the adjacent through lane after the merge area, if feasible.
- Highlight the conflict area with a green-colored pavement and dotted bike lane markings, as necessary, or ~~shared lane~~shared-lane markings. See Figure 6-32.

**Figure 6-32: Separated Bike Lane to the Left of a Right-Turn Lane (left) or Transitioning to a Shared RightTurn Lane (right)**




**Commented [JW123]:** Remove reference to IA per July ORE markup

**Commented [JW124R123]:** Update bike symbol

## 6.5.3 Bicycle Lanes at Intersection Design

As a bicycle lane approaches an intersection, designers should provide a continuous and direct route through the intersection, driveway, or alley that is legible to all users of the roadway. Designers should minimize or eliminate conflict areas between bicyclists and motor vehicles, where possible. To minimize the potential for conflicts, designers should adhere to the following design principles:

- 
- Designers should communicate where motorist are expected to yield to bicyclists.

  Bicycles should not operate between turning lanes and moving lanes with traffic operating over 30 mph on either side of them for distances longer than 200 ft. (see further discussion in the Right Turn Only Lanes section).
- Bicycle crossings of weaving or merging movements by motor vehicles operating over 20 mph should be avoided or minimized to a length of 200 ft. or less.

- It is preferable for motorists merging and crossing movements across bike lanes to be confined to a location where motor vehicles are likely to be traveling at speeds less than 20 mph.
- It is preferable for bicycle crossings of intersections to be marked (see Section 6.5.1. General Bikeway Design at Intersections & Crossings)

A conventional or buffered bike lane can be transitioned to a protected bike lane and follow the design of a protected intersection to increase the comfort of the bikeway at the intersection. Designers should consider this design as operating speeds reach 35 mph or higher. See Chapter 3 for bicycle lane taper rates and Section 6.5.2 for protected intersection design. When a protected intersection is not feasible for operating speeds of 35 mph or greater or motor vehicle turning volumes exceed 150 turning vehicles per hour, a bicycle ramp (Section 6.3.8) should be considered to give bicyclists a choice to exit the roadway to a side path or sidewalk prior to the intersection.

### Approach Markings

Bike lane lines ~~may~~ should be ~~solid or~~ dotted on the approach to and within intersections where motor vehicles are permitted to enter a bike lane to prepare for a turning, crossing, or merging maneuver~~.~~

**Commented [JW125]:** Bike markings should be dotted where turns are allowed Section 9E.02 P 11

**Commented [JW126R125]:** Updated

The choice between a solid or dotted lane line should be based on several factors including the speed and volume of turning vehicles, the presence of bus stops and frequency of transit use, and the types of vehicles that may cross or enter the bike lane (see Figure 6-6). A key consideration is the legibility of the bike lane network to both bicyclists and drivers and consistency of application within a community.

At locations with infrequent conflicts, the bike lanes should remain solid to the intersections. Dotted lane lines should be used to delineate conflict areas within the bike lane at locations where:

- intersections are signalized and bicyclists and motorists operate concurrently. where
- right turn lanes are not provided and turning motorist volumes are high. buses
- frequently cross the bike lane at transit stops.

As buffered bike lanes approach intersections, the buffer should not be marked where motorists must cross or enter the bike lane and a bicycle crossing should be considered. Where bike crossings are marked, the bike crossing should be widened to match the width of the full bike lane and buffer. Where a bike crossing is not marked, the buffer should be discontinued by dropping the inside lane line along the bike lane as shown in Figure 6-33 to ensure the motor vehicle travel lane is provided a continuous edge line. As buffered bike lanes approach intersections with shared through/right lanes, the buffer may terminate as shown in Figure 6-34.

## Shared Through/Right Motor Vehicle Lanes

When bicycle lanes are present on two-lane roadways, designers should see the Approach Marking guidance above for when to provide a solid or dotted line at the intersection approach.

**Figure 6-33: Buffered Bike Lane Treatments at Merge Areas**

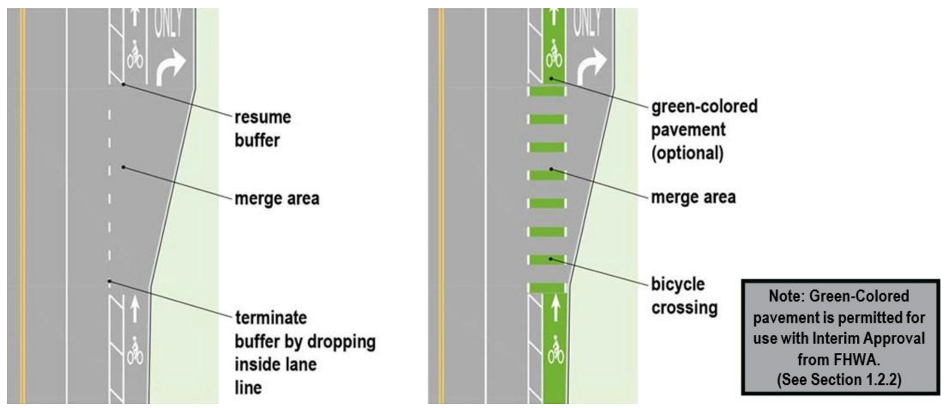
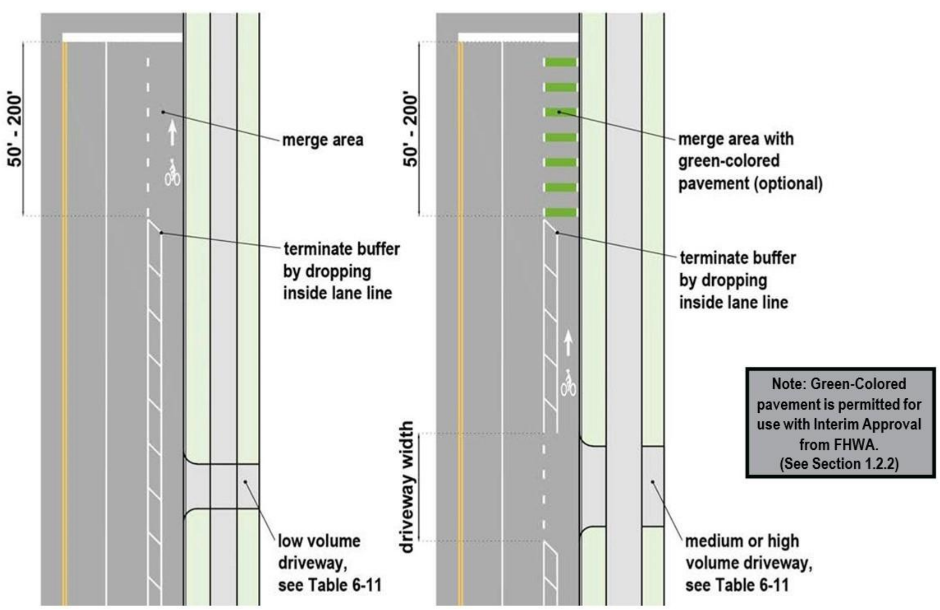



**Figure 6-34: Buffered Bike Lane Treatments Approaching Intersections**




**Commented [JW127]:** Remove reference to IA per July ORE markup

**Commented [JW128R127]:** Update bike symbol

**Commented [JW129]:** Remove reference to IA per July ORE markup

**Commented [JW130R129]:** Update bike marking

At intersection approaches with limited space where a right-turn lane is not required but there are relatively high right-turn volumes (more than 150 vehicles during the peak hour) or an existing crash history, designers should consider converting the conventional bike lane to a separated bike lane by adding a 2 ft. wide minimum buffer with flexible delineator posts beginning 50 ft. in advance of the intersection to provide added comfort for bicyclists, slow the speed of turning motorist, and reduce the length of the conflict area (see Figure 6-35). Signal phase separation of bicyclists and motorists should be considered, but if concurrent movements are permitted a bike box or forward bicyclist queuing area should be considered.

**Figure 6-35: Bicycle Lane Treatment for high turning volumes from a shared through/right motor vehicle lane**

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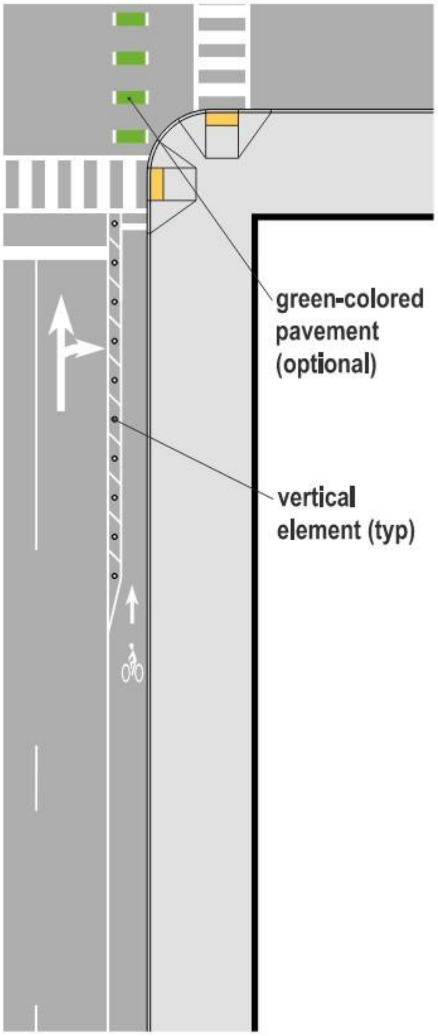



## Right Turn Only Lanes

Vehicular right turn only lanes are often used where higher volumes of right-turning motor vehicles warrant an exclusive right turn lane to increase motor vehicle capacity at intersections or for safety benefits. As right turn

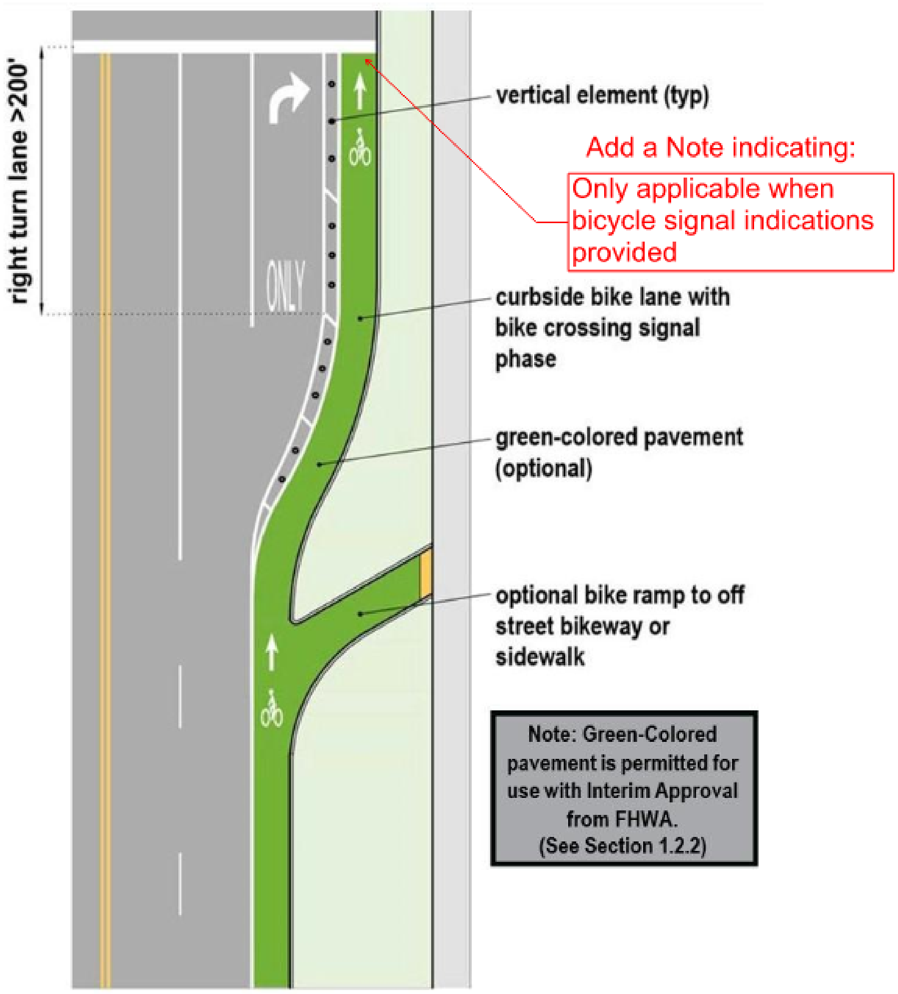
**Commented [JW132]:** Section 9E.02 and 9E.06 do not permit bike lanes outside of right turn lanes.

**Commented [DH133R132]:** Note this situation is permitted ONLY IF bike signal provided. Does ODOT want to modify to include bike signal or eliminate the possibility of bike lanes outside right-turn lane?

**Commented [PB134R132]:** Neither 9E.02 or 9E.06 are modified by the Ohio Supplement, so a bicycle signal should be included volumes increase, the potential for conflicts between bicyclists and motor vehicles also increases at merging or crossing locations.

The following are common scenarios for bike lane approaches to intersections with right turn lanes. These scenarios and subsequent treatments are discussed in order of most separated to least separated. Designers should work to provide the highest level of separation feasible to both accommodate the Interested but Concerned user and reduce motorists and bicyclists conflict points.

**Figure 6-36: Example Bike Lane Approach to a Right Turn Only Lane**

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**Commented [JA136R135]:** This figure is still in the MDG, but was modified.

**Commented [JW137R135]:** Noted

## Right-Turn Only Lane with Separated Bike Lane

At signalized intersections where a right-turn lane is provided, the bike lane ~~can~~ may be transitioned to a separated bike lane placed to the right of a right-turn lane only with the provision of a bicycle signal face and ~~separate~~ bicycle crossing signal phase that eliminates any conflicts with turning movements. See Figure 6-36.

**Commented [BS138]:** While not conflicting MUTCD, I think the language in this section is not clear.

A bike lane may be positioned to the right of a right turn only lane provided that the bicycle lane is controlled by a traffic signal with bike indications.

**Commented [JW139R138]:** Yes the MUTCD is ambiguous. It does not reference the right turn lane in conjunction with the separated bike lane, only the regular bike lane and buffered bike lane sections.

**Commented [JW140R138]:** Updated

## Bicycle Lane Adjacent to a Right Turn Only

On roadways when a right-turn only lane is added on the approach to an intersection by either widening or by restricting on-street parking, drivers must yield to bicyclists when merging across the bicycle lane into the right-turn lane. To reduce bicyclist exposure on roadways with operating speeds of 35mph or less (see Figure 6-37) and turn lanes less than 200 ft. in length, designers should:

- Mark the merging area with dotted pavement markings for no length greater than 200 ft.
- Mark the merging area where motorists' speeds are lower, typically within 400 ft. of the intersection. For these locations, designers should:
- Provide the 'BEGIN RIGHT-TURN LANE YIELD TO BIKES' (R4-4) signs to remind drivers of yielding obligations.
- Add green colored pavement to highlight the conflict area and reinforce that drivers should yield to bicyclists.

**Figure 6-37: Example Bike Lanes on Streets under 35 mph with Right Turn lanes < 200 Ft. in Length**

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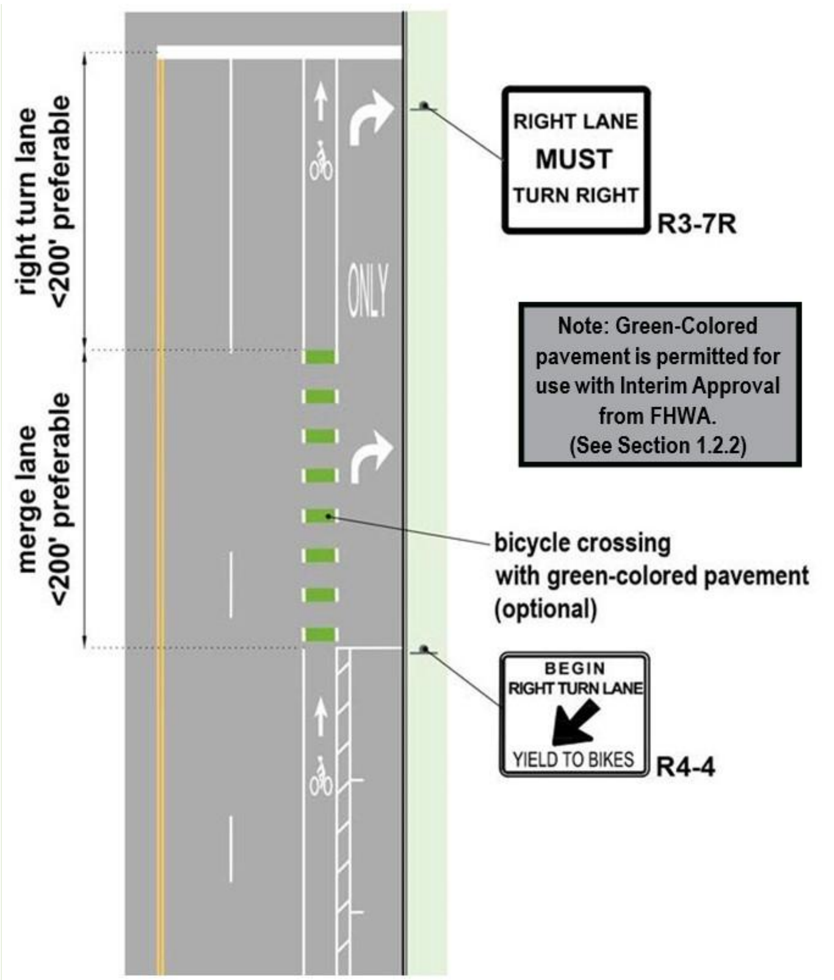
**Commented [JW142R141]:** Update bike symbol




Commented [BS143]: Update bike lane marking and remove the Interim Approval note

- Include vertical elements, such as medians or flexible delineators, between the bike lane and through lane to force motorists to enter the turn lane at the clearly defined beginning, thus providing a more predictable conflict point.

On roadways with operating speeds over 35 mph (see Figure 6-38), or at locations where right turn lanes exceed 200 ft. in length, designers should also:

- Provide a bicycle lane as wide as possible, with a bike lane width of 6 ft. or greater and a minimum 2 ft. buffer on either side. In constrained locations, the minimum bike lane width is 4 ft. with a minimum 2 ft. buffer adjacent to the through traffic lane.
- Consider providing a bicycle ramp to allow bicyclists to exit the roadway to an off-street bikeway or sidewalk prior to the merge area, if desired.
- Consider providing mountable medians or flexible delineators within the buffer adjacent to the through travel lane (where present) to prevent motorist encroachment into the bike lane and constrain the motorists merging area across the bike lane.

**Figure 6-38: Example Bike Lanes on Streets over 35 mph or Right Turn Lanes > 200 ft. in Length**

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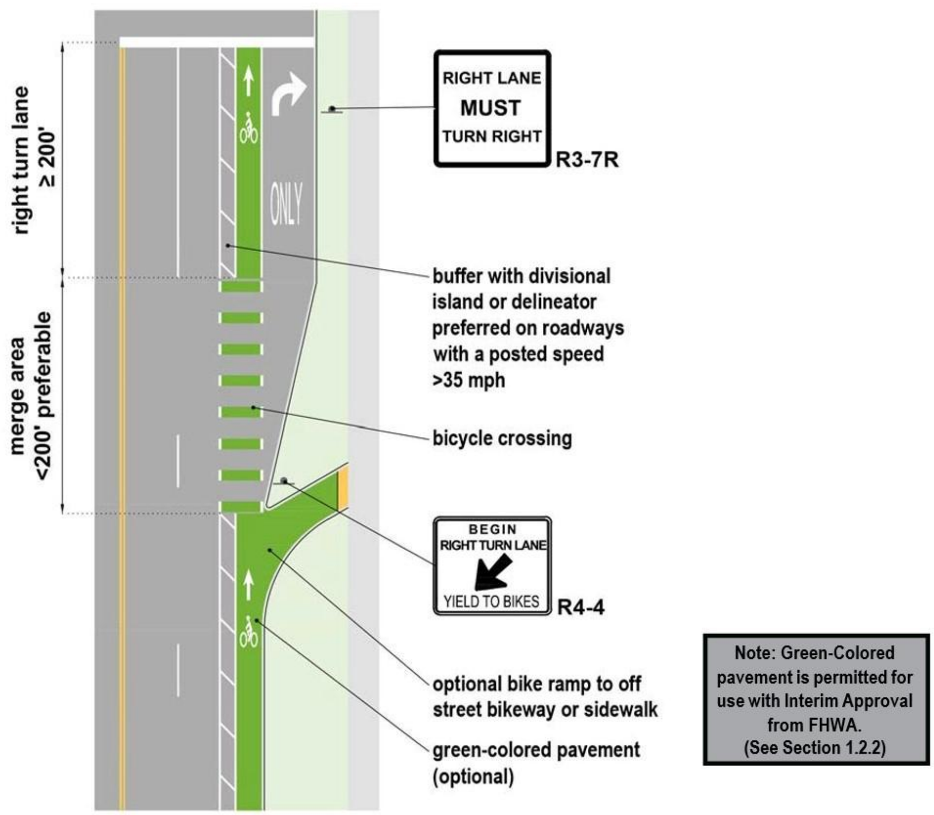
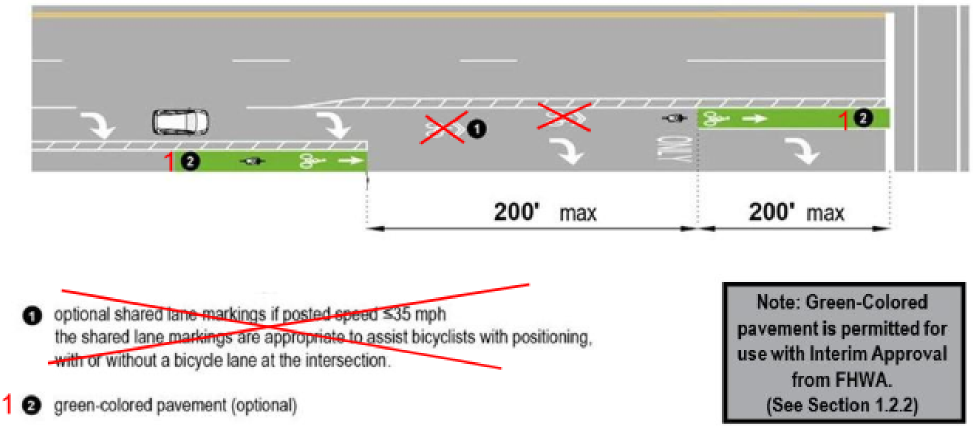


**Figure 6-39: Through Lane Drops to Right Turn Lane with Bike Lane**




Where buffered bike lanes or bike ramps to an off-street bikeway or sidewalk are not feasible for roadways with operating speeds greater than 35 mph or right turn lanes that exceed 200 ft. in length, the bike lane may remain along the curb until it is within 400 ft. of the intersection, at which points the bike lane shall transition to the left side of the right turn lane, as shown in Figure 6-39.

## Through Lane Transitions to a Right Turn Only Lane

Figure 6-39 shows an intersection where a through travel lane becomes a right turn only lane or an auxiliary lane. In this scenario, the bicyclist must transition to the left side of the turn lane. This is a challenging maneuver for bicyclists, and it increases crash risk as traffic speeds exceed 30 mph and motorist volumes increase. To compensate for this, the bike lane should remain along the curb until it is within 400 ft. of the intersection. The bike lane drops at this point and is re-introduced on the left side of the right turn lane. Design treatments should be selected based on the operating speeds:

- Operating speeds less than 35 mph - ~~shared lane~~shared-lane markings may be used to delineate the likely path of travel of bicyclists transitioning to the shared-lane and then into the bike lane. The bike lane should not be striped diagonally across the travel lane, as this inappropriately suggests to bicyclists that they do not need to yield to motorists when moving laterally. In this situation, the BEGIN RIGHT TURN YIELD TO BIKES (R4-4) sign should not be used, since bicyclists are the users who need to yield as they are weaving across the path of motor vehicle traffic. A BICYCLE warning sign (W11-1) or BICYCLES MERGE (W9-5a) sign should be placed where the curb side bike lane ends.

**Commented [JW145]:** Remove reference to IA per July ORE markup

**Commented [JW146R145]:** Update bike symbol

**Commented [JW147]:** Consider adding MUTCD designation

**Commented [JW148R147]:** Updated

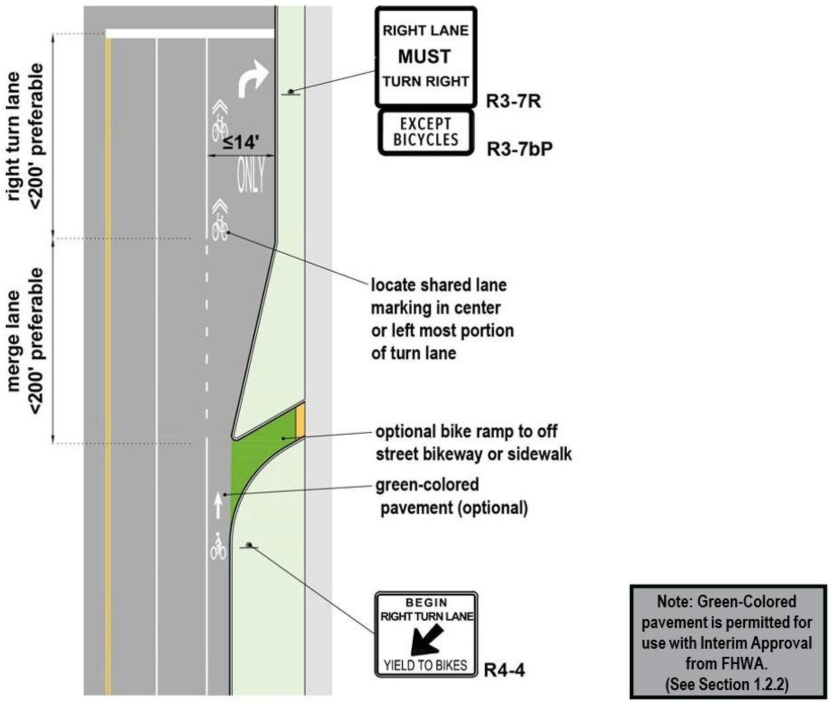
- Operating speeds over 35 mph - a bicycle ramp should be considered to allow bicyclists to exit the roadway, if desired, to an off-street bikeway or sidewalk prior to the merge area.

### Bike Lane Ends to Develop a Right Turn Lane

If there is insufficient space for a bike lane and a right turn only lane, designers must select from three primary design alternatives. Bicyclists often prefer to operate within the lane that has a lower traffic volume, experiences less queueing, and has lower operating speeds than the adjacent lane. Designers should select the treatment that maximizes bicyclist safety and comfort:

- Bike Lane Transitions to a Shared Right-Turn Lane - If the right turn only lane is best suited for bicyclists, the adjacent travel lane should be narrowed to the minimum width allowed by the L&D Manual Volume 1 to maximize the width of the turn lane for shared operation. At locations where the right turn lane is 14 ft. or less in width and posted speeds are less than 35 mph, ~~shared lane~~shared-lane markings may be located within the center or left-most portion of the turn lane (See Figure 6-40).
- Bike Lane Transitions to a Shared Through Lane - At locations where the right turn lane experiences extensive or frequent queuing or there is no bike lane present on the downstream side of the intersection, and has operating speeds below 35 mph, the ~~shared lane~~shared-lane markings may be located within the right-most through lane instead of within the right-turn lane. In these locations, the ~~shared lane~~shared-lane markings should be located following the guidance provided in Section 6.3.1 and Figure 6-3 and Figure 6-41.

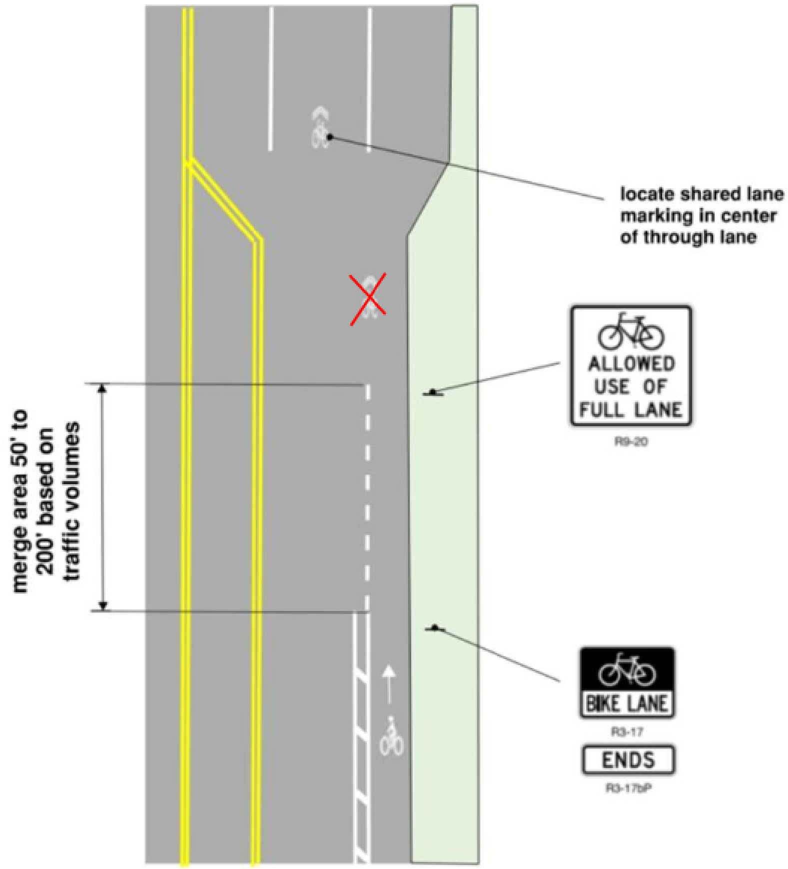
**Figure 6-40: Example Right Turn Only Lane with ~~Shared Lane~~Shared-Lane Markings**




**Commented [JW149]:** Update graphic per July ORE markup (bike symbol still needs to be updated)

**Figure 6-41: Through Lane with ~~Shared Lane~~Shared-Lane Markings when Bike Lane Ends before Intersection**

Commented [DH150]: Update bike lane marking




- Bike Lane Transitions to an Off-Street Bikeway or Sidewalk - At locations where operational speeds exceed 35 mph or motorist volumes exceed 150 turning vehicles per hour, a bicycle ramp should be considered to allow bicyclists to exit the roadway to an off-street bikeway (separated bike lane or side path) prior to the termination of the bike lane.

### Dual Right Turn Only Lanes

Avoid installing dual right turns on streets with bicycle lanes. If dual right turn lanes are necessary to accommodate heavy right-turn volumes, a designer should transition the bike lane to a separated bike lane or side path in advance of the intersection (see Figure 6-36). The high right turn volumes will require the provision of a separate bike crossing phase (see Chapter 8).

If the bike lane cannot be transitioned to a separated bike lane, ~~shared lane~~shared-lane markings may be located in the adjacent through lane if posted speeds are less than 40 mph.

### 6.5.4 Raised Bike Lanes at Intersections

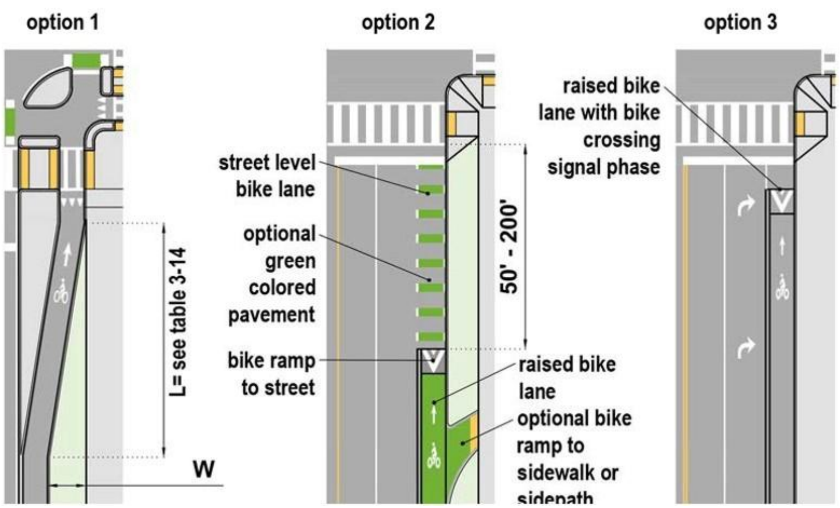
At locations where bike lanes are raised and located near adjacent travel lanes, it will be necessary for the raised bike lane to transition to a street level bike lane, shared-lane, or to a sidewalk, side path or separated bike lane (see Figure 6-42).

It is preferable to transition the raised bike lane to bend away from the travel lane to form a protected intersection where space allows to minimize conflicts with turning motorists (Option 1).

Where it is determined to transition the raised bike lane to a standard bike lane or shared-lane, that transition should occur 50 ft. to 200 ft. prior to the intersection (Option 2). A bike ramp should be considered to allow bicyclists to transition to the adjacent sidewalk or side path at locations where bicyclist may encounter high volumes of motorized traffic.

**Figure 6-42: Intersection Approach Options for Raised Bike Lanes**

**Commented [JW151]:** Update figure per July ORE markup (bike symbol still needs to be updated)



Where protected intersections are not feasible, the raised bike lane should transition to street level. It is preferable for the raised bike lane to continue to the intersection and return to street level on a ramp within 10 ft. of a pedestrian crosswalk (Option 3). This option is only applicable when the bike movement is phase separated (see Chapter 8).

### 6.5.5 Counter fFlow Bike Lanes Intersection Design

At intersecting streets, alleys, and major driveways, DO NOT ENTER (R5-1) signs and turn restriction signs should include a supplemental plaque reading EXCEPT BICYCLES (R3-7bP) to establish that the street is two-way for bicyclists and to remind motorists to expect two-way bicycle traffic. At traffic signals, bicycle signal ~~heads~~ faces and suitable bicycle detection measures ~~should~~ shall be provided for counter-flow bicyclists. ~~If bicycle specific lenses are not used, a supplemental plaque reading BICYCLE SIGNAL may be needed beneath the signal to clarify its purpose.~~ Bicycle crossing may be marked to further emphasize the counter flow movement of bicyclists to motorists.

Counter-flow transitions should normally occur at intersections or locations where bicyclists may return to normal two-way travel or naturally transition to the correct side of the street in another bikeway. If transitions are not made at logical locations, bicyclists may continue to ride counter flow in a shared- lane, in a bicycle lane, or on a sidewalk which can substantially increase their crash risk.

**Figure 6-43: ~~Signing for Counter-flow Bike Lanes~~** RESERVED FOR FUTURE USE

**Commented [JW152]:** Consider adding MUTCD sign desgination

**Commented [JW153R152]:** Updated

**Commented [JW154]:** As noted earlier this is not permitted. Need to also clarify with FHWA if their intent is to require bike signals on a counterflow facility

**Commented [PB155R154]:** Use bicycle signal heads

**Commented [JW156R154]:** Updated

**Commented [KF157]:** Question for FHWA: Is this Figure of concern? Should this remain?

The Two-Way Bicycle Cross Traffic warning plaque (W16-21P) can alert drivers to unique operations, especially when a counter-flow or two-way bicycle facility has an approach that is counter to the customary scanning behavior of a motorist. When used, the Two-Way Bicycle Cross Traffic (W16-21P) warning plaque shall be installed below a STOP or YIELD sign.

**Commented [DH158]:** New sign in MUTCD 11th Ed and supported by ODOT staff for inclusion

### 6.5.6 Bicycle Boulevard Intersections and Crossings

#### Low-stress Intersection Crossings

An important principle of bicycle boulevards is to ensure that street crossings maintain the low- stress nature of the bikeway with minimal delay. Many of the intersections a bicyclist will cross will be local streets crossing other local streets. These are commonly all-way or two-way stop or yield-controlled, fully uncontrolled, or fully uncontrolled with traffic circles (see Chapter 7). Frequent stopping along a bicycle boulevard can significantly increase the bicyclist's total ride time and may result in reduced stop sign compliance where stops are closely spaced and crossing traffic volumes are low. For a bicycle boulevard to function as an alternative route to a parallel arterial, it should provide a similar travel time for the bicyclist as they would experience on the parallel arterial. In many cases, achieving this outcome may involve intersection control changes along the bicycle boulevard.

#### Traffic Controls for Minor Street Crossings:

- Limit locations where stop control is used on the bicycle boulevard to less than one location per half mile (in the direction of travel along the bicycle boulevard). Yield controls are preferable to stop controls as it allows bicyclist to slow and assess the cross traffic without having to stop and restart.
- On long corridors with a frequent application of all-way or two-way stop control, efficiency of the bicycle boulevard can be improved by removing stop controls on the bicycle boulevard and requiring the cross street to stop or yield, or by utilizing mini-roundabouts.
- Parking restriction signs may be necessary to provide the required sight distance at intersections where stop signs are removed or where yield control is provided.
- Consider supplementing STOP or YIELD signs with either CROSS TRAFFIC DOES NOT STOP (W4- 4P) signs and Bicycle Guide Signs. When used, Bicycle Guide Signs shall be installed on a separate post than the STOP sign.

Designers should be aware that the removal of stop signs can result in increased motor vehicle speeds and volumes. When bicycle boulevards run parallel to a congested arterial or are the only route through an area with few connecting streets, it may attract cut-through motorized traffic. Designers should consider traffic calming or diversion treatments to discourage or prevent increased traffic volume, speeds, or both (see Chapter 7).

Traffic Controls for Major Street Crossings:

Major street crossings along bicycle boulevards can be significant barriers. At intersections where a bicycle boulevard crosses an arterial road, or any other major road where the bicycle boulevard is stop- or yield-controlled, an uncontrolled crossing of the major roadway is common. Where traffic signals are not present, additional crossing measures may be needed to ensure bicyclists can continue along the route. Designers should ensure that there are sufficient crossing opportunities (see Table 6-8) and apply appropriate countermeasures as needed (see Section 6.4). Chapter 8 provides design guidance for beacon and signal countermeasures. Bicycle boulevards are commonly used by families with children because they often originate in neighborhoods and provide connections between neighborhoods. At major streets, bicycle boulevard crossings may also be used by pedestrians. For these reasons, intersection crossings should assume pedestrians are crossing and include crosswalk markings, along with other appropriate design measures to accommodate pedestrian and bicycle crossings. Designers should be guided by the following performance criteria when evaluating and designing bicycle boulevard crossings at major intersections:

- Crossing time and acceleration should accommodate pedestrians and child bicyclists (Section 3.3.1 and Section 3.5.2 - Case D)
- Sight distance eye height should be based on recumbent bicyclist (Section 3.5)

In some instances, warning beacons or traffic signals may be present to control the major street. At intersections with bicycle boulevards, it may be considered to allow coordinated traffic signals to operate on half signal cycle lengths or to operate in “free” or uncoordinated mode during off-peak hours to reduce delays for bicyclists and provide frequent service (see Chapter 8).

## Offset Intersections:

Along a bicycle boulevard, there may be discontinuities in the street grid. In order to continue, a bicyclist may be required to turn or travel for a brief distance on a roadway with higher motorist volumes and/or speeds. Without comfortable crossing treatments, offset intersection with these streets become a barrier along the corridor. In general, designers should select a bikeway for the major street based on the bikeway selection criteria identified in Figure 3-3 and follow the guidance for traffic control devices at major crossings in this section. Example connections could be a bicycle lane with two-stage turn boxes (Section 6.5.1) or a two-way separated bike lane or side path connection as shown in Figure 6-44.

**Figure 6-44: Reserved for Future Use**

## 6.5.7 Paved Shoulder Intersection Design

Designers can transition a shoulder to a bicycle lane prior to intersections and driveways, and then transition back to a paved shoulder. Figure 6-45 shows an example of introducing a bike lane at an intersection where a right turn lane is present. For instances where a dedicated right turn lane is not present, see Section 6.5.3. Designers should follow signing and striping design in Section 6.3.4 and 6.5.3.
Transitioning a paved shoulder to a separated bikeway at intersections may be desirable at locations near high-speed exit and entrance ramps to highways, or along high-volume, high-speed rural arterials with long deceleration, and right turn lanes where on-street bike lanes are not a preferred treatment.

When paved shoulders are not transitioned into bicycle lanes, bicyclists crossing an intersection from the paved shoulder or merging into the adjacent travel lane to turn left, continue straight, or turn right on to a roadway without a shoulder must yield to all vehicles within the roadway. As noted previously, the yielding requirements for vehicles traveling along the paved shoulder may not be clear to all roadway users. At a minimum, a regulatory sign reinforcing Ohio state law should be posted stating “BICYCLIST ON SHOULDER MUST YIELD” when the paved shoulder is wide enough to allow for bicycle use and it is a designated bikeway, such as a state and U.S. bicycle route, or where bicyclists are expected. The paved shoulder striping should not taper towards the cross street at intersections, but it can transition to a dotted edge line where motorists are expected to use the paved shoulder to begin their turning movement. Figure 6-45 shows both of the above described conditions for typical paved shoulder designs to accommodate bicycling.

Bypass lanes at T-intersections of two-lane roadways can be incorporated, so as to facilitate the passing of motorists stopped to make left turns onto intersecting roads. Where this is done on a highway with paved shoulders, a minimum of 4ft. of shoulder pavement should be carried through the intersection along the outside of the bypass lane and designated as a bike lane. This is especially critical on roadways with higher volumes and operating speeds where bicyclists operating on the shoulder are likely to be in conflict with bypass lanes. See Figure 6-46.

**Figure 6-45: Example Paved Shoulder Markings to Accommodate Bicycling**

**Commented [JW159]:** Update bike symbols

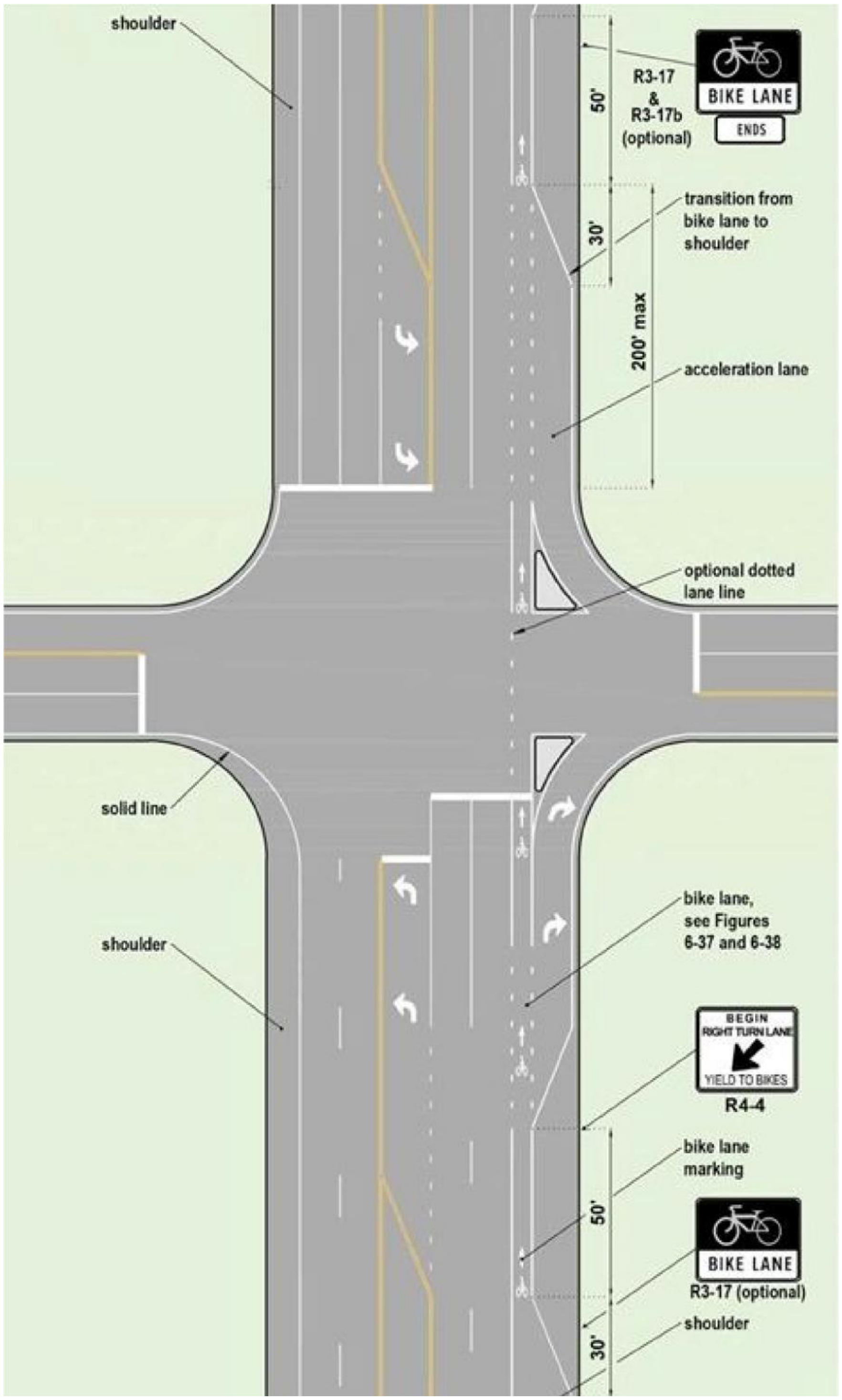
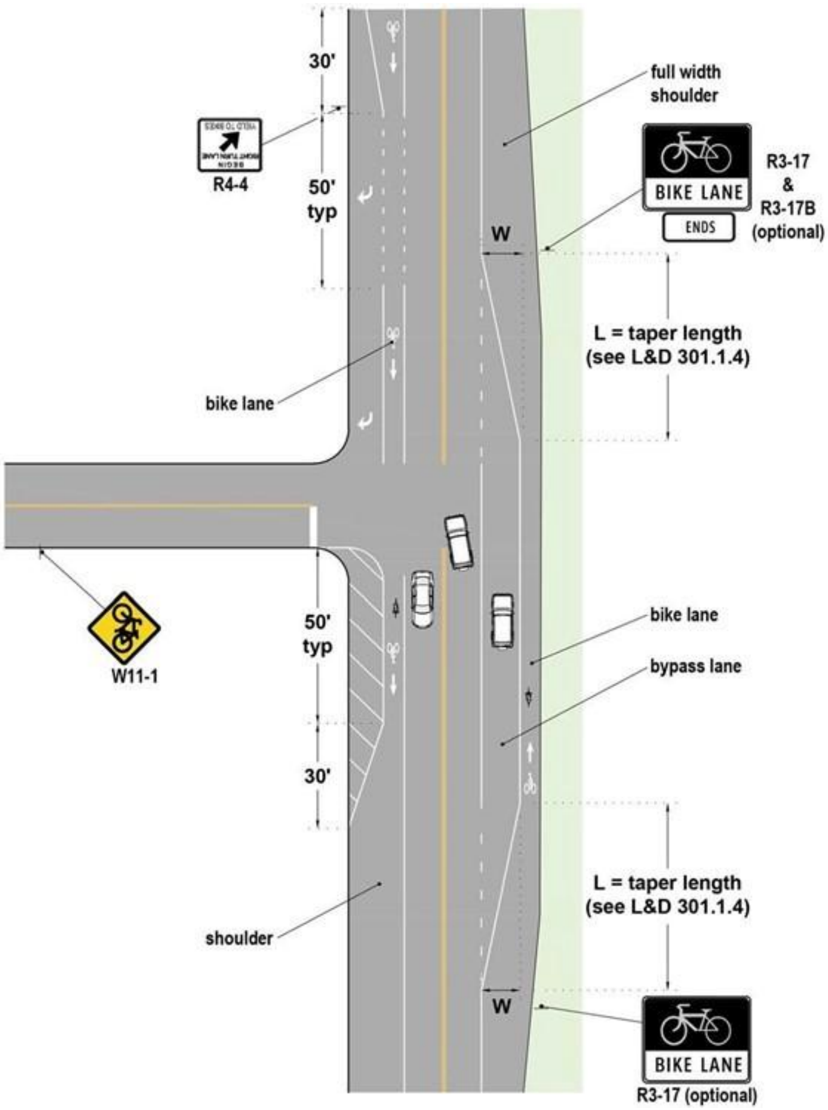
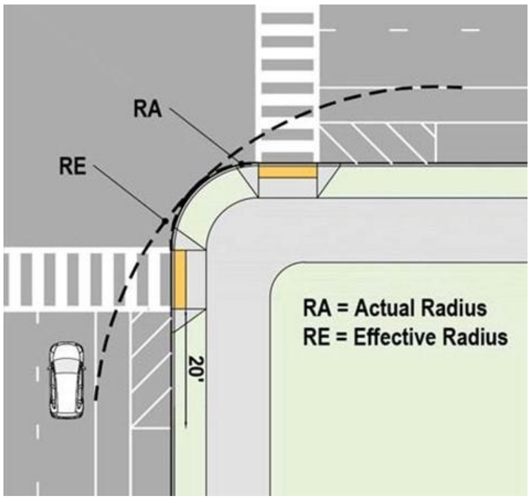

shoulder
50'
R3-17
&
R3-17b
(optional)
BIKE LANE
ENDS
30'
transition from
bike lane to
shoulder
200' max
acceleration lane
optional dotted
lane line
solid line
bike lane,
see Figures
6-37 and 6-38
shoulder
BEGIN
RIGHT TURN LANE
YIELD TO BIKES
R4-4
bike lane
marking
50'
BIKE LANE
R3-17 (optional)
30'
shoulder

**Figure 6-46: Motorist Bypass Lane with Bicycle Lane**




**Commented [JW160]:** Update bike symbols. Consider adding bike crossing markings

**Figure 7-1: Actual Corner Radius vs. Effective Turning Radius**




Commented [JW1]: The diagonal lines in these No Parking Zone markings are angled the incorrect direction.

## 7.2.4 Designing Intersection and Driveway Corner Radii

Designers should strive to provide the smallest appropriate corner radius for the given IDV and ICV, target turning speeds, acceptable lane encroachment, number of receiving lanes, and effective pavement width. In addition to discouraging higher turning speeds, smaller corner radii are preferred in order to better align curb ramps with pedestrian paths of travel and shorten crossing distances.

To achieve the smallest appropriate corner radius, designers should follow these strategies:

- Using vehicle turning software or turning template, designers should minimize the corner radius while accommodating the effective turning radius of vehicles.
- Where pedestrians or bicyclists are expected and the effective turning radius exceeds 15 ft., consider the following:
    - Push back the stop line of the receiving street beyond the minimum 4 ft. from crosswalks where appropriate. Ensure that any encroachment does not conflict with overlapping phases at signalized intersections. In general, stop lines should not be pushed back more than 30 ft. from crosswalks as motorist compliance may be diminished; however, the maximum distance from stop

accommodations (e.g., curb ramps, crosswalks) must be placed to prevent these users from waiting in the travel way. Colored concrete and/or pavement markings should be used within the truck apron area to provide a visual contrast from the adjacent roadway and sidewalk. This communicates to drivers of smaller vehicles that this is not an area to drive over. Where widths exceed 15 ft., the intended use of the apron may not be clear and designers may consider a channelizing island to limit the street crossing distance for pedestrians and bicyclists (see Section 7.2.6).

In retrofit conditions, a truck apron that extends all the way to the existing curbline may not be possible without significant stormwater system modifications. In these situations, truck pillows that maintain drainage along the existing curbline may be more practical and feasible.

See DWG 7-1 for additional design details for truck aprons and truck pillows.

An edge line should be provided along the outside edge of wider truck aprons to ensure that the path of travel is visible. Gore markings may be installed on the truck apron itself, but this is often unnecessary if colored pavement is used, see Figure 7-3.

Where buses are likely to traverse the truck apron with regularity (such as transit routes), truck aprons should be designed to allow the bus to complete the turn without traversing the truck apron. A tiered truck apron with a curb reveal from 0 to 1 inch can be constructed for use by buses while the second tier can be designed with a 3 inch curb reveal for use by larger trucks, see Figure 7-3.

**Figure 7-2: Typical Truck Apron Layout at a Protected Intersection**

**Commented [KF2]:** Bike lane symbol needs to be updated per the 11th Edition of the MUTCD

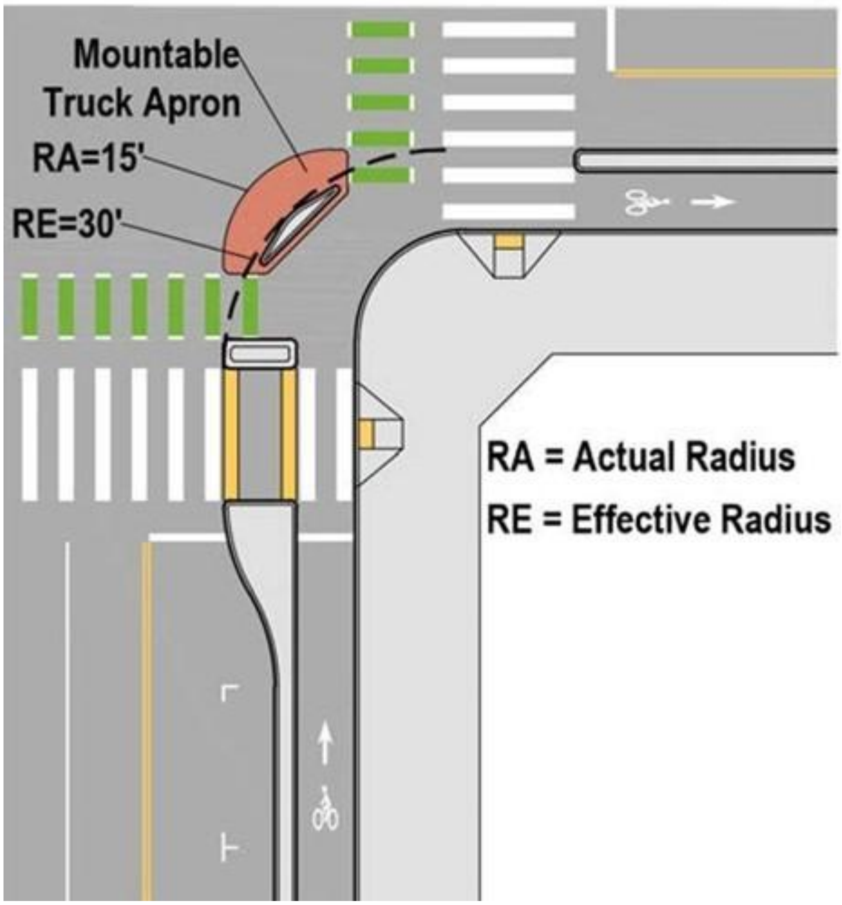


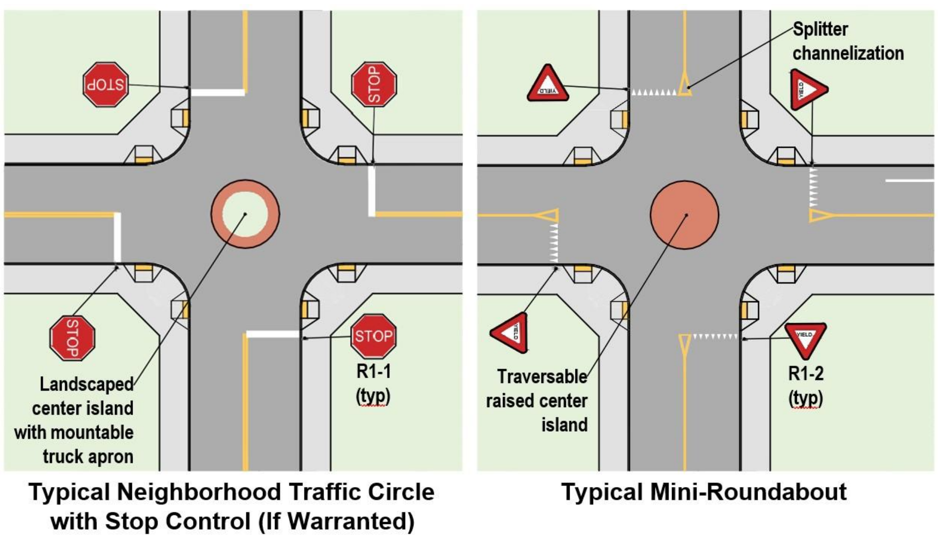

**Figure 7-3: Truck Apron with Concrete and Pavement Markings (top) and Tiered Truck Apron with Colored Concrete (bottom)**

- Bikeways should be maintained throughout to avoid abruptly squeezing bicyclists into motorvehicle traffic on streets with higher traffic volumes, particularly in locations with uphill grades where bicyclists may be traveling slower than other roadway traffic.

## Traffic Circles

Neighborhood traffic circles are primarily used at four-leg, two-lane local streets and are installed to reduce crash severity and slow traffic speeds. Splitter islands are not required on approaches (unlike a modern roundabout), and the central island is typically raised with a mountable apron to prevent a straight-through movement of the typical design vehicle. The occasional control design vehicle should not be precluded from operating within the intersection with encroachment, if necessary, which may include going the "wrong way" to the left of the traffic circle to make a left turn. Landscaping may be planted with the center median if it does not need to be traversable. The local streets typically do not have marked centerlines.

**Figure 7-11: Schematic Examples of Mini-Roundabouts and Neighborhood Traffic Circle**




Designers should consider the following:

**Commented [JW3]:** YIELD control shall be used at roundabouts per MUTCD Section 2B.10 P 05.

**Commented [JA4R3]:** Replace stop signs with yield signs and stop bars with yield lines in left graphic.

- The aesthetic value of a traffic circle is an important part of its design. Well-designed traffic circles fit naturally into the neighborhood and can include landscaping, green street elements, or decorative pavement such as stamped concrete, pavers, etc.
- Traffic circles should be visible to street users with pavement marking, signing and reflectors used where appropriate. Regulatory and/or warning signage should be provided to advise traffic to proceed counterclockwise around the circle.
- Careful attention should be paid to the available lane widths and turning radius used with traffic circles to accommodate the design vehicles.
- Maintaining access to underground utilities must be considered.

### Mini-Roundabouts and Modern Roundabouts

Mini-roundabouts are primarily used on two-lane collector streets and require all vehicles to yield to traffic in the roundabout and traverse counterclockwise around the circle. Because of their traffic calming effects, they are installed primarily to reduce crashes, but can also reduce delays at minor approaches. Mini roundabouts share the characteristics of modern roundabouts (See Chapter 9 and L&D Manual Volume 1, Section 403) with approach splitter islands and yield control on each approach. The splitter island may be raised or painted. The central island may be raised with a mountable apron (See Section 7.2.5 and D Manual Volume 1, Section 403.6.4) to constrain the circulating roadway width while still accommodating larger vehicles. Where the diameter of the center circle is less than 8 ft., it may be painted. Mini-roundabouts are typically constructed to fit within existing curb lines at intersections but in some locations may require reconstruction of corner radii to accommodate larger design vehicles. In most cases the addition of new accessible curb ramps will be necessary to accommodate pedestrians at a crossing setback from the circulating roadway. The intersecting streets will typically include marked centerlines.

## 7.8.3 Vertical Deflection

Vertical deflections, which include speed tables, speed humps, speed cushions, and raised crosswalks, are effective means for controlling the speeds of motor vehicles. OMUTCD Sections 2C- 2~~9~~7, 3B.2~~5~~9 and 3B.30~~26~~ provides guidance on markings and signage for vertical deflection treatments. Vertical deflection as a traffic calming measure is only permitted across local, collector, and urban arterial streets where posted speeds are less than or equal to 35 mph and where roadway grades do not exceed 8 percent.

In general, all vertical traffic calming devices within roadways should be built with a bicycle friendly vertical deflection profile. The front edge or lip of the device should be as smooth as practical and meet the road with minimal vertical.  See Table 7-1 for additional guidance on vertical deflection considerations.

**Table 7-1: Vertical Deflection Characteristics and Desired Motorist Speed at Crossing [3]**

| **Desired Motorist Speed** | **Maximum Table Height** | **Appropriate Locations** | **Min Ramp Length and Target Slope** |
|---|---|---|---|
| **<= 20 MPH** | 4.0 inches | Local Streets | 6 Feet or 1:12 |
| **<= 25 MPH** | 3.5 inches | All Streets <u>without</u> Designated Emergency Response, Truck or Frequent Transit Routes | 6 Feet or 1:18 |
| **<= 30 MPH** | 3.0 inches | Arterial or Collector Streets <u>without</u> Designated Emergency Response, Truck or Frequent Transit Routes | 6 Feet or 1:24 |
| **<= 35 MPH** | 3.0 inches | Arterial Streets with Designated Emergency Response, Truck or Frequent Transit Routes | 9 Feet or 1:24 |

## Speed Humps

Where speed humps are used to control speeds along a roadway, they are most effective when they are placed periodically along the route (every 200 – 400 ft.) to reinforce speed control. These devices should be designed to maintain existing drainage patterns to avoid requiring additional inlets and storm sewer. DWG 7.2 provides additional speed hump design details, which includes tapering the speed hump near the edge of pavement or curbline to minimize retrofit installation costs and allow stormwater to flow into existing gutters. The details also show options for speed humps with gaps between separate humps. These may be desirable on bicycle boulevards, or to better accommodate emergency services vehicles, as they allow the bicyclist or the wider emergency services vehicles to straddle the hump while narrower passenger vehicles cannot avoid them. Designers should consider the existing site conditions and make adjustments where necessary.

#### Raised Crossings and Speed Tables

See Section 4.5.5. for speed considerations.

For both speed tables and raised crosswalk, a 10 foot minimum flat area should be provided. Speed tables are most effective when they are placed periodically along the route (every 200 – 400 ft.) to reinforce speed control.

Raised crossings require additional design considerations (see Section 4.5.5). Raised crossings may also be placed at intersections to reduce both left and right turning vehicular speeds.

### 7.8.4 Street Width Reduction

Research has shown that motorist speeds can be reduced by creating a sense of enclosure or by creating shared travel spaces that eliminate the perception of motorist priority.[3] This can be accomplished through the provision of continuous or intermittent elements that reduce the effective travel lane width and narrow the field of view, resulting in a naturally slow-speed environment. Designers should consider additional streetscape elements to further enforce to drivers the need to drive slowly and with caution.

#### Road Diet

A road diet is the conversion of an undivided roadway to a cross-section with fewer or narrower through motor vehicle travel lanes. The elimination or width reduction of travel lanes can reduce the severity of crashing through vehicle speed reduction. It is appropriate for arterial, collector, and local streets in an urban, suburban, or rural setting. The reduction on traveled way widths may also provide space for other improvements such bicycle lanes and crossing islands. See Section 7.5.2 for more design information.

#### Narrow (Yield) Streets

In many communities, particularly residential neighborhoods, streets are quite narrow. Some of these streets are called “yield streets,” “queuing streets,” or “woonerfs” because they require motor vehicles to pull to the side, usually into a parking lane or driveway, to allow motor vehicles approaching in the opposite direction to pass. Yield streets are appropriate in residential environments where drivers are expected to travel at low speeds and volumes are low, see Table 7-2.

**Table 7-2: Yield Roadway Motorized Traffic Volume and Speed Characteristics**

| | Average Daily Traffic Volume (ADT) | Operating Speed (mph) |
|---|---|---|
| Preferred | 500 | 15 |
| Maximum | 2000 | 25 |

Yield streets are typically 24–28 ft. wide with parking on both sides, or 21 ft. wide with parking on one side to limit the effective width of the operating space to require motorists to pull into empty parking spaces or driveway openings to allow approaching motorists to pass. Width reduction measures may include on-street parking (See Section 7.2.7), curb extensions (See Section 7.7), median islands (See Section 4.5.3), or a combination of these measures.

For a yield street to function properly, parking density must be relatively high, but motorists must also have regular opportunities to pull to one side. In general, yield streets are most effective where on- street parking utilization falls within 40 to 60 percent of available spaces or when 40 to 60 percent of the curb space is available due to parking restriction and parking demand. When more than 60 percent of the curb is space is regularly available, curb extension or pinch points can be installed to reduce the curb space and create a similar effect. If parking demand is expected to increase, painted curb extensions may be used as an interim measure and removed as parking demand increases.

Yield streets should provide enough room for emergency vehicle access, the occasional moving van or large delivery truck, as well as school buses, trash trucks, and snow plows (when these vehicles are expected), to navigate safely.

## One-Lane Pinch-Points

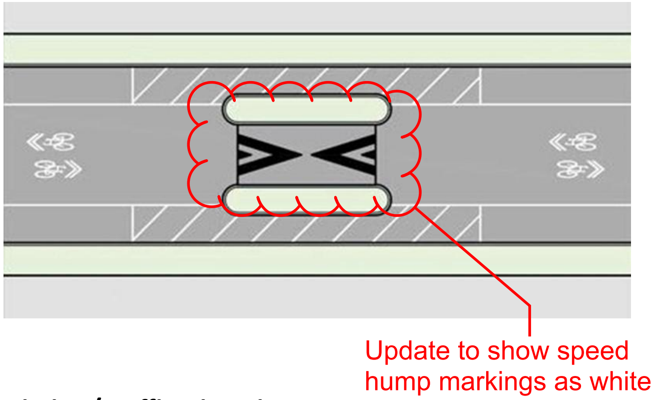
Pinch-points are curb extensions that are constructed to narrow a two-way roadway to one travel lane which requires approaching motorists to yield to each other. This treatment should be reserved for mid-block locations along low-volume local streets. This treatment may be most appropriate on streets with more than 18 ft. of clear operating width which are functioning as two-lane streets, streets with low parking demand, or streets with parking on one side.

Designers should consider the following:

- To function effectively, the width of the opening should not allow two cars to pass: 14 ft. is effective and allows emergency services to navigate the opening.
- The one-lane portion may align with one direction of travel to prioritize that direction or may be centered in the roadway with no directional priority.
- A ROAD NARROWS warning sign (W5-1~~ROAD NARROWS~~) and YIELD sign~~s~~ (R1-2) may be considered upstream of the pinch point.
-
- Any vegetation provided in the medians should be low growing and low maintenance.

Vertical deflection (see Section 7.8.3) may be located within the single-lane section to further reduce speeds. In these instances, a bicycle bypass can be considered to maintain bicyclist speeds (see Figure 7-12).

**Figure 7-12: One-Lane Pinch Point Centered in the Roadway with Speed Hump and Bicycle Bypass Lanes**




## 7.8.5 Routing Restriction/Traffic Diversion

Traffic diversion strategies are used to reroute traffic from one roadway onto other adjacent streets by installing design treatments that restrict motorized traffic from passing through. These type strategies require a traffic study before implementation. These are often used on Bicycle Boulevards (See Section 6.3.2 and

Section 6.5.6) to reduce motorist volumes but can also be used on other roadways where volumes are above desired thresholds for other bikeway types (See Section 7.2) or the expected pedestrian volumes.

The NACTO Urban Street Design and Bikeway Design guides and FHWA Traffic Calming Primer[4] provide additional types of volume management strategies beyond those discussed here.

### Regulatory Signage

Signing can be used to prohibit vehicles from entering a roadway using movement prohibition signs (R3-1, R3-2, R3-3, R3-5, R3-27), etc., or DO NOT ENTER signs (R5-1). These prohibitions can be for all hours or could be for peak hours only to optimize flow during times of heavy traffic. Signs shall ~~should~~ be supplemented with an EXCEPT BICYCLES plaque (R3-7bP) when bicyclists are permitted to perform the movements that are prohibited for motorists.

Signs may be supplemented by right and/or left turn pavement marking arrows to emphasize the restriction, but pavement markings should not be used when restrictions vary by time of day. Signs and pavement markings alone may not be effective at discouraging motor vehicle access. The following sections depict physical treatments that can be used to supplement signing and markings.

### Diverters

A diverter is an island built at an intersection to alter the movement of through and/or turning vehicle traffic. Diverters are commonly designed to maintain through travel for people walking and bicycling while altering routes for motor vehicles. For all diverters, designers should consider the following:

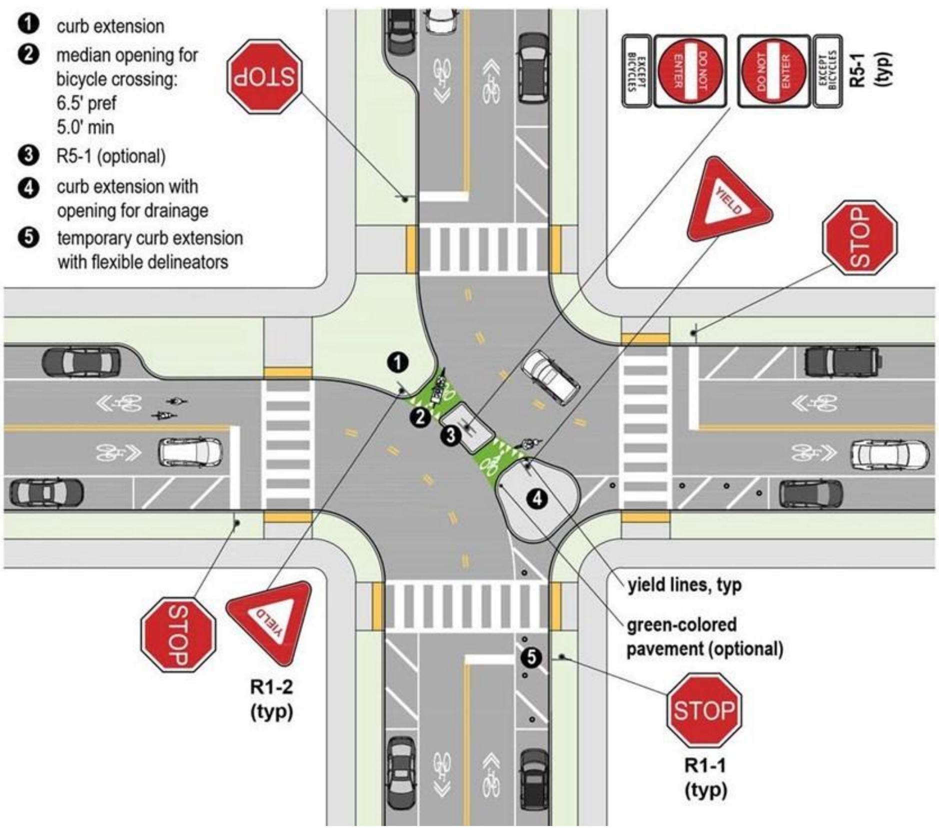
- Diverter islands are designed to maintain bike and pedestrian access by providing cut-throughs. Standard cut-through width for bicyclists is 6 ft.
- Diverter islands can include a combination of public art or other vertical elements, so long as they keep sight lines clear for bicyclists. Other vertical elements such as signing, flexible delineator posts, etc. may be appropriate to make the features more visible to motorists and assist snowplow operators when clearing roadways.
- A diverter's effectiveness at limiting speeds is generally limited to the intersection where it is installed. The street may require additional traffic-calming treatments in addition to the intersection treatments to achieve the desired operating characteristics.

- Diverters must be designed with transit and emergency vehicle navigation in mind. In some cases, emergency vehicles must be able to travel over or through the diverter if gaps are spaced to accommodate them or if breakaway gates are used.

## Diagonal Diverters

Diagonal diverters (Figure 7-13) are the most common form of full diversion. Diagonal diverters connect diagonal corners creating two disconnected streets. Vehicles are forced to turn, while through travel is maintained for bikes and pedestrians.

**Figure 7-13: Diagonal Diverter**



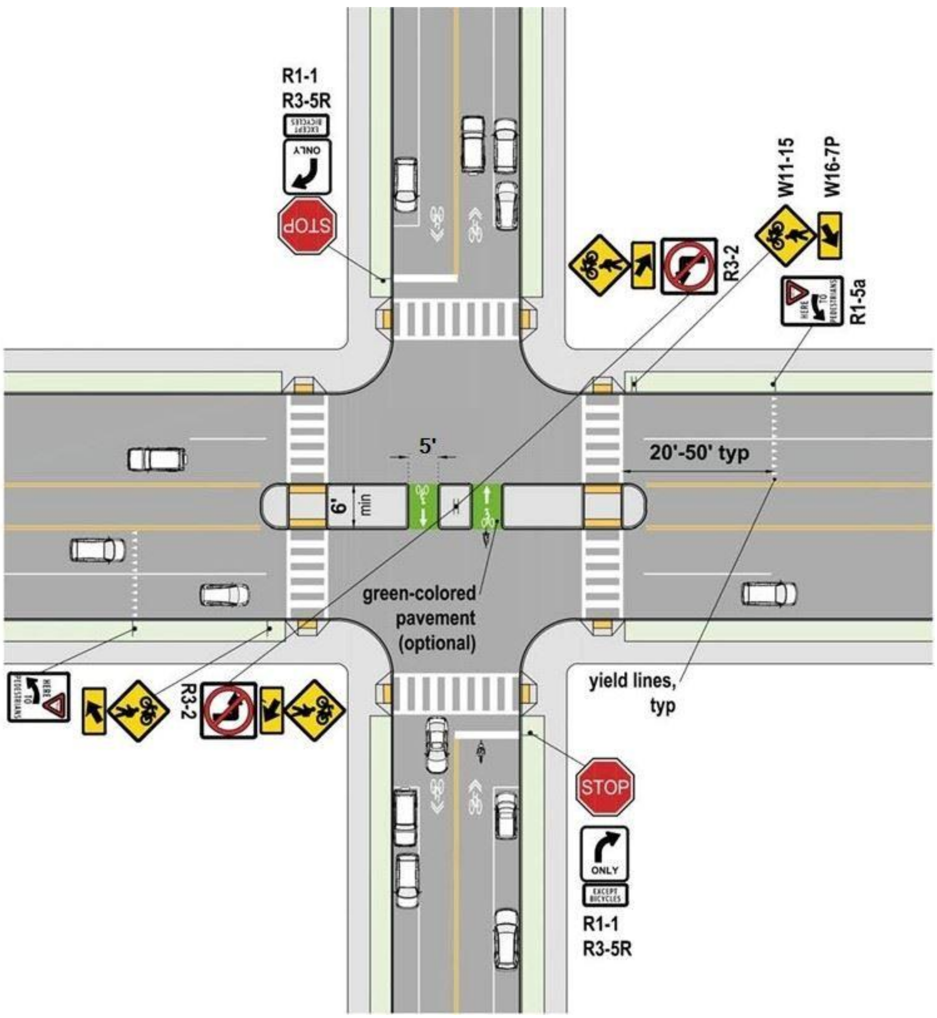

**Commented [JW5]:** Bicycle symbol in the green paint needs to be updated per the 11th Edition of the MUTCD

**Commented [JW6R5]:** These STOP signs should all have ALL-WAY plaques per the 11th Edition of the MUTCD (Section 2B.04 P 04)

## Median Diverters

Median island diverters (Figure 7-14) are a common form of diversion used when minor roadways that include bikeways intersect with major roadways. Median island diverters restrict motorist left turns from the major roadway and restrict the motorist through movement along the minor roadway. They can also provide a crossing island for bicyclists so that the major street crossing can be accomplished as two separate crossings.

**Figure 7-14: Median Island Diverter**




**Commented [JW7]:** Bicycle symbol in the green paint needs to be updated per the 11th Edition of the MUTCD

**Commented [JW8R7]:** Per MUTCD Section 2B.28 P 02, the R3-5R signs shall only be mounted overhead.

**Commented [JY9R7]:** Need to confirm R3-5R; however, except bicycles cannot be co-located with a stop sign. The intersection control sign may need to be mounted separately.

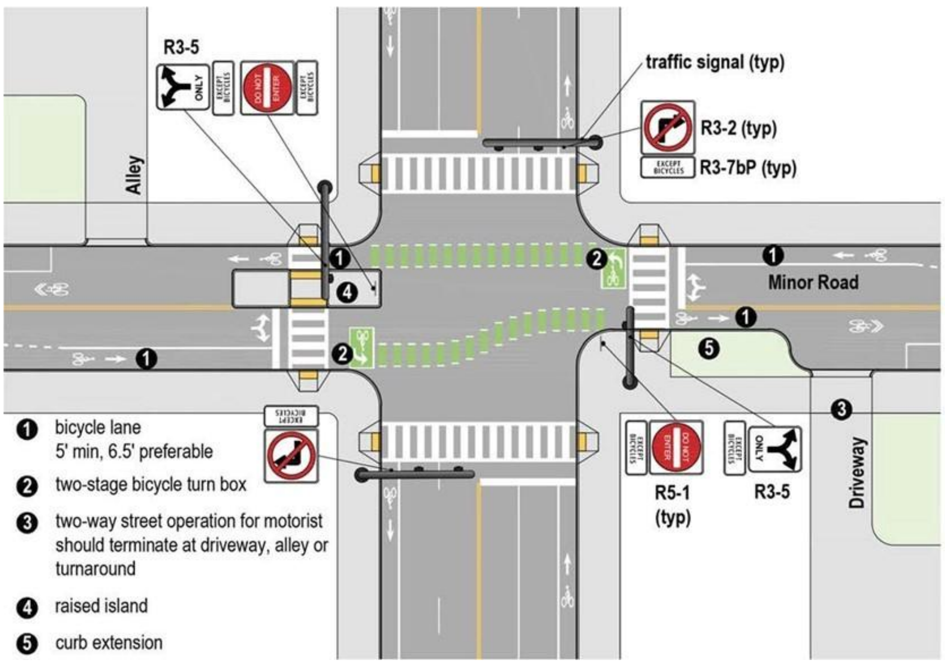
## Forced Turn Diverters

A forced turn diverter, or directional closure (Figure 7-15), is a curb extension or vertical barrier extending to approximately the centerline of a roadway, effectively obstructing (prohibiting) one direction of traffic.

Bicycles are typically permitted to travel through a directional closure in both directions, including the direction in which motor vehicle traffic is obstructed. In some cases, gaps or a contra flow bicycle lane are used to provide bicycle access.

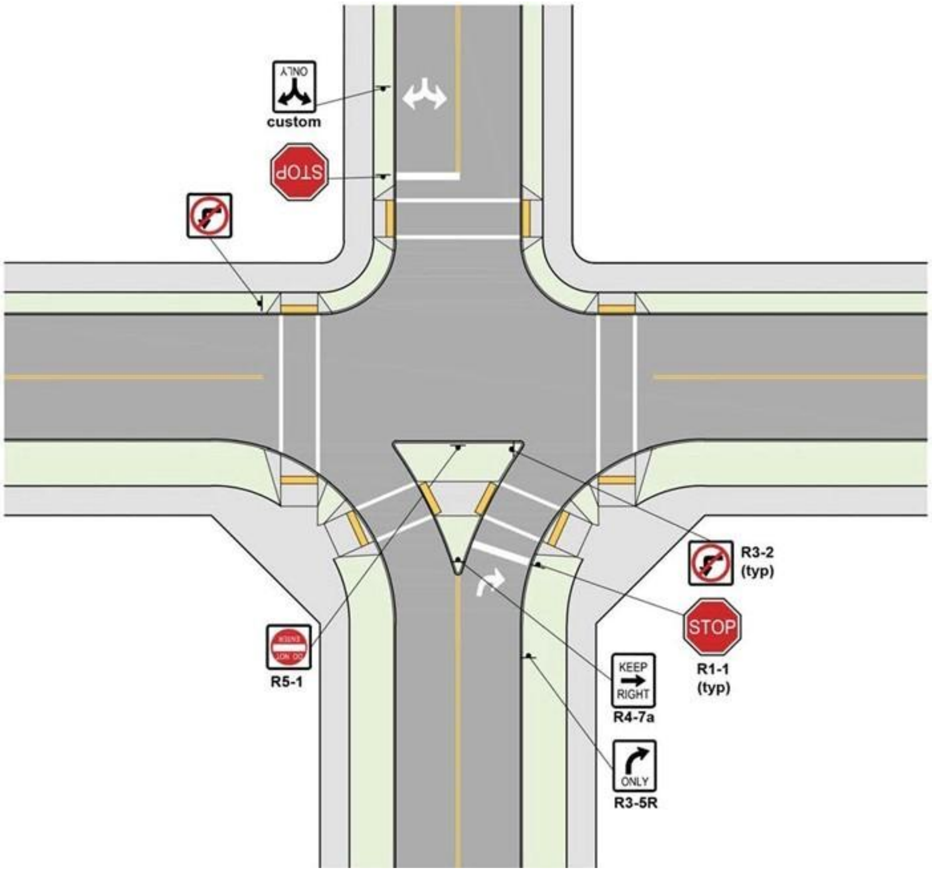
**Figure 7-15: Forced Turn - Directional Closure**

**Commented [JW10]:** The bicycle lane symbol marking needs to be updated per the 11th Edition of the MUTCD




A second type of forced turn diverter is a right-in/right-out island (Figure 7-16), which prohibits the through and left turn movements. This treatment can be achieved with less infrastructure than the directional closure described above and can better accommodate two-way motor vehicle traffic but may result in higher motor vehicle volumes.

**Figure 7-16: Forced Turn - Right-In/Right-Out**




Commented [JW11]: Per MUTCD Section 2B.28 P 02, the R3-5R signs shall only be mounted overhead.

## Chapter 7 Endnotes


1. New York City Department of Transportation. Don't Cut Corners: Left Turn Pedestrian and Bicyclist Crash Study. New York City, August 2016.
2. Tefft, B. C. Impact speed and a pedestrian's risk of severe injury or death. Accident Analysis & Prevention. 50. 2013.
3. City of Los Angeles, Bureau of Engineering, Department of Engineering. City of Los Angeles Supplemental Street Design Guide, May 2020.

~~3.~~4. Federal Highway Administration. Traffic Calming ePrimer,
https://highways.dot.gov/safety/speed-management/traffic-calming-eprimer

(PHB) installation at crossing locations where one or more of the following conditions occur:

- Where one or more OMUTCD traffic signal warrants or PHB guidelines are met;
- Sight distance is restricted, based on prevailing motor vehicle speeds;
- Motor vehicle approach speeds exceed 30 mph;
- There are four or more through lanes of major street traffic;
- There are insufficient crossing opportunities (including crossings of two through lanes) within about a quarter of a mile from the location in question.

Traffic control signal installation should be limited to locations where less restrictive traffic control devices do not provide adequate crossing opportunities for pedestrians and bicyclists. A traffic signal can increase delays, motorized traffic volumes on minor street approaches, and some types of crashes. PHBs intended specifically for bicycle use can also introduce challenges for bicyclists' timing (see Section 8.6.2).

**8.2.1 OMUTCD Traffic Control Signal Warrants**

See OMUTCD Chapter 4C and TEM Section 402 for more information and guidance on Traffic Control Signal Studies and warrant requirements.

**8.3 Signal Design Guidance for Pedestrian Facilities**

Pedestrian signal heads should be provided at all signalized intersections with sidewalks and curb ramps on the approaches and at all signalized intersections where pedestrian activity may be expected or anticipated based on land uses, transit stops, or other factors likely to generate pedestrian activity, regardless of the presence of sidewalks. See ODOT's Signal Design Reference Packet (SDRP) for additional details and references related to pedestrian signal design and installation.

**8.3.1 Pedestrian Signals**

The OMUTCD (Section ~~4E~~4D.~~03~~02) defines the conditions under which pedestrian signals shall be provided. At all locations where signals are newly installed, replaced, or significantly modified and pedestrian signals are provided for street crossings, countdown pedestrian displays are required. Pedestrian signals with countdown displays show the number of seconds remaining in the clearance interval and their use has been shown to reduce both pedestrian and vehicular crashes at signals[1].

Accessible pedestrian signals (APS) are devices that communicate information about pedestrian signal timing in nonvisual formats and are integrated with pedestrian pushbuttons. All intersections where pedestrians are expected, regardless of whether the pedestrian phase is automatic or requires actuation, shall be accessible for people with disabilities. This often means that accessible pushbuttons are installed in locations with automatic pedestrian phases. APS installation is required by PROWAG (R209.1) with any new traffic signal that has pedestrian signals or where there will be significant changes to an existing signal. APS guidelines include the following:

- APS should be placed in consistent locations;
- APS should be located as close as practical to the crosswalk line farthest from the center of the intersection and as close as practical to the curb ramp;
- When installed at signals or PHBs, APS pushbuttons must have both audible and vibrotactile components. Vibrotactile indications integrated into the pushbutton provides information to persons with hearing or visual disabilities;
- APS pushbuttons shall have a locator tone that operates during the DON'T WALK and the FLASHING DON'T WALK intervals only to assist those with low or no vision to find the correct device for a particular crossing;
- APS pushbuttons shall have a vibrotactile arrow that indicates the crossing direction activated by the pushbutton;
- One post and pushbutton assembly should be provided for each crossing. Ideally, pushbuttons on the same corner should be placed a minimum of 10 ft. from each other. This helps clarify which percussive locator tone is applicable to each button for the respective crossing. In constrained areas (e.g., limited building setbacks, unusual geometric conditions), should two APS assemblies be separated by less than 10 ft., an audible walk indication shall include speech pushbutton information and walk messages. These information messages tell pedestrians the name of the street they are crossing. Braille or raised lettering on the pushbutton housing may also provide street name information;
- If an extended pushbutton press feature provides additional crossing time, then an R10-32P plaque shall be mounted adjacent to or integral with the APS pushbutton. For these locations, APS pushbuttons shall be marked with three braille dots forming an equilateral triangle in the center of the pushbutton;
- If the pedestrian clearance time is sufficient only to cross from the curb or edge of pavement to a median to wait for the next cycle, then an additional APS pushbutton shall be provided in the median.

Some pushbutton housings include a map of the intersection in relief on the side of the housing that informs pedestrians about the number of lanes and islands they will have to cross. These should be provided at wide or complex intersections and when a two-stage crossing may be necessary. However, using a two-stage crossing where pedestrians are required to cross to a median and then to the other side of the street on separate signal phases should be discouraged where sufficient physical protection (e.g., concrete curbing, wide medians) is not included. When installed, two-stage pedestrian crossings should consider a “z”-median where pedestrians are required to traverse a short distance (10 ft. min.) in a center island, facing on-coming traffic, prior to activating a second pushbutton. The center median distance may require adjustments to accommodate site specific conditions.

APS audible messages and tone volumes should be adaptive to the surrounding ambient noise. APS units produce a louder signal message when motor vehicle and other noise at a given intersection is higher. Automatic volume adjustment provides flexibility and allows APS units to adjust so they are not disturbing to neighbors at night or times of low traffic volume. This is also helpful to visually impaired pedestrians, as the APS does not drown out essential traffic sounds necessary for crossing. See Section ~~4E~~4K.~~11~~ 03 of the OMUTCD for volume setting requirements and guidance.

When APS and countdown pedestrian display improvements are made, all crossing associated with the system must be upgraded (see Section 4.3 for ADA requirements, standards, guidelines). Among the requirements provided in Section ~~4E~~4I.~~04~~ 02 of the OMUTCD, pedestrian signals should be placed in a conspicuous location, visible to pedestrians waiting to cross. See Section 8.3.~~1~~ 2 for additional information on the placement of pedestrian pushbuttons for accessibility.

**8.3.2 Pedestrian Detection**

Pushbuttons

Where pushbuttons are provided for detection, they shall be accessible. Pushbutton placement must be within easy reach of a pedestrian (and bicyclist when applicable) and obvious to which crosswalk they are associated with.

In addition to standards laid out in Chapter ~~4E~~4I.~~08~~ 05 of the OMUTCD, Section 404-2 of the TEM, and Section 8.3.1 of this guide, accessible requirements and best practices are as follows:

- Place pushbuttons so they are adjacent to curb ramp landing or similar surfaces. A level surface with a 1.56 percent cross slope (max.) in each direction shall be provided.

- Pushbuttons should be placed between 1.5 ft. and 6 ft. from the face of curb or from the outside edge of the shoulder (or if no shoulder exists, from the edge of pavement). In some cases, placement as far as 10 ft. may be necessary with placement further than 10 ft allowable in constrained conditions. A distance of 6 ft. is preferable as it allows bicyclists and pedestrians pushing strollers to stop at the button without the front end of their wheel(s) getting closer than 2 ft. from the face of curb or edge of road and provides greater physical separation from moving traffic.
- When placing pushbuttons, consider expected users and their needs. Where bicyclists are expected, a slightly taller pole can provide a surface to hold while waiting for the right of way.

Passive Detection

Passive detection devices are less common, but may be used to actuate or extend pedestrian signals in specific applications. Flashing beacons can be outfitted with motion or break-beam sensors, though care is needed to ensure detection is for only those intending to cross. Infrared crosswalk sensors can detect the presence of slow-moving pedestrians in crosswalks and extend the clearance time.

Passive detection may be used in lieu of or in addition to pedestrian pushbuttons, though careful consideration will be necessary in doing so. Passive detection may be helpful in reducing intersection noise, though pedestrians with vision disabilities may not approach the crossing within the detection zone nor wait at the exact crossing area for activation to occur. They may also not know passive detection is present unless they are familiar with the intersection. In addition, passive detection systems need to be carefully calibrated and monitored to avoid or limit detecting something other than pedestrians. Passive detection may be an option where compliant pushbutton placement is not feasible at a given intersection. Such factors may include lack of right-of-way, limited building setbacks, or pushbutton placement that would limit or block pedestrian access.

### 8.3.3 Signal Timing and Reducing Pedestrian Delay

Frequent crossings that accommodate walking speeds for people of all ages and abilities are key to creating a safe, accessible, and connected pedestrian network. Signals are typically timed to prioritize the “major” street movements which may, under certain conditions, increase delay for pedestrians and bicyclists waiting to cross the major street. In addition, when pedestrians and bicyclists are faced with long delays, they may be more likely to ignore signals entirely and cross the road when they perceive an adequate gap in traffic. When this occurs, pedestrians will sometimes choose to cross away from intersections, potentially increasing crash risks. The following section describes best practices for reducing delay and providing accessible crossings to improve safety for all users.

While there are many factors associated with signal timing as it relates to reducing pedestrian delay, corridor consideration should be a factor. Streets in lower density, suburban settings, often do not have comparable pedestrian volumes relative to more dense, urban networks. However, these corridors may have transit operation, which may make road crossing decisions challenging without appropriate crossing opportunities.

#### Signal Cycle Length

In some instances, where pedestrians routinely experience long delays at signals, they may elect to cross away from the crosswalk at locations where conflicts are not controlled by a signal. Therefore, strategies to reduce overall cycle length can be particularly important for pedestrian safety. Where pedestrians are expected regularly, cycle lengths greater than 60 to 90 seconds should often be discouraged. In addition to reducing cycle lengths, designers may also consider using half-cycle lengths, particularly during off-peak hours. Adaptive signal control, where employed, should have limited variation in cycle length. Operations for adaptive signal control should be confined to suburban settings and event venues where traffic patterns can be highly variable.

Designers should be aware that shortening signal cycle lengths can impact the amount of WALK time that a pedestrian is provided in the pedestrian signal phase (see "Pedestrian Signal Phase Timing", discussed later in this section). While long cycle lengths can increase pedestrian non- compliance, at wider intersections shorter cycle lengths may not be possible without implementing two-stage pedestrian crossings which could increase pedestrian delay compared to providing a longer cycle length. Single stage crossings are preferable in most instances (see Chapter 9 for complex locations where two-stage crossings may be appropriate). Designers can also shorten crossing distances using curb extensions (see Chapter 7), eliminating the need for a longer pedestrian cycle length and potentially reducing the current cycle length. If a two-stage crossing is provided, designers shall provide a crossing island (see Section 4.5.3) and provide a pushbutton within the crossing island.

#### Pedestrian Signal Phase Timing

Pedestrian signals provide a WALK phase (steady white walking man symbol) followed by a FLASHING DON'T WALK clearance phase (flashing orange upraised hand symbol with integrated countdown timer). Details for programming the walk and clearance interval is provided in the OMUTCD (Section ~~4E~~4I.06) and the TEM (Section 404). Pedestrian signal timing shall meet the following requirements:

- The duration of the WALK indication should allow sufficient time for a pedestrian to react to the signal and enter the crosswalk. The OMUTCD states that a minimum walk interval of seven seconds should be provided, though it allows for a walk interval as low as four seconds in certain situations;
- A clearance interval based on a maximum walking speed of 3.5 ft. per second from the face of curb or edge of pavement to the point where they have cleared the farthest lane in the crosswalk;
  - Where a crossing has a higher proportion of slow-moving pedestrians, slower walking speeds of 3.0 ft. per second or lower may be programmed. A longer clearance interval can also be requested by pedestrians using a longer push on the pushbutton.
  - Passive detection may also be considered, provided that the system can sense slower pedestrians and extend the clearance time.
- The total WALK + FLASHING DON'T WALK phase (walk plus clearance interval) shall be long enough to allow a person with a walk speed of 3.5 ft./sec. to walk from the pushbutton to the point where they have cleared the farthest lane in the crosswalk. When a pushbutton is not present, the crossing distance should be 6 ft. wider than the width of the road;
- In addition to the standards and guidance in the OMUTCD, designers should consider a longer walk interval (e.g., sufficient for a pedestrian to react and walk to the center of the intersection) at locations where there are more than two travel lanes to be crossed or roadway posted speeds are higher than 30 mph.

Signal timing should strive to maximize the WALK + FLASHING DON'T WALK phase such that the total pedestrian time is equal to the total concurrent vehicle green timing (see Figure 8-1). Providing a shorter WALK phase is sometimes proposed to split the green phase between the pedestrian crossing and turning vehicles. This application is discouraged as it is an informal treatment that does not clearly convey the phasing intention; pedestrians may elect to cross anyway after observing that the concurrent through movement is still green. To address conflicts, designers should instead use one or a combination of treatments listed in Section 8.3.4.

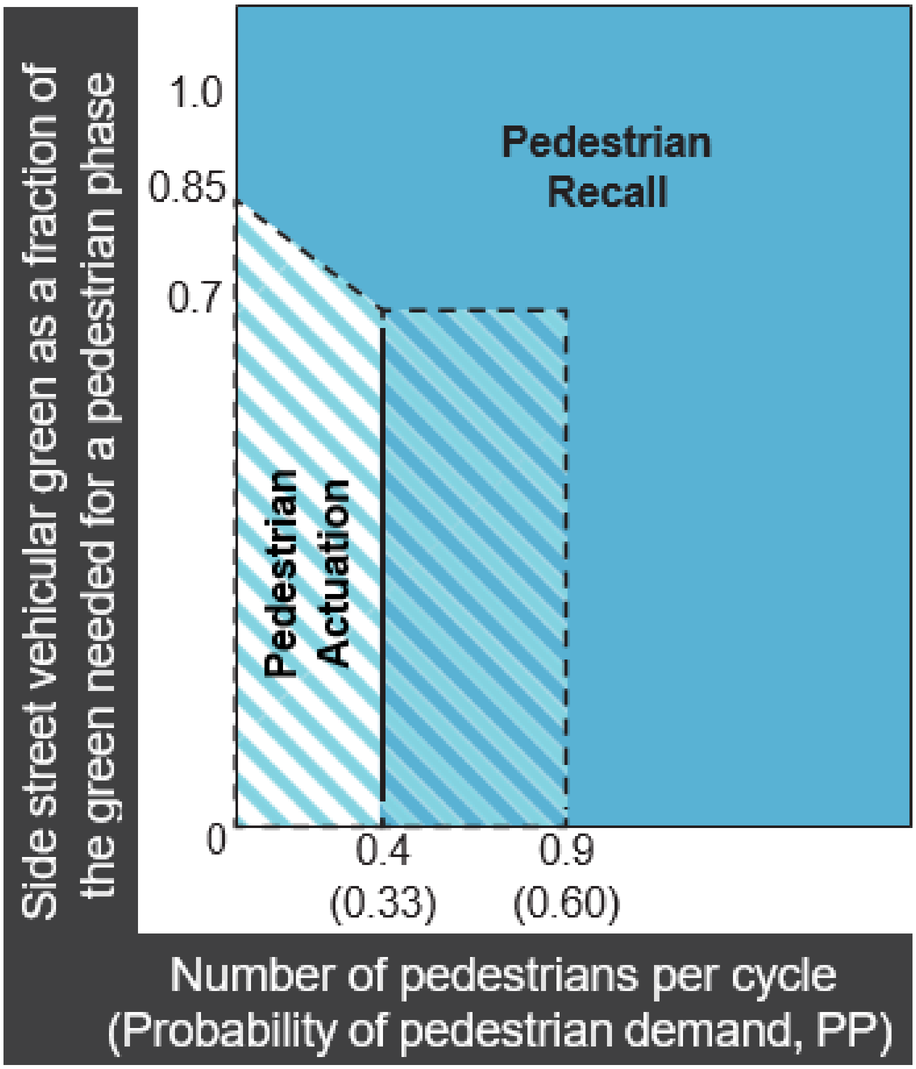
**Figure 8-1: Maximizing the WALK Interval**


ODOT's typical practice is to terminate the FLASHING DON'T WALK phase at the same time as the concurrent vehicular green indication.

Pedestrian Recall and Actuation

Pedestrians should not always be required to push a button to call the pedestrian phase at locations with high pedestrian volumes. This is particularly important in downtown corridors or business districts where there tends to be significant pedestrian volume and relatively short cycle lengths. In such environments, fixed time operation with time-of-day phase plans often functions more efficiently compared to actuated or semi-actuated signal timing. Fixed time operation allows for signal controllers to call pedestrian phases each cycle. In a fixed time grid, pedestrian WALK + FLASHING DON'T WALK intervals are often the maximizing factor for phase length, as the time necessary to accommodate pedestrian movements exceeds the time needed for motor vehicles. Designers should follow the guidance in Figure 8-2 for providing pedestrian recall or actuation[2]. This could be accomplished based on different signal timing plans at certain times of day or day of the week.

**Figure 8-2: Recall versus Actuated Pedestrian Phase for Coordinated-Actuated Arterials**




Signal timing plans, when updated, shall provide a sufficient walk phase for all crossings. If it is determined that the pedestrian phase should switch from actuated to recall based on the time of day, designers can minimize confusion by ensuring the pushbutton includes a confirmation light. When the signal operations have switched to pedestrian recall, the detection indicator can be programmed to illuminate by default.

**8.3.4 Signal Phasing for Managing or Reducing Conflicts**

There are a variety of alternative signal phasing options for reducing or eliminating conflicts between motorist and pedestrians. Designers should consider both the operational and safety impacts of signal phasing changes at an intersection. Designers should also be aware that a phasing scenario may necessitate a separate motor vehicle turn lane and an additional signal phase, which may increase delay for some users, including pedestrians. Fully separated crossings may require longer cycle lengths, which may result in reduced user compliance with signal indications and increased potential for conflict. The following sections describe four major phasing scenarios, criteria, and considerations. Often, there may not be one solution, but a combination of treatments for specific periods or scenarios to address pedestrian safety.

8.3.4.1 Leading Pedestrian Intervals (LPIs)

Leading Pedestrian Intervals (LPIs) or Leading Through Intervals (LTIs) may be used to give pedestrians a head start (typically a minimum of three seconds) when crossing the street. LPIs are a proven safety countermeasure to reduce vehicle-pedestrian crashes at intersections. Implementation allows waiting pedestrians to enter the crosswalk where they become more visible to conflicting motorists. Both LPIs and LTIs accomplish the same goal through different strategies:

- Leading Pedestrian Intervals - With traditional signal phasing, parallel pedestrian WALK and motor-vehicle circular green indications start at the same time, immediately after the conclusion of the red clearance interval. With LPIs, the walk phase begins as usual and parallel motor vehicle circular green indications start after a brief period. Designers should provide APS units where LPI’s are provided; without APS units, pedestrians with low or no vision may not be able to maximize the advantage of LPIs, as they otherwise use the noise of concurrent vehicles to determine when to begin walking. When APS units are not provided, the minimum walk time should be LPI time plus 7 seconds as mentioned in Section 4I.06 of the OMUTCD.
- Delayed Turn or Leading Through Intervals -A delayed left (or right) turn or LTI provides a green signal to through movements while delaying permissive left (or right) turns for a specific period. This delay time may vary based on site specific conditions, but (similar to an LPI) is usually between three and six seconds. This option minimizes intersection capacity impacts while providing a partially protected pedestrian phase, allowing those on foot a head start in order to establish

themselves in the intersection before turning movements are allowed after the protected left (or right) turn phase.

When curb extensions or a protected intersection is provided, pedestrians can establish themselves in the crossing before vehicles due to the distance between the stop line and the edge of the curb where a pedestrian would wait.

Table 8-1 provides the equation for calculating the LPI interval (rounded to the nearest second) found in ODOT's Signal Design Reference Packet (SDRP).

**Table 8-1: Formula for Leading Pedestrian Interval (LPI)**

$$\text{LPI (sec.)} = \frac{(W_1 + W_2)}{S_w}$$

Where:

| Value | Meaning |
|---|---|
| LPI | Leading pedestrian interval (sec.) |
| $W_1$ | Width of first lane of moving vehicles (ft.) |
| $W_2$ | Width of shoulder, bike lane, and/or parking lane (ft.) |
| $S_w$ | Walking speed (typically 3.5 ft./sec.) |

An approach meeting any one of the following criteria may be a good candidate for the installation of an LPI:

- Reported crash history finds one or more crashes per year have occurred over the last three years between vehicles turning on green and pedestrians crossing the street on the associated crosswalk with the pedestrian WALK signal;
- A visibility issue exists between the driver's view of pedestrians on the crosswalk due to obstructions or poor sight distance at an intersection approach that can be improved through an LPI. LPIs by themselves don't resolve sight distance limitations, as they don't protect pedestrians who arrive at the end of the WALK phase. Physical measures to remove corner sight obstructions should be given primary consideration;

- Intersection observations reveal conflicts between crossing pedestrians and turning vehicles in which there is a risk of collision should their movements and speeds remain unchanged;
- One of the two movement volumes (turning vehicle volume (A), or pedestrian volume (B), identified below) meet a minimum of one of the thresholds identified in Table 8-2 for a given warrant.

When a protected left turn phase is provided, it should occur as a lag to prevent left turning vehicles from continuing to cross during the LPI. Designers must avoid the "yellow trap" (see TEM Section 403-9) when providing a lagging turn phase.

**Table 8-2: LPI Volume Warrant Thresholds**

| Warrant | Turning Vehicles Volume (A) | Pedestrian Volume (B) |
|---|---|---|
| **Vehicle Peak Hour** | ≥130 per hour | ≥25 per hour |
| **Pedestrian Peak Hour** | ≥100 per hour | ≥50 per hour |
| **4-Hour Vehicular and Ped Volume** | ≥105 per hour | ≥30 per hour |
| **8-Hour Vehicular and Ped Volume** | ≥100 per hour | ≥25 per hour |
| **School Crossing** | ≥50 per hour | |

#### 8.3.4.2 Protected Pedestrian Phase and Turn Restrictions

Protected pedestrian phases or protected-only signal phasing for turn movements can significantly reduce conflicts between pedestrians and motorists. This process involves eliminating specific motor vehicle phases (e.g., left turns) that cross concurrent pedestrian phases. For example, if the permissive left turns (either green ball or flashing yellow arrow) that cross pedestrian WALK/ FLASHING DON'T WALK phases is eliminated, there is no longer a turning conflict for the crossing during that phase. In these cases, pedestrian phases may occur before (lead) or after (lag) conflicting vehicular movements.

Turn restrictions or protected pedestrian phases may be considered when one or more of the following criteria are met:

- There are high conflicting turning vehicles volumes. High turning volumes are defined as equal to or exceeding:

    - 200 total right and left turning vehicles per hour;
    - 50 left turning vehicles per hour when crossing one lane of through traffic; or
    - 100 right turning vehicles per hour.
- There is a high volume of total approaching traffic (greater than 2000 vehicles per hour for all approaches);
- There are high pedestrian volumes (pedestrians are 30 percent of vehicle volumes or 300 pedestrians per hour);
- Crash patterns at the study location or nearby locations with similar geometry support the use of separating motor vehicle and pedestrian phasing. Typically, this encompasses three or more left- turn or right-turn collisions where pedestrians had the right of way over a three-year period;
- The available sight distance is less than the minimum stopping sight distance criteria listed in the L&D Manual Volume 1;
- The intersection geometry is unusual (streets intersect at acute/obtuse angles or streets have significant curvature approaching the intersection), which may result in unexpected conflicts and/or visibility issues;
- An intersection in close proximity to senior housing, elementary schools, recreational areas, playgrounds, and/or health facilities.

Protected pedestrian phases or protected-only turn phases may be implemented on a permanent basis, during specific hours, or “on-demand” when a pedestrian is present and activates the pushbutton. If only one movement or street meets the criteria above, consider a treatment to address those specific issues before implementing an intersection-wide approach (i.e., provide protected-only turns for the major roadway and allow for permissive turns on the minor roadway, if turning volumes are low on the minor roadway).

Turn Restrictions

Permissive left turns may be prohibited on demand through programming a signal controller to display a red left arrow when a conflicting pedestrian movement is called. Such programming may require staff time on the part of the jurisdiction where the signal is located in order to maintain signal flexibility and coordination.

A NO TURN ON RED (R10-11) sign may be used to prohibit right turn movements at all times, or a dynamic NO TURN ON RED sign may be installed to limit turns at specific times or conditions. Motorists turning right on red tend to focus on finding a gap in cross traffic. Driver attention in these situations tends to be on conflicting traffic approaching from their left, and not necessarily a pedestrian beginning to cross from the driver's right. Drivers may also encroach into the crosswalk while waiting for a gap in traffic, effectively blocking the crosswalk. Right turn on red restrictions may be used to reduce these conflicts, though such signs may not be effective if sight distance is not limited by geometry or other roadway features (landscaping, business signs, etc.) without significant enforcement efforts. Where left turns on red are legal on one-way streets, such restrictions may be appropriate for similar reasons.

Right turn on red restrictions increase the number of turns on green, which tend to be higher speed maneuvers, particularly at intersections with larger curb radii. Consequently, such restrictions may not always improve pedestrian safety and shouldn't be used as a default treatment without an engineering study.

8.3.4.3 Concurrent Pedestrian Phase with Permissive Vehicle Turns

At most signals, the WALK indication for pedestrians is displayed concurrent with the green indication for parallel through vehicular movements. Concurrent timing often allows vehicles to turn left or right across the crosswalk during the WALK and FLASHING DON'T WALK phases with change interval countdown indication (pedestrian clearance interval), provided the motorists yield to pedestrians. To mitigate conflicts and improve motorist yielding, designers may consider the following treatments:

- Regulatory signs, such as the R10-15~~a~~ series "TURNING VEHICLES YIELD TO [PEDESTRIANS]" (see Section 8.8.1);
- Flashing Yellow Arrows (see below);
- Geometric treatments to reduce vehicle speeds and increase sight distances such as raised pedestrian crossings and curb extensions (see Chapters 3, 4, and 7).

Flashing Yellow Arrows

Flashing yellow arrows (FYAs) may be used for left or right turning motor vehicles to emphasis that drivers may proceed after yielding to oncoming traffic and/or pedestrians in a crosswalk. FYAs allow flexibility in providing permissive turns while warning drivers of potential conflicts. For all ODOT roadways, designers shall follow standards in both the TEM, Section 403-7and OMUTCD, Section ~~4D~~4F.04 and 4F.08~~.18~~.

8.3.4.4 Exclusive Pedestrian Phases

An Exclusive Pedestrian Phase (EPP), sometimes referred to as a “Barnes Dance”, stops vehicular traffic in all directions, allowing pedestrians to cross the intersection in all directions, including diagonally. This treatment can produce a safer operation over conventional phasing but delay for both pedestrians and motorists can be higher than conventional signal timing.3 Most often, a protected pedestrian phase, specific turn restrictions with appropriate signage, or LPIs are more appropriate solutions. An EPP may be preferred over a protected pedestrian crossing for the following scenarios:

- A combination of the criteria listed in Section 8.3.4.2 is met and 15 percent of pedestrians desire to cross diagonally;
- During special events that occupy a substantial portion of the public right-of-way (e.g., street fairs, parades);
- The start and end of school days for major school crossings;
- Intersections where certain motor vehicle turning movements are either not permitted or not in conflict with designated pedestrian crossings.

Signs may be attached to signal poles or pedestrian pushbuttons to inform people that the intersection has an EPP and they may cross diagonally; to inform where an EPP must be actuated by a person waiting to cross; or to deter crossing against the pedestrian signal concurrently with vehicle traffic. Signals that include EPP should time pedestrian phases to accommodate the longest possible crossing.

If a diagonal crossing is employed, designers may need to consider how a person with a visual disability would know that they could cross diagonally. Such determinations need to be carefully considered along with pushbutton placement and pedestrian ramp design for accessibility.

Pavement markings should be designed in accordance with the OMUTCD (Figure ~~3B~~3C-2~~0~~).

**8.4 Signal Design Guidance for Bicycle Facilities**

This section’s design guidance covers traffic signal head options for controlling bicycles, signal phasing, signal timing, and detection. The decision to install a traffic signal or pedestrian hybrid beacon (PHB) involves a holistic evaluation of numerous factors at the study location and requires an evaluation of OMUTCD warrant criteria in addition to the use of engineering judgment. Bicycle signal faces shall not be used at a pedestrian hybrid beacon. Additional details on this process can be found in Section 8.2. The design guidance provided in this chapter supplements intersection design guidance provided in other chapters.

#### 8.4.1 Indication Options

A vehicular signal head controls a bicyclist traveling in a shared--lane or adjacent bicycle lane. Where it is necessary or desirable to control a bicycle separately from a motor vehicle, a bicycle may be controlled by a traffic signal with bicycle signal faces, or by a pedestrian signal head. Traffic signal indications for a bicyclist along a corridor should be as uniform as possible.

Standard Traffic Signal Face for Motor Vehicles and Bicycles

Standard signal control is appropriate to control both motor vehicles and bicyclists riding for both shared--lanes and adjacent bicycle lanes. Supplemental signage may be appropriate to instruct bicyclists to follow motor vehicle signal control in cases where applicability is ambiguous.

Pedestrian Signal Heads

Using pedestrian signals to control bicyclist movements is generally discouraged except on shared--use paths, but may also be appropriate for:

- separated bikeways traveling in the same direction as the closest motor vehicle travel lane and the pedestrian signal is well oriented for bicyclists to see,
- locations where an LPI is provided and allowing bicyclists to follow the pedestrian signal means they are provided a protected time to cross without turning vehicles, and
- projects with insufficient funding to provide separate bicycle signals, such a quick-build (rapid implementation) projects or those implemented as part of a resurfacing project where signal work is not part of the project scope.

Where a bicycle is required to follow the pedestrian signal, a “[BICYCLE] USE PED SIGNAL” (R9-5) sign shall be posted and the pedestrian signal must be readily visible and discernable to bicyclists.

Where bicyclists are required to follow a pedestrian signal, they are only legally allowed to enter the crosswalk during the WALK phase. Research has found low bicyclist compliance rates at locations where bicyclists are directed to follow pedestrian signals.4 Most bicyclists continue to enter crosswalks on the FLASHING DON’T WALK phase, as it is timed for a pedestrian who moves much more slowly than a bicyclist. Additionally, at locations where the WALK indication is only four to seven seconds, bicyclists who comply with the signal are likely to experience more delay than bicyclists who enter during the FLASHING

DON'T WALK phase. Caution should be exercised when requiring bicyclist to use pedestrian signals, particularly at locations with long crossings or unique signal timing.

**8.4.2 Bicyclist Detection**

At locations with active warning devices, pedestrian hybrid beacons, or traffic signals, there are various techniques that can be used to actively or passively detect bicyclists. Semi- or fully-actuated signals should passively detect bicycles for phases with "no recall" (i.e., to call the signal and extend the side street green) or "min recall" (i.e., to extend the green on the main street). If a signalized intersection approach cannot accommodate passive detection, a curb-side pushbutton for active detection should be provided. The designer should also reference TEM, Section 402-5.1 for detection technology considerations, design, and placement.

Detection Technology

Passive detection equipment does not always reliably detect bicyclists. Bicycle detector installations should be tested under a variety of lighting and weather scenarios to confirm effectiveness. Below is a list of detectors commonly used to detect bicyclists at traffic signals as well as considerations for each type:

- Radar Detection System – It is ODOT's standard that radar detection be used at state-owned and maintained intersections, see TEM, Section 420.5. Some radar detection can distinguish between user types. Detection systems that are not able to do so should be either replaced or supplemented if signal operations require a distinction between bicyclists and motor vehicles.
- Inductive Loop Detection - Quadrupole inductive loops, Type Q and Type D, are two options for loop detector configurations for bicycles. Powerhead loops provide better bicycle detection at stop lines while quadrupole loops are typically used for dilemma zones to extend green phases. They can be used to detect bicycles on shared-use paths and bike lanes, as well as in travel lanes on roadways.
    - Type Q loops can best detect bicyclists when they are above the loop wire.
    - Type D loops have a magnetic field everywhere within the loop and thus are better for detecting bicycles within the entire loop area. Type D is also particularly effective at rejecting vehicles in the adjacent travel lane, allowing the use of a higher sensitivity setting on the detector amplifier.
- Video Detection System - Video detectors may have challenges detecting vehicles, including bicycles, due to poor streetlighting. Video detection can also be problematic when the sun is low in the sky, which can cause glare and potentially

skip phases. This may also be the case during inclement weather (e.g., heavy rain, fog, or snow), though it can be somewhat mitigated by ensuring detection zones are appropriately illuminated.

- Infrared Detection – Bicyclists can be detected through fog, snow, and other environmental constraints that impair video detection.

Bicycle pushbuttons may be used to supplement passive detection. Pushbuttons may also be used where it is desirable for a bicyclist to be detected, but not a motorist (e.g., a bicycle boulevard crossing an arterial with a pedestrian hybrid beacon or a Toucan crossing). Where used, pushbuttons should be reachable by bicyclists. Pushbuttons shall be accompanied by explanatory signage.

Location

Passive bicycle detection should:

- be located in the expected path of bicyclists;
- extend across most of the bicycle lane or shared roadway lane width;
- be adjacent to a curb or other type of footrest, when present.

Detection ~~should~~ shall also be included in bicycle boxes and two-stage turn queue boxes. In bicycle boxes, detection should be provided both in front of general purpose lanes and bicycle lanes. In two-stage turn queue boxes, the detection zone should include the full area of the marked queue box. ~~Both bicycle boxes and two-stage turn queue boxes have Interim Approval from FHWA (see Section 6.5.1).~~

When used, bicycle pushbuttons should be placed within a reasonable reach from a bike lane or shared-use path. They should allow bicyclists to actuate them without dismounting while satisfying lateral offset requirements from the AASHTO Roadside Design Guide. This can be accomplished by placing bicycle pushbuttons a maximum of 18” from the face of curb.  If there are concerns about a motor vehicle striking the pushbutton pole, bollards may be installed to protect the equipment with the understanding that this could be a hazard to turning motor vehicles. Alternatively, bike ramps should be provided so that a bicyclist can access a sidewalk or separated bike lane to actuate a pushbutton.

Pushbuttons intended both for pedestrians and bicyclists shall be located and operated in accordance with accessibility requirements. Section 8.3.2 provides guidance on the location of pushbuttons when they are on a sidewalk or shared-use path. Where bicycle pushbuttons are installed, they do not have to meet accessibility guidelines or OMUTCD requirements for placement. In locations where pedestrians and bicyclists have parallel crossings and pushbuttons are used to activate a warning device or other active traffic control device, pushbuttons for pedestrians and bicyclists may be placed on the same pole or separate poles. While there is a minimum spacing of 10 ft. between two pedestrian pushbuttons on the same intersection corner, separate pushbuttons for bicyclists and pedestrians do not have a minimum separation requirement. Pushbutton placement 6 ft. behind the curb is preferable to allow bicyclists and pedestrians pushing strollers to stop at the pushbutton without the front end of their wheel(s) getting closer than 2 ft. from the face of curb or edge of road.

Signs and Markings

When installed, a bicycle detection marking should indicate to bicyclists where they should position themselves to be detected. OMUTCD Section ~~9C~~9E.~~05~~ 15 includes bicycle detector pavement markings that can be used. The pavement marking can also be supplemented with a BICYCLE SIGNAL actuation sign (R10-22). This marking and sign can be used with any type of bicycle detection.

**8.4.3 Signal Design Considerations**

The OMUTCD establishes requirements for the size, arrangement, number, visibility, and positioning of vehicle traffic signals at an intersection. Bicycle signal locations are guided by similar principles. The following guidance is intended to supplement the OMUTCD. In general, designers should minimize the number of mast arms and/or pedestal poles by combining equipment where possible. This minimizes the number of fixed objects that can be damaged or cause injury and reduces clutter.

Size and Layout of Displays

All signal indications in a bicycle signal face shall be the same size~~, including those that display arrows and those that display bicycle symbols~~. The primary bicycle signal head for the bicycle movement shall use an 8 inch or 12 inch diameter lenses. When the primary bicycle signal face is located on the far-side, a 12 inch diameter bicycle signal shall be used if it is located more than 120 ft. from the stop line.

Bicycle signal faces with 4 inch diameter lenses may only be used as a supplemental, near-side signal. Near-side bicycle signal faces may alternatively be 8 inches in diameter. The smaller size allows it to be mounted at a lower height, improving visibility to approaching bicyclists.

Number of Displays

The OMUTCD and SDRP prescribe the use of two signal faces for a primary motor vehicle movement. As bicycles are rarely the primary movement, the use of one bicycle signal face is generally sufficient.

A supplemental near-side signal head shall be provided when the primary bicycle signal head is located more than 120 ft. from the stop line.

A supplemental near-side signal should be considered in the following situations:

- Locations with protected bicycle phases, as bicycle crash risk is increased if the bicycle signal fails;
- Where the signal head is located more than 80 ft. beyond the bicycle stop line;
- Intersections that require diagonal or unusual bicycle movement through the intersection.

An additional benefit of a second bicycle signal display is that it provides an added safety feature in case one of the displays malfunctions.

Visibility

One signal face should be visible a minimum of 120 ft. before the stop line based on stopping sight distance for a bicycle traveling 15 mph on a flat grade. This distance should be increased where higher bicycle speeds are expected, such as on downhill grades (see Section 3.2.1). Where bicyclists do not have a continuous view of the signal for the minimum sight distance, a W3-3 sign “SIGNAL AHEAD” should be installed.

Bicycle signal faces should be placed such that visibility is maximized for bicyclists and minimized for adjacent or conflicting vehicle movements not controlled by the bicycle signal face. Visibility-limiting lenses may be appropriate so long as bicyclists can still see the indication, though such equipment may not effectively shield adjacent travel lanes. As such, other methods to distinguish bicycle signals may be necessary. These may include lower or pole mounted placement, use of smaller signal heads than those controlling motor vehicle traffic (e.g., 8 inch vs. 12 inch).

Where existing vehicle traffic signal heads are anticipated to be the sole source of guidance for bicyclists, designers shall check that they are located within the cone of vision measured from the bicycle stop line, as described in the OMUTCD. If bicyclists are required to follow optically programmed or shielded vehicle signals, the signals shall be visible to approaching bicyclists. If the vehicle signal faces fall outside the cone of vision, supplementary vehicular or bicycle signals should be provided.

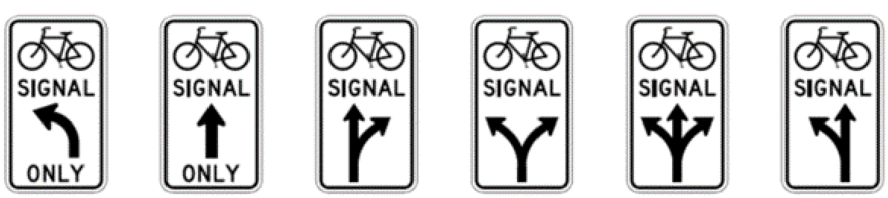
Placement

The primary bicycle signal head should be mounted in a lateral position that reduces the potential for pedestrians, landscaping, or other signal equipment to block the view of the signal for approaching bicyclists. The minimum distance from the edge of the bikeway is 5 ft. or less. If possible, mounting bicycle signal heads overhead is preferred. If bicycle heads are side-mounted, they should be installed on the same side (i.e., left or right) of the bikeway along an entire corridor.

The spacing between bicycle signal heads and motor vehicle signal heads should be maximized. Bicycle signal heads should not be placed between two motor vehicle signal heads with the same signal face as another motor vehicle signal head. Bicycle signal heads should have a minimum separation of 3 ft., either vertically or horizontally, from other signal heads to reduce the potential for confusion. However, bicycle signal head placement on existing traffic poles may make it difficult to meet the OMUTCD lateral signal separation requirement. Where bike signals and traffic signals are located in close proximity, it may be desirable to consider one or more of the following strategies to reduce potential for confusion:

- Provide optical programming or shielding on both signal faces;
- Mount the bicycle signal face at a lower height then the vehicular traffic signal faces;
- Use 8 inch signal heads for far-side signals. 8 inch signal heads should only be considered if other signal heads are 12 inches in diameter for the same direction of travel.

A Bicycle Signal (R10-40, R10-40a, R10-41, R10-41a, R10-41b, R10-41c) shall be placed adjacent to all bicycle signal faces. These signs shall show which movements are permitted for that signal head. The primary purposes of these signs are to inform road users that the signal indications in the bicycle signal face are intended only for bicyclists and to inform bicyclists which specific bicyclist movements are controlled by the bicycle signal face.




R10-40 R10-40a R10-41 R10-41a R10-41b R10-41c

Mounting height

When newly erecting a pole for adding a bicycle signal or adding a bicycle signal to an existing pole, the following applies:

- If a bicycle signal head is mounted on a mast arm, the bottom of the housing shall be between 15 and 25.6 ft. above the pavement;
- The bottom of the signal housing of an 8 inch or 12 inch bicycle signal face that is not located over a roadway shall be a minimum of 7 ft. above the sidewalk or ground. Where supplemental signing is installed below the bicycle signal face, the minimum mounting height to the bottom of the supplemental sign should be 10 ft.;
- If a 4 inch bicycle signal face is used as a near-side supplemental signal, the bottom of the signal housing shall be between 4 and 8 ft. above the sidewalk or ground.

When feasible, mounting bicycle signal heads at a different height than adjacent vehicle signal heads can reduce confusion.

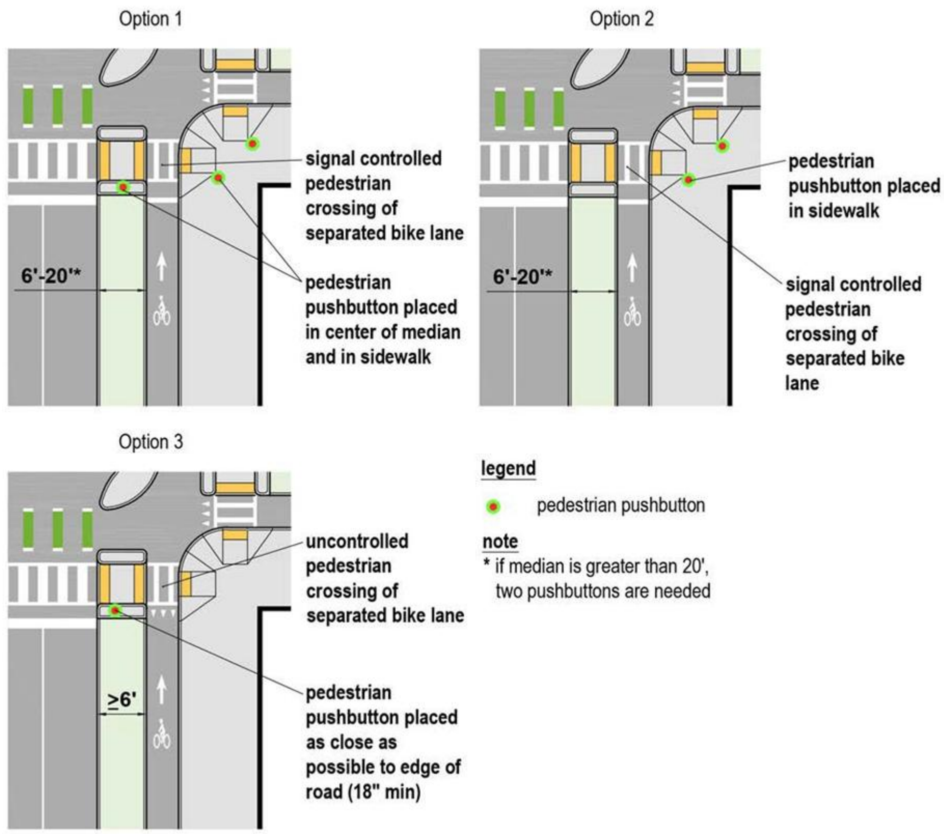
Considerations for placement with pedestrian signal equipment

Designers must determine if a pedestrian crossing of the separated bike lane should be controlled or uncontrolled at intersections with a separated bike lane and a street buffer that is 6 ft. or wider. For all ODOT projects, controlled crossings are preferred. When floating transit stops are present along a separated bike lane at a signalized intersection, the platform will serve as a pedestrian crossing island; as such, a second pushbutton must be placed in the buffer (see Chapter 10 for floating bus stops). The following discusses uncontrolled and controlled crossing considerations:

- **Controlled crossings** – Can be used where it is desirable to ensure bicyclists are stopped prior to the pedestrian crossing (see Option 2 and 3 in Figure 8-3). In these cases, the separated bike lane movement across the pedestrian crossing is signal controlled. The pedestrian clearance interval should be based on a crossing distance beginning/ending at the sidewalk, which will increase the signal cycle length and delay for all users. Additionally, the benefits of the forward queuing area to reduce bicyclist conflicts with turning traffic are diminished. If the street buffer is greater than 6 ft., an additional pushbutton may need to be placed in the median to meet pedestrian accessibility guidelines, such as where a floating transit stop is present (see Option 2 in Figure 8-3).

**Figure 8-3: Accessible Pedestrian Pushbutton Locations with Separated Bike Lane**

**Commented [KF1]:** Update to show new Bike Symbol per MUTCD




- **Uncontrolled crossings** – Can be used where it is desirable to prioritize a shorter pedestrian crossing distance and maintain the ability to allow bicyclist to wait in the forward queueing area of a protected intersection (see Option 1 in Figure 8-3). In this option, the separated bike lane movement across the pedestrian crossing is uncontrolled and the pedestrian clearance interval is based on a crossing distance beginning/ending at the median (i.e., street buffer).

When the buffer is less than 6 ft. wide at an intersection with a separated bike lane, the pedestrian pushbutton should not be placed in the buffer area. In these cases, pushbutton placement should follow the layout shown for Option 3. In all scenarios, designers should ensure all proposed pedestrian ramps, pushbuttons, and signals meet current accessibility guidance, see OMUTCD ~~Section 4E~~ Chapter 4I and Section 8.3.2 of this guide for additional details.

#### 8.4.4 Signal Timing and Reducing Bicycle Delay

Existing signals are usually timed for prevailing motor vehicle speeds. Designers should evaluate minimum clearance intervals based on bicyclists' operating characteristics and make adjustments that provide the safest design for all users. Signal cycle length and signal coordination can also impact bicyclist delay, which may lead to traffic control device non-compliance. Designers should balance traffic operations and consider delay and safety impacts to all users.

A bicyclist design speed of 8 mph and acceleration of 2.5 ft./s$^2$, which is a typical speed and acceleration profile of a slow-moving adult bicyclist, should be used for minimum green signal timing. A bicyclist design speed of 15 mph should be used for red clearance interval signal timing. The designer should adjust the design speed and acceleration values as appropriate at locations where the typical bicyclist may be slower or faster moving, such as on downhill or uphill grades.

Signal Cycle Length

Signal cycle length can have a significant impact on pedestrian and bicyclist travel. Signal cycle lengths of 60 to 90 seconds are common in urban areas, as they allow frequent street crossings and can encourage more efficient street network use. In suburban areas where vehicle traffic is often consolidated on a relatively small number of arterial and collector streets, signal cycle lengths are typically longer compared to denser, urban corridors that may have a number of one-way facilities. Cycle lengths are generally between 90 and 150 seconds, though some intersections run longer cycle lengths during peak travel periods. At intersections with a longer signal cycle length, users approaching from a minor street can experience significant delays. This can result in reduced signal compliance for bicyclists where gaps are present, when bicyclists are unaware that they have been detected, or if they have not been detected at the intersection. Consideration should be given to providing shorter signal cycle lengths when feasible, or operating in “free” or fully actuated mode during off-peak periods so that the signal switches to the side street phase more quickly to minimize delays to side street users including bicyclists. However, signal cycle length reductions must not come at the cost of adequate pedestrian crossing intervals (see Section 8.3.3).

In some cases, the signal cycle length at an intersection is determined based on adjacent intersections that are part of a coordinated system described later in this section.

Bicycle Minimum Green

When an approach receives a green indication, a bicyclist waiting at the stop line needs enough time to perceive, react, accelerate, and establish themselves in the intersection before the beginning of the yellow signal indication. The minimum green time for a bicyclist is long enough for a bicyclist to travel halfway across the intersection so that a bicyclist is visible to conflicting traffic and has established themselves in the intersection before the signal turns yellow.

Where bicyclists and motorists follow the same signal, the minimum green at an intersection should be based on the bicycle minimum green. Different minimum green time for bicyclists and motor vehicles may be established under the following scenarios:

A. The traffic controller has the capability to set bicycle minimum green parameter;

B. Separate detection or detection that can differentiate bicycles from motor vehicles is implemented.

When bicycle signals (either a standard traffic signal face designated for bicycle use or a bicycle signal face) are used for exclusive bicycle phases, the bicycle minimum green should be used.

Table 8-3 defines the bicycle minimum green time based on the distance from the stop line. At a minimum “d” is defined as the distance from the stop line to the middle of the intersection. However, designers may choose a higher value of “d” up to the full width of the intersection. A larger “d” will enable a bicyclist to get farther through the intersection before the green indication ends, potentially improving bicyclist comfort when crossing the intersection.

A minimum green time based on a bicyclist traveling halfway across the intersection will typically result in a phase length long enough for a bicyclist to fully clear the intersection before the conflicting approach receives the green indication. However, at some wider crossings, the total phase time may not be sufficient. Designers should also verify that the total phase time is greater than the total time for a bicyclist starting from a stop to cross the intersection (see Table 8-4). Designers should increase the minimum green time until the total phase time is greater than or equal to the total time for a bicyclist to cross the intersection.

Note that the assumed bicycle travel speed for both minimum green time and total phase length is 8 mph. However, a higher speed may be considered for the red clearance interval, since slow moving bicyclists are not likely to enter the intersection at the end of the yellow change interval. See the discussion of “Red Clearance Interval” below.

**Table 8-3: Bicycle Minimum Green Time Equation**

$$G_{min} = t + \frac{1.47v}{2a} + \frac{d+L}{1.47v}$$

Where:

| Value | Meaning |
| --- | --- |
| $G_{min}$ | 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) |

**Table 8-4: Total Phase Length, Minimum Green**

$$G_{min} + Y + R_{clear} \geq t + \frac{1.47v}{2a} + \frac{W+L}{1.47}$$

Where:

| Value | Meaning |
| --- | --- |
| $G_{min}$ | time required to attain crossing speed (s) |
| Y | yellow change interval (s) |
| $R_{clear}$ | all-red (s) |
| W | intersection width (ft) |
| L | bicycle length (assumed 6 ft) |
| v | bicycle travel speed (assumed 8 mph) |
| a | bicycle acceleration (2.5 ft/s$^2$) |

| Value | Meaning |
| --- | --- |
| t | perception reaction time (assumed 1.5 s) |

Yellow Change Interval

The OMUTCD, Section ~~4D~~4F.~~26~~ 17 states that a vehicle yellow change interval should be a minimum of three seconds, which provides sufficient reaction time for a bicyclist traveling at up to 15 mph to stop before entering the intersection. When a bicycle signal ~~(either standard traffic signal face designated for bicycle use or a bicycle signal face) are~~ is used ~~exclusively for bicycle phases,~~ the minimum yellow change interval of three seconds should be used per OMUTCD, section 4H.11.

When bicyclists and motor vehicles follow the same signal, the yellow change interval for a motor vehicle should be used, as motor vehicles will likely be traveling at higher speeds and need additional time to react, See TEM Section 403-2.

Red Clearance Interval

The red clearance interval allows for a roadway user that legally entered the intersection before the end of the yellow change interval additional time to complete their movement prior to crossing movements receiving a green indication. Designers should determine where a bicyclist would be positioned if they entered the intersection at the end of the yellow interval. For shorter red clearance intervals, the bicyclist may not be visible to motorist stopped on the conflicting approach waiting for a green indication. In these instances, designers should lengthen the red clearance interval so that a bicyclist will have established themselves in the intersection or traveled beyond the conflict point with a conflicting approach (see Figure 8-4).

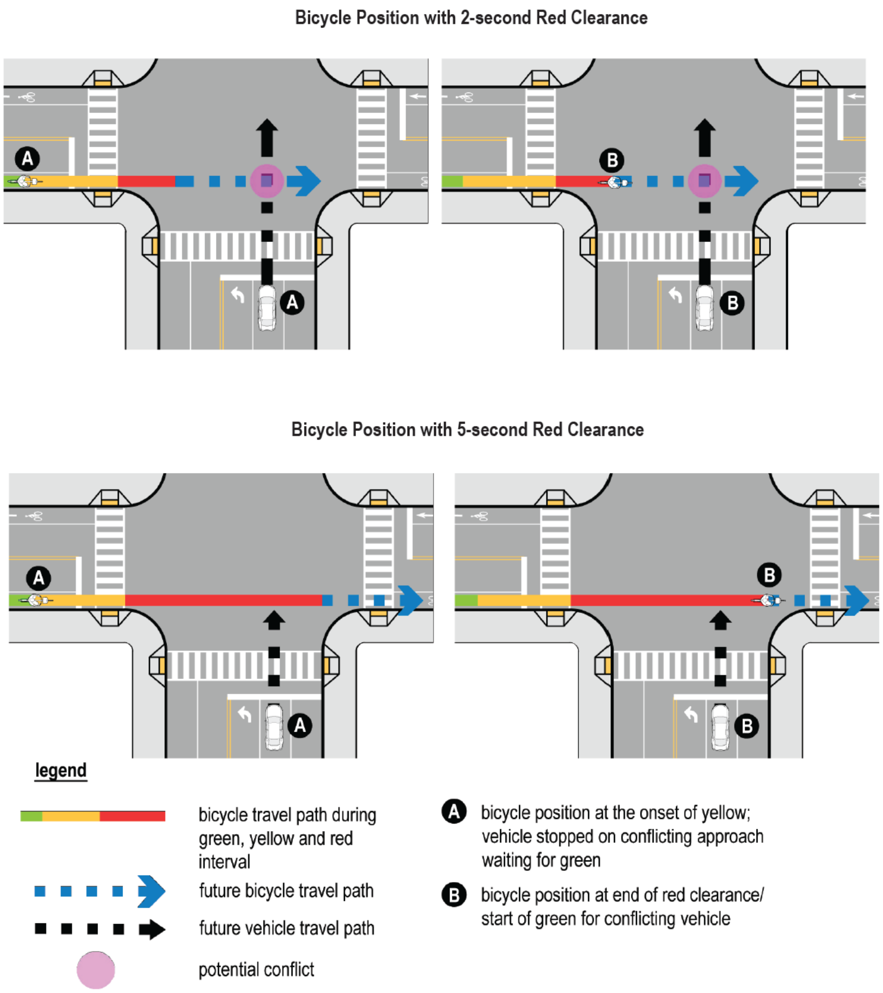
As previously mentioned in the "Bicycle Minimum Green" section, a higher design speed may be considered for the red clearance interval when taking bicycles into account. If a bicyclist determines not to stop during the yellow change interval, they are likely accelerating to clear the intersection. In this case, a higher design speed of 15 mph may be considered for the red clearance interval. Such a calculation is not likely to significantly change the overall interval if rounded to the nearest second.

When bicyclists on the major street intend to use a two-stage bicycle turn box place in line with the lanes of the minor street approach, the designer should consider extending the red clearance interval because the bicyclist must slow to access the bicycle turn box. If the subsequent phase includes side street through traffic, a longer red clearance may be necessary to accommodate bicycle traffic entering the box. However, if the subsequent phase does not include side street through traffic (e.g., lagging left turn on the major approach), a longer red clearance would not be necessary.

Bicycle Green Extension

In locations where bicycle volumes are heavy during a particular time of day, additional green time may be needed. In these cases, the approach may include a detector at the stop line or in advance of the stop line to extend the green interval in order to allow bicycle traffic to move through the intersection. The length of the extension should be determined by the speed of bicyclists, the detector distance from the stop line, and the amount of extension time that can be provided. Once the phase has begun, each bicyclist will extend the green time for each bicycle detected up to the maximum green.

**Figure 8-4: Bicycle Position During Red Clearance**




Signal Coordination Considerations

Corridors with coordinated signals are often timed to progress motor vehicles at speeds which are significantly faster than typical bicycle travel. Consequently, in these cases, most bicyclists will not gain progression benefits.

Cycle length is usually selected based on the needs of the largest or most congested intersection. These signal cycle lengths are sometimes longer than optimal for smaller or less busy intersections and can result in higher delays for users on side streets. These side streets are often more comfortable for bicyclists, assuming they provide reasonable network connectivity and comfort for bicycles. Significant intersection delays degrade the value of these corridors and can result in reduced signal compliance when traffic gaps are available. This can be a significant barrier at bicycle boulevard crossings or shared-use paths where there may be an expectation of a higher level of service for bicycle travel (See Chapters 5 and 6).

To offset these challenges, on streets that are designed to accommodate bicyclists, designers should consider the following:

- **Half signal cycle lengths or a shorter corridor-wide signal cycle length during lower volume and off-peak periods.** On coordinated corridors with semi-actuated signalized intersections (i.e., detection on the side street), signals could operate in "free," or uncoordinated mode, to reduce delays on the side streets. Designers should consider signal spacing, traffic volumes, and delay for all users when evaluating whether to run a signal in "free" or uncoordinated operation. In signal networks with fixed time operation and lower cycle lengths (90 seconds or less), coordination should be maintained.
- **Progression speeds closer to bicycle operating speeds to support and encourage bicycle traffic on the coordinated corridor.** These are referred to as "Green Wave" progressions for bicycles. They allow bicyclists to operate at a consistent speed, reduce stopping, and improve compliance. Common green wave progression speeds are between 12 and 15 mph. This speed can vary depending on corridor geometry and geography (e.g., grade, sight distance). A "Green Wave" encourages slower travel speeds for motor vehicles, which improves safety for all roadway users. Where a "Green Wave" is provided, SIGNALS SET FOR XX MPH (I1-1) signs may be posted to advise road users of the design speed.

"Green Wave" progression would be most appropriate on bikeway corridors (e.g., bicycle boulevards) with reasonable volumes of bicycle activity. Lowering progression speeds could needlessly increase delay for motor vehicles and transit passengers, so the installation of "green wave" progression should consider the effects on all travel modes.

In some instances, bicycles may be traveling in the opposite direction of signal progression. For example, there may be counterflow movement of a two-way separated bike lane or side path. There may also be a designated bike lane traveling the opposite direction of motor vehicle traffic on a one- way street. These scenarios should be designed with signal progression similar to a conventional two-way street.

#### 8.4.5 Signal Phasing for Managing or Reducing Conflicts

Conventional, buffered, and raised bike lanes will follow either traffic signals or pedestrian signals, as directed. Where right turn only lanes are present (see Section 6.5.3) a conventional or buffered bicycle lane cannot be placed to the right of the turn lane. If a bicycle lane must be placed to the right of a right turn lane for safety and to accommodate the design user (i.e., high volume of vehicles crossing the bicycle lane to turn right), designers shall convert the bicycle lane to a raised bike lane or separated bike lane and follow the principles set forward in this section. Signal phase separation is required for a raised bicycle lane located to the right of a right turn lane (see Section 6.5.4).

8.4.5.1 Phasing Schemes

Designers may incorporate a bicycle signal phase at a signalized intersection to reduce potential conflicts between bicyclists and motor vehicles. Designers should consider both the operational and safety impacts of signal phasing changes at an intersection. Designers should be aware that a phasing scenario may necessitate a separate motor vehicle turn lane and an additional phase, which may increase delay for some users, including bicyclists. Fully separated movements may require longer signal cycle lengths, which may result in reduced user compliance with signal indications and therefore increase potential for conflict. However, the need to protect bicyclists from turning conflicts should be considered a higher priority over reducing bicyclist delay.

Many of the signal phasing options described in Section 8.3.4 for pedestrians can also be adapted to eliminate or manage conflicts between bicyclists and motorists. This section describes four schemes of bicycle signal phasing that employs some of the techniques discussed in Section 8.3.4. There are numerous phasing options available to designers, and not all options are possible depending on the type of bikeway provided at the intersection (e.g., conventional bike lane, raised bike lane, separated bike lane). These schemes are intended to provide examples of some of the options available.

Exclusive Bicycle Phase

This phasing scheme represents a fully separated bicycle movement. All motorized vehicle movements, including conflicting vehicle turns across the bikeway, are restricted during the exclusive bicycle phase. Exclusive turn lanes for the conflicting vehicle turns are not required since all vehicle movements are stopped. Some pedestrian movements may be allowed during the exclusive bike phase.

If bicyclists move independently of pedestrians, this phasing requires the use of ~~a standard traffic signal face designated for bicycle use or~~ a bicycle signal face that is separate from the motor vehicle signal. Alternatively, bicyclists may be directed to follow pedestrian signals during a shared, protected bicycle and pedestrian phase. In this case, a [BICYCLE]

USE PED SIGNAL sign (R9-5) should be installed. R9-5 sign installation should only be considered for use on shared--use paths, raised bike lanes, or separated bike lanes. Right (or Left) turn on red shall be prohibited during the protected bicycle phase. Depending on the signal phasing, a blank out or static NO TURN ON RED (R10-11) sign shall be provided.

Where a pedestrian-only phase is provided, a text-based BICYCLE USE PED SIGNAL sign may be used to allow bicyclists to use the pedestrian-only phase. See Section 8.4.1.

Depending on right and left turn volumes, the exclusive bike phasing scheme is more likely to have an impact on motor vehicle operations. To accommodate queues or an increase in signal cycle, consider extending turn lane storage lengths, if feasible.

Concurrent Protected Bicycle Phase

This phasing scheme also represents a protected-only bicycle movement. The bicycle phase runs concurrently with parallel through motor vehicle phases, but conflicting turns across the bikeway are restricted. Right and left-turn movements across the bikeway operate under a protected-only phase. Exclusive turn lanes for conflicting vehicle turns will be necessary. In this phasing scheme, a bicycle shall be controlled by a bicycle signal head separate from the vehicle signal. See Section 8.4.1 for signal indication options. Vehicular Right (or left) turns on red shall be prohibited during the protected bicycle phase. Depending on the signal phasing, a blank out or static NO TURN ON RED (R10-11) sign shall be provided.

Depending on left and right turning volumes, this phasing scheme may have an impact on motor vehicle operations, especially for the turning movements across the bikeway. Turn lane storage lengths may need to be extended to accommodate queues; reducing split times for other phases or increasing signal cycle length may also be necessary. This phasing scheme can be effective for bikeways along streets with high through movement volumes and low turning volumes.

Leading Bicycle Interval

At locations where bicycle volumes and/or motor vehicle turning volumes are lower than the threshold shown in Table 8-5, or at locations where a bicycle protected phase is not feasible, there may be benefits to providing a leading bicycle interval (LBI) or leading through interval (LTI). For LTI, designers should refer to Section 8.3.4.1. This phasing scheme represents a partially separated bicycle movement. Leading intervals are typically between three and eight seconds long and occur in advance of the green indication for turning motor vehicles. For pedestrians, if a protected intersection is used and bicyclists are allowed to queue in front of the crosswalk, the leading interval may be reduced as bicyclists will be positioned ahead of adjacent motor vehicle lanes and, by design, will be able to establish themselves in the intersection sooner with a short leading interval. Because it only requires a few seconds, a leading bicycle interval may have only a minor impact on motor vehicle operations and, in general, does not require a longer signal cycle length. However, on higher travel corridors, the designer may wish to perform a microsimulation of the proposed phase plan prior to implementation to estimate the difference in travel time between scenarios.

An LBI allows a bicyclist to enter the conflict area prior to a turning motorist, improving their visibility as they cross the intersection. In some cases, an LBI may allow bicyclists to clear the conflict point before motor vehicles enter the intersection. A parallel LPI may also be considered where there is a parallel pedestrian crossing. When a protected left turn phase is provided, it should occur as a lagging phase to prevent left turning vehicles continuing to cross during the LBI. Designers shall also avoid the “Yellow Trap” (see TEM [403-9]) when providing a lagging turn phase.

In this phasing scheme, a bicycle must be controlled by a signal head that is separate from the motor vehicle signal. ~~Any of the signal indication options from Section 8.4.1 may be used to control bicyclist movements for an LPI except for the bicycle signal face.~~ Right (or left) turns on red shall be prohibited during the LBI under this scenario. At locations where additional motor vehicle capacity is desired or there are concerns about compliance with a static sign, the use of a blank out NO TURN ON RED (R10-11) sign may be considered.

LBIs only assist bicycles waiting at the stop line at the beginning of the green interval. They do not provide any protection to bicyclists who arrive after the LBI has ended. Section ~~4D~~ 4F of the OMUTCD provides additional signal information using protected and permissive signal design for right and left turns.

**Figure 8-5: Reserved for Future Use**

Concurrent Bicycle Phase with Permissive Vehicle Turns

This phasing option represents a common scenario at most intersections where bicyclists in a shared-lane or bike lane are not provided any exclusive time in the intersection. In this case, bicyclists are crossing the intersection concurrent with parallel through motor vehicles, and motorists may make permissive turns that cross their path if separate right turn lanes are not provided. This phasing scheme has the lowest impact on motor vehicle operations but may not adequately address turning motorist/through bicyclist conflicts. Any of the signal indication options from Section 8.4.1 may be used to control bicyclist movements with concurrent bicycle phases except for the bicycle signal face. Designers should apply the following treatments as appropriate:

- An offset bicycle crossing to create space for yielding (see Chapter 6);
- Geometric treatments to reduce vehicle speeds and increase sight distances (see Chapters 3 and 7).

**8.5 Toucan Crossings with Traffic Signals**

A Toucan crossing, originating from the phrase 'two can cross,' is a traffic signal complemented by a geometric design treatment that restricts some motor vehicle movements while providing a signalized bicycle and pedestrian crossing. The pedestrian crossings may be located in their traditional location, from corner-to-corner, or may be consolidated to one crossing of the roadway adjacent to the bicycle crossing ~~(see Figure 8-6)~~. A consolidated crossing may reduce conflicts with motorists, but it requires pedestrians to cross away from their traditional line of travel and require a larger central island size to accommodate them while maintaining separation from bicyclists.

This design stops motor vehicle traffic on the major street during the entirety of the bicyclist and pedestrian crossing. These intersections restrict through and left turn motor vehicle movements from the side street, creating a protected crossing for bicyclists. Motorists are permitted to make a right turn movement from the side street, thus removing it from signal control.

This design may be considered for major arterial crossings where it is not desirable to provide a PHB or a full traffic signal. A typical application for a Toucan crossing is where a bicycle boulevard crosses an arterial street. Toucan crossings may also be used at T-intersections.

**8.5.1 Geometric Design Features and Signal Equipment Placement Considerations**

There are several key features of this type of crossing:

- Minor street center medians for bicyclist separation from motor vehicles and space for bicycle signal placement;
- Raised median or raised bike lane to create a queueing area for bicycles;
- Pedestrian crosswalks on all legs or consolidated to one crossing of the major street;
- Channelization island to restrict motorist through and left turns from minor street;
- Pedestrian signals for pedestrians crossing motor vehicle movements;
- Pedestrian signals for pedestrians crossing signalized bike lanes (if a two-stage crossing is provided);

- Bicycle signals for bicycles crossing the major street.

Parking restrictions on the minor street may be necessary within 75 ft. to 100 ft. from the intersection to accommodate motorist shifting tapers and space for the bicycle queuing area and pedestrian crossing island. In addition, median noses of channelization islands should be plowable. Due to the center of the roadway alignment for the bicycle movement, green-colored pavement may be used to delineate the bicycle lane and crossings.

Where pedestrians cross from corner-to-corner, the pedestrian pushbuttons are needed for crossings from all four corners and actuation for bicyclists would be separate. Where pedestrians crossing to the center of the intersection and cross parallel to the bicycle crossing, all pedestrian and bicycle pushbutton equipment is located within the raised islands and the number of pedestrian pushbuttons is reduced.

**Figure 8-6: Reserved for Future Use**

**8.5.2 Toucan Crossing Signal Timing Considerations**

A Toucan crossing's signal timing should accommodate both pedestrian and bicycle crossings and their unique operating characteristics. Since the pedestrian crossing and bicycle crossings are separated, there is flexibility in how the signalized crossing is timed:

- When a bicyclist is detected, the bicycle signal should be activated, and the total phase length should be based on the signal timing guidance in Section 8.4.4;
- When a pedestrian is detected, the pedestrian signal should be activated and the total phase length (WALK and FLASHING DON'T WALK) should be based on pedestrian clearance times in the OMUTCD. The bicycle signal should also be activated with the pedestrian phase since the bicycle signal phase length is less than the pedestrian phase length and there are no conflicts between the two phases in this timing plan;
- Designers have the option of activating the pedestrian signal when a bicyclist is detected to reduce potential pedestrian delay. This is a particularly important consideration if the pedestrian crossing is moved to the center of the intersection; as described in Section 8.5.1.

Designers should consider the impact of the signal activation in a coordinated signal system. The guidance in Section 8.6 for PHBs in coordinated signal systems will also apply to Toucan signals.

**8.6 Pedestrian Hybrid Beacons**

A Pedestrian Hybrid Beacon (PHB) is a type of traffic beacon that facilitates a roadway crossing by stopping major street traffic with a red indication. PHBs are similar to pedestrian signals and are used in variety of applications to improve crossing safety and reduce crossing delay for pedestrians and bicyclists. These devices may be used in a variety of contexts (urban, suburban, and rural).

The decision to provide a PHB at either an intersection or a mid-block crossing is discussed in Sections 4.4.3, 4.4.4, 6.4, and 8.2. PHB operation is described in the OMUTCD (Section ~~4F~~4J.03).

**8.6.1 General Design Considerations**

In addition to the standards specified in the OMUTCD (Sections ~~4F~~4J.01 and ~~4F~~4J.03), the following design considerations may be applicable:

- Pedestrian signals shall be provided in accordance with Section 8.3.1;
- Pedestrian pushbuttons shall be provided in accordance with Section 8.3.2;
- When PHBs are installed for bicycle use, refer to guidance in Section 8.6.3;
- Parking and other sight obstructions should be prohibited for 100 ft. in advance of and 20 ft. beyond the marked crosswalk, or site accommodations should be made through curb extensions or other techniques to provide adequate sight distance;
- A W11-2 (PEDESTRIAN), S1-1 (SCHOOL), or W11-15 (TRAIL) crossing warning sign should be provided on the mast arm overhead or to the right with a diagonal downward arrow (W16-7P) plaque;
- A similar sign to those listed in the previous bullet point with an “AHEAD” plaque (W16-9P) may be installed in advance of a PHB;
- Warning beacons may be installed in advance of PHBs, though if installed, they should only activate when the PHB is not in “dark” mode;
- An R10-23a (STOP ON STEADY RED—YIELD ON FLASHING RED AFTER STOP~~CROSSWALK, STOP ON RED~~) sign, mounted overhead on the PHB mast arm, shall be included for each major street approach at a PHB.

**8.6.2 Pedestrian Hybrid Beacon Timing & Reducing Delay**

Designers should follow the pedestrian signal phase timing guidance in Section 8.3.3 for PHBs. Designers may consider inserting a steady red clearance interval before the walk interval begins. At locations where both bicyclist and pedestrians use PHBs, the crossing interval should be timed based on pedestrian crossings design parameters and speeds.

Pedestrian signal timings will most likely provide sufficient time for a bicyclist to clear the entire intersection. See Section 8.4.3 for additional design guidance for signal timing for bicyclists.

See sections 4J.02 and 4J.03 of the OMUTCD for the guidance on PHB operations.~~To minimize delay for both pedestrians and bicyclists and increase compliance, a PHB should operate in isolation from other intersections (i.e., in "free operation"), if possible. The maximum length of the "dark until activated" period after activation of the pushbutton should be as short as feasible (i.e., less than 30 seconds).~~

~~If a PHB is installed within a coordinated system, the designer may choose to run the timing plan in coordination. While not always desirable from a non-motorist user perspective, coordination may be necessary if a PHB is installed near the intersection of two major streets (less than 750 ft.). To mitigate potential pedestrian and bicycle non-compliance, the designer may consider using a half cycle length to reduce pedestrian and bicycle delay.~~

**8.6.3 Considerations for Bicycle Traffic**

When installed, PHBs should be located to respond to bicyclist desire lines with respect to crossing major roadways. Bicyclists should not be expected to significantly detour from their direct travel path to reach an intersection or mid-block location with a PHB, as this can create additional delay for bicyclists and may encourage unwanted crossing behaviors.

Pedestrian hybrid beacons intended for bicyclist use should provide clear and unambiguous messages to bicyclists, and beacon actuation should be accessible to bicyclists. Where PHBs are provided, side street motor vehicle traffic is stop sign controlled, pedestrian traffic is pedestrian signal controlled, and bicycle traffic may be controlled by either of the following:

- Stop sign – bicyclists cross as motorists at intersections;
- Pedestrian signal – bicyclists are directed to cross as a pedestrian.

At such intersections, bicyclists have the choice to use the stop sign if there are adequate gaps in traffic on the major road. If there are not adequate gaps or if a bicyclist would be more comfortable using the pedestrian signal, they can activate the PHB and wait for the WALK indication. The following discussion provides contextual considerations for each crossing strategy (see Section 8.4.2 for detection guidance).

Stop Sign Control

After stopping at the intersection and finding an adequate gap in traffic, the bicyclist may cross the street. This option minimizes bicyclist crossing delays during periods where there are sufficient gaps in major street traffic. During periods of higher traffic volume, bicyclists may exhibit unwanted crossing behavior if gaps in traffic are inadequate and it is not clear how to activate the PHB (see Section 6.4). For this reason, bicyclists should be given the option of using the pedestrian signal control. The PHB should be designed to clearly communicate how a bicyclist can activate the beacon, as described below.

Pedestrian Signal Control

A bicyclist should be provided with one or more of the following options to activate the beacon:

- Curbside pushbutton (this pushbutton is in addition to the pedestrian pushbutton located at or near the top back of the pedestrian ramp);
- Opportunity to exit the roadway to access the pedestrian pushbutton via a curb ramp to the sidewalk;
- Passive detection in the location where bicyclists are likely to operate.

The BIKES USE PED SIGNAL sign (~~OMUTCD~~ R9-5) should be mounted adjacent to the pedestrian signal heads. If passive detection is used at an intersection, the detection should be designed to discern between a bicycle and motor vehicle, or a bicycle lane or separated bike lane should be provided so a motorist does not activate the PHB. See Section 8.4.2 for additional design guidance on bicycle detection.

Pedestrians and bicyclists are not legally allowed to start crossing during FLASHING DON'T WALK. If a bicyclist perceives that they can clear the intersection, they might enter crosswalks during this phase. During FLASHING DON'T WALK at a PHB, motor vehicles typically have an alternating "wig-wag" red indication and can proceed through the intersection if it is clear. Given the higher speed of a bicyclist compared to a pedestrian, it may be difficult for a motorist to see the bicyclist. At locations with higher volumes of bicyclists. it may be desirable to consider a full traffic signal.

At a PHB, designers may consider creating a separated bicycle lane approaching an intersection and cross bicyclists parallel to the crosswalk. To minimize conflicts with merging or turning motorists near the intersection, bicyclists should be channelized into a separated bicycle lane 50 ft. to 100 ft. in advance of the intersection (see Figure 8-7).

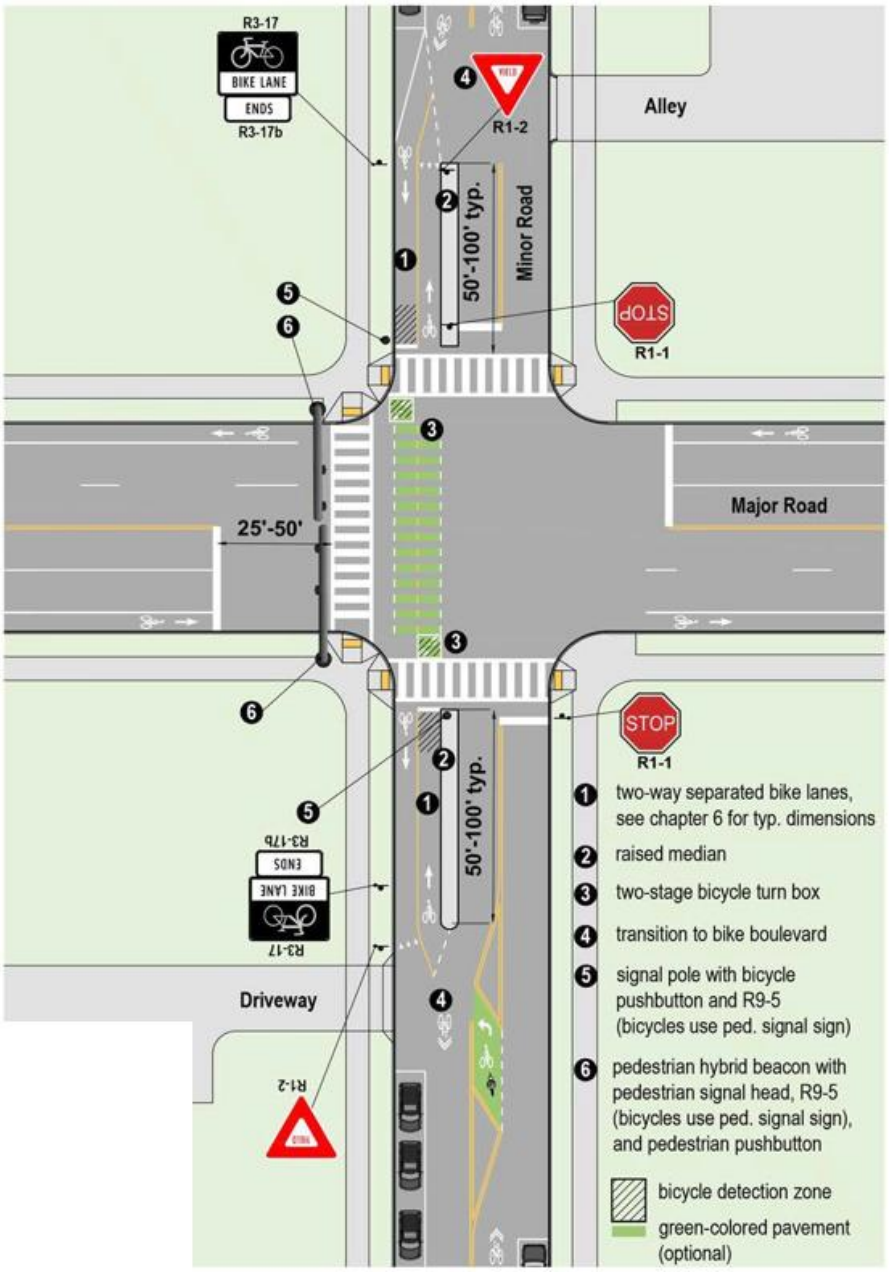
### 8.7 Warning Beacons

Warning Beacons are yellow flashing lights that supplement warning signs, or in some cases regulatory signs, to provide advance notification of a confined space (such as a bridge or tunnel) or shared--use path crossing where bicyclists may be present. Yellow

Beacons used as warning devices shall not be installed without an appropriate warning or regulatory sign. See the OMUTCD (Section ~~4L~~4S.03) for additional details.

**Figure 8-7: Pedestrian Hybrid Beacon at High Volume Major Road**

**Commented [KF2]:** Update to show new Bike Symbol per MUTCD


R3-17
BIKE LANE
ENDS
R3-17b
R1-2
Alley
50'-100' typ.
Minor Road
STOP
R1-1
25'-50'
Major Road
Driveway
two-way separated bike lanes, see chapter 6 for typ. dimensions
raised median
two-stage bicycle turn box
transition to bike boulevard
signal pole with bicycle pushbutton and R9-5 (bicycles use ped. signal sign)
pedestrian hybrid beacon with pedestrian signal head, R9-5 (bicycles use ped. signal sign), and pedestrian pushbutton
bicycle detection zone
green-colored pavement (optional)

#### 8.7.1 Warning Beacons

Warning Beacons are actuated yellow flashing lights that supplement warning signs to provide advance notification of a specific roadway feature (tunnel entrance, pedestrian crossing, etc.). Flashing beacons may be activated either passively (e.g., video detection, radar detection, by time of day) or actively by using a pushbutton.

One example of this application is a bridge with limited sight distance and lacking bicycle specific infrastructure. Similar applications may be appropriate to warn motorists of unexpected or less visible pedestrians or bicyclists on facilities such as in tunnels or on roads with significant horizontal or vertical curvature. See Figure 8-8 for an example of warning beacon applications.

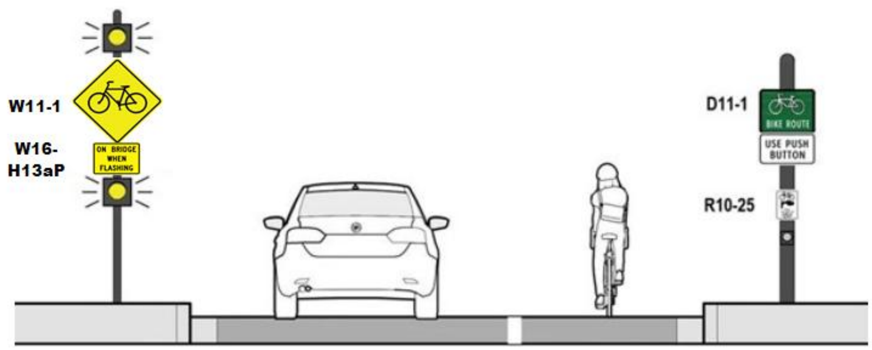
When used at uncontrolled crossings, warning beacons are most effective along streets with three or fewer travel lanes and posted speed limits at or below 35 mph. Research has found yielding rates of 45% can be achieved at locations with these characteristics.5

For the design of Warning Beacons, designers should reference the following:

- Flashing Beacons – OMUTCD (Section ~~4L~~4S) and TEM (405)
- Warning Signage – OMUTCD (Section 2C)
- Detection – Sections 8.3.2 and 8.4.2

Flashing beacons may be used in a number of different applications for bicycles and pedestrians. However, use of passive, continuously flashing beacons should not be used, as indiscriminate use can degrade their effectiveness and affect the usefulness of other flasher locations.

**Figure 8-8: Warning Beacon Example**




8.7.2 Rectangular Rapid Flashing Beacons

Rectangular Rapid Flashing Beacons (RRFBs) are user-actuated, high-intensity yellow LEDs that flash in a rapidly repeating sequence. Like Warning Beacons, RRFBs may supplement crossing warning signs. However, RRFBs, installed at appropriate locations, can achieve high driver yielding rates. Research has shown that RRFBs can achieve motorist yielding rates between 80 and 100 percent both during the day and during periods of darkness when installed under appropriate conditions. Designers should follow the guidance in Section 4.4.3, 4.4.4, and Section 6.4 for when an RRFB may be an appropriate treatment.

While RRFBs have been used on roadways with posted speeds 45 mph and above and on roads with more than four travel lanes, caution should be used in these applications as driver yielding percentages may be lower compared to lower speed and volume scenarios. When used at such locations, the use of a raised median refuge is highly recommended.

RRFBs may also be beneficial at multi-lane roundabout exits where motorist yielding compliance may be poor and gaps are infrequent during peak hours (see Section 9.4.4). ~~RRFBs may be used per FHWA Interim Approval 21 (IA-21).~~

The general crossing design and standards of an RRFB will be the same as for a crossing without an RRFB (see OMUTCD [Section 2C] for crossing sign types, sizes, and placement). In addition, the following design considerations apply to RRFB installation:

- When used, RRFBs shall supplement post-mounted W11-2 (PEDESTRIAN), S1-1 (SCHOOL), or W11-15 (TRAIL) crossing warning signs with a downward diagonal arrow (W16-7P) plaque, or an overhead-mounted W11-2, S1-1, or W11-15 crossing warning sign, located at or immediately adjacent to an uncontrolled marked crosswalk. The RRFB shall be installed on the same support as the associated crossing warning sign and plaque.

- For any approach where RRFBs are used to supplement post-mounted signs, a minimum of two (2) W11-2, S1-1, or W11-15 crossing warning signs (each with an RRFB unit and a W16-7P plaque) shall be installed at the crosswalk, one on the right-hand side of the roadway and one on the left-hand side of the roadway. On a divided highway, the left- hand side assembly should be installed on or within the median, if practical, rather than on the far left-hand side of the highway. Careful consideration needs to be given to RRFB installation with especially wide medians (20 ft. or greater) where prevailing speeds are 45 mph or greater.
- Except for crosswalks across the approach to, or egress from, a roundabout, or crosswalks across free-flow turn lanes separated by a channelizing island, an RRFB shall not be used for crosswalks across approaches controlled by YIELD signs, STOP signs, traffic control signals, or pedestrian hybrid beacons.
- RRFBs shall be pedestrian or bicycle actuated. Pushbuttons are the most common method, though passive detection methods such as motion or break-beam sensors may be appropriate in locations where they will not erroneously activate for those not wishing to cross the street. See Sections 8.3.2 and 8.4.2 for design guidance on pedestrian and bicycle detection, respectively.
- The RRFB unit associated with a post-mounted sign and plaque may be located between and immediately adjacent to the bottom of the crossing warning sign and the top of the supplemental plaque or within 12 inches above the crossing warning sign. If the RRFB unit is supplementing an overhead-mounted sign, the RRFB unit shall be mounted directly below the bottom of the sign.
- RRFB timing shall be based on the procedures provided in the OMUTCD (Section ~~4E~~4L.~~06~~03) for pedestrian clearance timing.
- When considering additional enhancements, such as crossing islands or additional signage, designers should follow the guidance in Table 4-5. In addition, the following should be considered:
- It is preferable to erect crosswalk signage on the far-side of crosswalks less than 20 ft. in width. This placement helps ensure that sightlines between pedestrians and motorists are not obstructed.
- Where sight distance approaching the crosswalk where RRFBs are installed is less than deemed necessary by the engineer, an additional RRFB may be installed on

that approach in advance of the crosswalk. This RRFB would supplement a W11-2 (Pedestrian), S1-1 (School), or W11-15 (Trail) crossing warning sign with an AHEAD (W16-9P) or distance (W16-2P or W16-2aP) plaque. If an additional RRFB is installed in advance of the crosswalk, it shall supplement, not replace, the RRFBs located at the crosswalk.

- If a speech pushbutton information message is used in conjunction with an RRFB: a locator tone shall be provided, the audible information device shall not use vibrotactile indications or percussive indications, and the message should say, "Warning lights are flashing." The message should be spoken twice.
- On four or six lane streets, RRFBs produce higher driver yielding rates when mounted in the median (or overhead) as well as on the right edge of the roadway in combination with advanced stop or yield lines.
- RRFBs may be solar powered and communicate with other assemblies via radio. This may eliminate the need for a power supply and/or conduit between the units, though the designer needs to ensure proper overhead lighting is present at the crossing.
- Unless RRFBs are specifically designed as warning devices for bicycle use, flashing operation should be timed for pedestrians. The flashing operation following each actuation should be based on the OMUTCD procedures for timing of pedestrian clearance times for pedestrian signals. When installed for both pedestrians and bicyclists, doing so will provide sufficient time for bicyclists to clear the roadway.

**8.8 Warning and Regulatory Signs**

The following section provides guidance for traffic control signs, which can improve pedestrian and bicyclists' safety and operation for all types of facilities. This guidance supplements the OMUTCD for these treatments. Per the OMUTCD, all signs must be legible and color distinguishable during dark and daylight conditions. This can be accomplished with external illumination or by using retroreflective materials.

**8.8.1 Crossing and Conflict Signage**

Pedestrian and Bicycle Crossing Warning Signage

Warning signs for pedestrian and/or bicyclist crossings are comprised of a BICYCLE W11-1, PEDESTRIAN W11-2, or PEDESTRIAN and BICYCLE W11-15 sign and a DOWNWARD POINTED ARROW W16-7P supplemental warning plaque, erected at the crossing. In general, the W11-2 signs should be used at sidewalk crossings where bicyclists are uncommon, W11-15 signs at shared-use path crossings with both users, and W11-1 for crossings where pedestrians are uncommon. The arrow should point to the crossing in the road, with right-hand signs using an arrow pointing left and left-hand signs using an arrow pointing right.

While the OMUTCD shows TRAIL X-ING (W11-15P) as an optional plaque for the PEDESTRIAN and BICYCLE W11-15 sign, the DOWNWARD POINTED ARROW W16-7P plaque is required at trail crossings, as it communicates the crossing location.

Signs may be mounted on the far-side of the crosswalk approach to improve visibility between waiting pedestrians or bicyclists and approaching motorists. To add emphasis, a second set of crossing warning signage may be placed within a median (when present), or the left side of the road. Signs should be placed on approaches with two or more approach lanes.

If there is insufficient intersection sight-distance (ISD) for motorists approaching the crossing, advance warning signage should be installed upstream of the crossing using the same warning sign type supplied at the crossing, supplemented by a plaque (W16-2P or -2aP) communicating the downstream distance to the crossing.

Yield Here to Pedestrians/Bicyclists Sign (R1-5)

At uncontrolled crossings where stop or yield lines are provided to denote the location where motorists should yield to pedestrians in a crossing, a YIELD HERE TO PEDESTRIAN sign may be used. If the yield condition includes bicyclists, a YIELD HERE TO BICYCLES AND PEDESTRIANS sign in black letters on a regulatory sign panel may be used.

While this sign may be used on single-lane approaches, they shall be used on all multi-lane approaches to encourage motorists to yield farther away from a crosswalk, improving visibility and reducing the risk of a multiple-threat crash. These signs are typically placed 20 to 50 ft. upstream of a crosswalk.

In-Street Crossing Signs (R1-6)

IN-STREET CROSSING Signs (R1-6) remind road users of state law regarding right of way at an unsignalized pedestrian crosswalks. Such signs should instruct vehicle operators to YIELD to pedestrians, and be placed on a centerline, lane line, or within a median. In-Street Crossing Signs are not to be post-mounted on the right or left side of the roadway.

When used on streets operating at or below 30 mph, the In-Street Pedestrian crossing sign (R1- 6 series) can achieve motorist yielding rates between 60 and 90 percent. The R1-6 sign has also shown to be effective when deployed in a “gated” configuration on multi-lane streets, meaning a sign on the center line and additional signs located on each travel lane line.7 These signs tend to require more frequent maintenance due to their in-street placement.

At locations where sight distance might be limited due to terrain or roadside visual clutter, the crossing may be enhanced with an OVERHEAD PEDESTRIAN CROSSING sign (R1-9 series). An R1-9 sign may be upgraded to a warning beacon if supplemented with a flashing yellow light.

For more information, see OMUTCD Section 2B.~~12~~20.

Turning Vehicles Yield to Pedestrians (R10-15)

TURNING VEHICLE YIELD TO PEDESTRIANS signs (R10-15) may be used to remind turning motorists of the right of way of pedestrians in a crosswalk.

While the R10-15 is listed as a sign to help regulate road users at signals (included under “Traffic Signal Signs” in the OMUTCD [Section 2B.~~53~~59]), this sign may also be used at unsignalized locations providing the same regulatory reminder. Unlike other signs in Section 2B.~~53~~59, the R10-15 does not reference signal indications or operations (i.e., “ON RED”). Further, the regulatory message is applicable to motorists on uncontrolled approaches who must yield to conflicting pedestrians who have the right of way when turning across their path.

~~Turning Vehicles~~Left Turn Yield to ~~Bicyclists~~Bicycles (R10-12b)

Where left turning vehicles interface with bikeways at intersections, a ~~TURNING VEHICLES~~LEFT TURN YIELD TO ~~BICYCLISTS~~ BICYCLES sign (R10-12b) ~~in black letters on a regulatory sign panel~~ may be installed to alert motorists of their requirement to yield to bicyclists within a crossing. ~~In cases where motorists need to be alerted to a potential conflict with pedestrians and bicyclists, the sign should include both the words PEDESTRIANS and BICYCLISTS.~~

The sign ~~can~~ should be located ~~at the near or far-side of the intersection~~adjacent to the left-turn signal face. ~~Engineering judgment should be used to determine a location that is conspicuous to the turning motorist.~~For more information, see OMUTCD 2B.59.

This sign may be used at controlled ~~or uncontrolled~~ crossing locations. Sign installation should be limited to the following:

- Crossings where turning motor vehicle volumes exceed 50 vehicles/hour;
- Locations where there is a documented history with drivers failing to yield;

- New installations of left side bicycle lanes or two-way bikeways where counterflow bicycle travel may be unexpected.

Blank-Out Signs

Blank-out signs are illuminated versions of static signs that may be active all of the time, or may be dark for specific conditions. They may be used in place of static warning or regulatory signs where it is desirable for the regulation or warning to be active a portion of the time. Where detection is used for sign activation, passive detection strategies should be considered instead of requiring bicyclists to actuate a pushbutton. The use of advance detection may also be considered to ensure the blank out condition is activated prior to the arrival of a bicyclist. See Chapter 8.4.2 for further guidance related to bicycle detection for bicyclists. Common applications of blank out signs to improve bicycle and pedestrian safety include the following:

- Providing a temporary NO TURN ON RED restriction at a signalized intersection during protected pedestrian or bicycle phases;
- Providing a temporary or time-of-day-based turn restriction.

**8.8.2 Bicycle Lane Signage**

Bicycle Lane Regulatory Signs (R3-17)

The standard BIKE LANE (R3-17) sign may be placed along bike lanes, separated bike lanes, or bicycle-only paths to indicate the restricted nature of the bikeway to motorists, bicyclists, and pedestrians. These signs should ~~may~~ be located at the beginning of the bike lane and ~~placed~~ in advance of the start of the bikeway. These signs may be ~~and~~ located at periodic intervals along a bikeway, as appropriate. Supplemental plaques indicating AHEAD and ENDS may be placed below the sign to communicate the start or end of a bikeway.

Intersection Lane Control Signs (R3-8x Series)

The R3-8x sign series include regulatory signs which communicates the presence and location of a preferential queue lane in advance of an intersection. ~~While use of a bicycle symbol is not permitted on these signs, the text BIKE may be used on an R3-8 sign.~~

Begin Right (Left) Turn Lane, Yield to Bikes (R4-4)

The R4-4 sign is a regulatory sign which communicates the start of an auxiliary turn lane and reminds motorists of the presence of bicyclists and their obligation to yield to through bicyclists. While the sign does not mention bike lanes, it is only used where a bike lane is present. This sign should not be used to inform bicyclists and motorists of a weaving maneuver necessary when a through travel lane adjacent to the bike lane becomes a drop turn lane (see OMUTCD [Section 9B.05]).

Wrong Way Bicycling Sign (R5-1b)

Bicycle WRONG WAY signs may be installed as a countermeasure to discourage wrong-way bicycling within bike lanes and shared travel lanes. A supplemental RIDE WITH TRAFFIC (R9-3cP) plaque may be added. This sign assembly can be mounted back-to-back with other roadway signs (such as parking signs) to reduce sign clutter and minimize visibility to other traffic. The RIDE WITH TRAFFIC plaque should be mounted immediately below the Bicycle WRONG WAY sign. Where used, the sign(s) face toward wrong-way bicyclists, placed on the left-hand side of a two-way street, or on one or both sides and facing away from traffic on one-way streets.

It may be difficult to discourage wrong way riding with regulatory signage alone, as this behavior can reflect a lack of wayfinding signs or insufficient bicycle network connections. If wrong way riding persists in the presence of this signage, consideration should be given to reevaluating the bicycle network to provide a suitable connection. One-way streets that have persistent wrong way bicycling may benefit from the conversion of the street to two-way operation for bicyclists.

Except Bicycles Plaque

For locations where warning or regulatory signs are not applicable to bicyclists, an EXCEPT BICYCLES (W16-209, R3-7bP) plaque should be used to supplement the warning or regulatory sign. These plaques may be applicable to supplement a variety of signs, such as DO NOT ENTER, NO OUTLET, ONE WAY, RIGHT LANE MUST TURN RIGHT, etc. The R3-7bP version of the sign should only be used with other regulatory signs; the version with black letters on a warning sign panel should only be used with other warning signs. The R3-7bP shall not be used to exempt bicycles from the legal requirement of a STOP or YIELD sign, Yield Here to Pedestrians Signs, Stop Here for Pedestrians Signs, or a traffic signal indication.

Bicycles Merging Signs

For locations where a bicycle lane ends, it may be desirable to warn both bicyclists and motorists of the merge condition. This can be accomplished with a BICYCLES MERGE (W9-5a) sign ~~in black letters on a yellow warning sign panel~~, located at the point where a bicycle merging maneuver may occur. A supplemental W16-2aP plaque may be used to communicate the distance to the merge or end of bike lane. Either warning sign may be used in lieu of a BICYCLE BIKE LANE (R3-17) sign with supplemental ENDS plaque (R3-

17bP). These warning signs should not be used where a bike lane drops in advance of intersection queue lanes and resumes immediately after the intersection.

**8.8.3 Use of Custom Signs**

Consistent with the OMUTCD, custom signs are permissible for situations in which ~~provided~~ standard signs do not convey necessary information or instruction for road users. ~~Such signs must be designed to OMUTCD standards. These include using appropriate shapes, colors, backgrounds, and legends consistent with the sign's function. The use of experimental symbols is prohibited.~~

Refer to OMUTCD Section 2A.04 for information on the design of signs not covered by standard signs. Signs with word messages other than those in the OMUTCD shall be of the same shape and color as standard signs of the same functional type. All symbols, colors, or other design features for custom signs that differ from the standard shall follow the procedures for experimentation and change described in OMUTCD Chapter 1B.

**8.9 Pavement Markings**

**8.9.1 Yield Lines**

Yield lines consistent with OMUTCD Section 3B.~~16~~ 19 may be used to indicate the point at which a bicyclist or motorist should yield in compliance with a YIELD sign or a YIELD HERE FOR PEDESTRIANS/ BICYCLES sign. Yield lines should comprise individual triangles with a base of 12 to 24 inches wide and a height equal to 1.5 times the base. The space between the triangles should be 3 to 12 inches wide. Yield lines may be desirable to emphasize the requirement to yield in advance of pedestrian or bicycle crossings at the following locations:

- Uncontrolled crossings;
- Exit legs of signalized crossings where motorists turn across a bicycle crossing during a concurrent phase;
- Motorist yield points at mixing zones (see Figure 6-32).

8.9.2 Green-Colored Pavement

Green-colored pavement may supplement other bikeway pavement markings to communicate to road users where portions of the roadway have been designated for exclusive or preferential use by bicyclists, and to enhance the conspicuity of a bicycle lane, bicycle lane extension, bicycle crossing, bicycle box, or two-stage bicycle turn box at or through an intersection. The use of green-colored pavement should be applied consistently throughout a bicycle network and can be used to improve the legibility of a bikeway network. See sections 3H and 9E of the OMUTCD for more information regarding green-colored pavement.

If green-colored pavement is not used throughout a bikeway network, it may be used to guide bicyclists through transition areas between bikeway types and bikeway crossings to improve the legibility of the route.

**Chapter 8 Endnotes**


1. FHWA Tech Brief – "Safety Evaluation of Pedestrian Countdown Signals", FHWA Publication No. FHWA-HRT-19-046.
2. (2021) Cesme, B., P.G. Furth, R. Cashman, and K. Lee. Development of pedestrian recall versus actuation guidelines for pedestrian crossings at signalized intersections. Submitted to Transportation Research Record.
3. AASHTO Pedestrian Guide 2004, p. 103.
4. Thompson, Samson Ray Riley, "Bicyclist Compliance at Signalized Intersections" (2015). Portland State University, Dissertations and Theses. Paper 2222.
5. Fitzpatrick, K., S. Turner, M. Brewer, P. Carlson, B. Ullman, N. Trout, E. S. Park, J. Whitacre, N. Lalani, and D. Lord. *National Cooperative Highway Research Program Report 562: Improving Pedestrian Safety at Unsignalized Crossings.* NCHRP, Transportation Research Board, Washington, DC, 2006.
6. Shurbutt, J. and R. Van Houten. *Effects of Yellow Rectangular Rapid-Flashing Beacons on Yielding at Multilane Uncontrolled Crosswalk.* FHWA-HRT-10-043. Federal Highway Administration, U.S. Department of Transportation, Washington, DC, 2010.
7. Western Michigan University. U*ser Guide for R1-6 Gateway Treatment for Pedestrian Crossings.* Prepared for Michigan Department of Transportation, Lansing, MI, 2016.

### Bicycle Considerations

At diamond interchanges, bicycle accommodations are generally similar to typical on-road bicycle facilities detailed in Chapter 6 of this manual. Care should be taken when designing bicycle facilities considering the speed of motorists and the lengths of turn lanes where bicyclists may be located between through and right-turning motor vehicles. It may be beneficial to provide opportunities to exit the on-road facilities to a side path where turn lanes are very long or encourage high speeds for motorists. Designers will need to make it visually clear where bicyclists are to remain in the roadway with enhanced striping and/or colored pavement to avoid trapping the bicyclist. Information on pavement markings in areas where bicyclists and motor vehicles may conflict with each other can be found in Section 6.5.

## 9.3.2 Cloverleaf Interchanges

Cloverleaf interchanges often utilize free-flow loop ramps to accommodate left-turn movements between the major and minor roadway. These free-flow ramps allow motorists to execute these left turn movements without traveling through an intersection and are often designed to allow drivers to navigate the interchange without stopping. Full cloverleaf interchanges use these loop ramps in all four quadrants while partial cloverleafs use loop ramps in one to three quadrants and diamond interchange intersection control options for the other quadrants. However, the use of high-speed free-flow ramps runs counter to the principles of safely accommodating pedestrians and bicyclists.

Free-flow ramps at cloverleaf interchanges often result in acute intersecting angles that limit visibility, permit drivers to accelerate or continue at a higher operating speed through the intersection, and orient vehicles so that drivers may not be pointed toward pedestrian crossings or looking in an opposite direction for oncoming traffic. These skewed crossings can increase the time that pedestrians and bicyclists are exposed to motor vehicles.

Limiting bicyclist exposure to motor vehicles at free-flow ramps can be challenging. The most complicated part of accommodating bicyclists is determining how to continue bicycle facilities through weaving areas where the ramp merges or diverges from the adjacent roadway.

### Pedestrian Considerations

There are multiple treatments that can be implemented to help improve pedestrian facilities within the interchange. Designers should implement high visibility crosswalks and install pedestrian warning signage, yield lines, and potentially rectangular rapid flashing beacons at uncontrolled crossings to warn drivers of the likely presence of pedestrians. Designers should also provide sidewalks through the interchange. Where adjacent land uses in the vicinity of the interchange are potential pedestrian generators, pedestrian facilities should be continuous along both sides of the interchange. Where it is determined that sidewalks should only be continuous along one sides of the interchange (e.g., to avoid a higher-volume, higher-speed free-flow ramps), designers should design the sidewalk network, approach roadways, and adjacent intersections to allow pedestrians to cross outside of the interchange area to the side where continuous sidewalk is provided.

Designers should consider treatments to slow traffic, improve sight distance, and encourage yielding to pedestrians in the intersection. By reducing speeds and improving sight distance, drivers have more time to react and yield to pedestrians waiting to cross or already crossing. Designing or reconstructing the on- and off-ramps from a free-flow condition to intersect the crossroad at an angle closer to 90 degrees with smaller radii reduces vehicular speeds and orients the driver to directly face the crossing location. If the control of ramps is modified, or the geometry of an interchange ramp is "squared up" closer to 90 ~~degress~~degrees, an Interchange Operations Study (IOS) or Interchange Modification Study (IMS) must be performed and coordinated with the Office of Roadway Engineering to confirm that the impacts are acceptable. See L&D Manual, Vol. 1, Section 550 for guidance.

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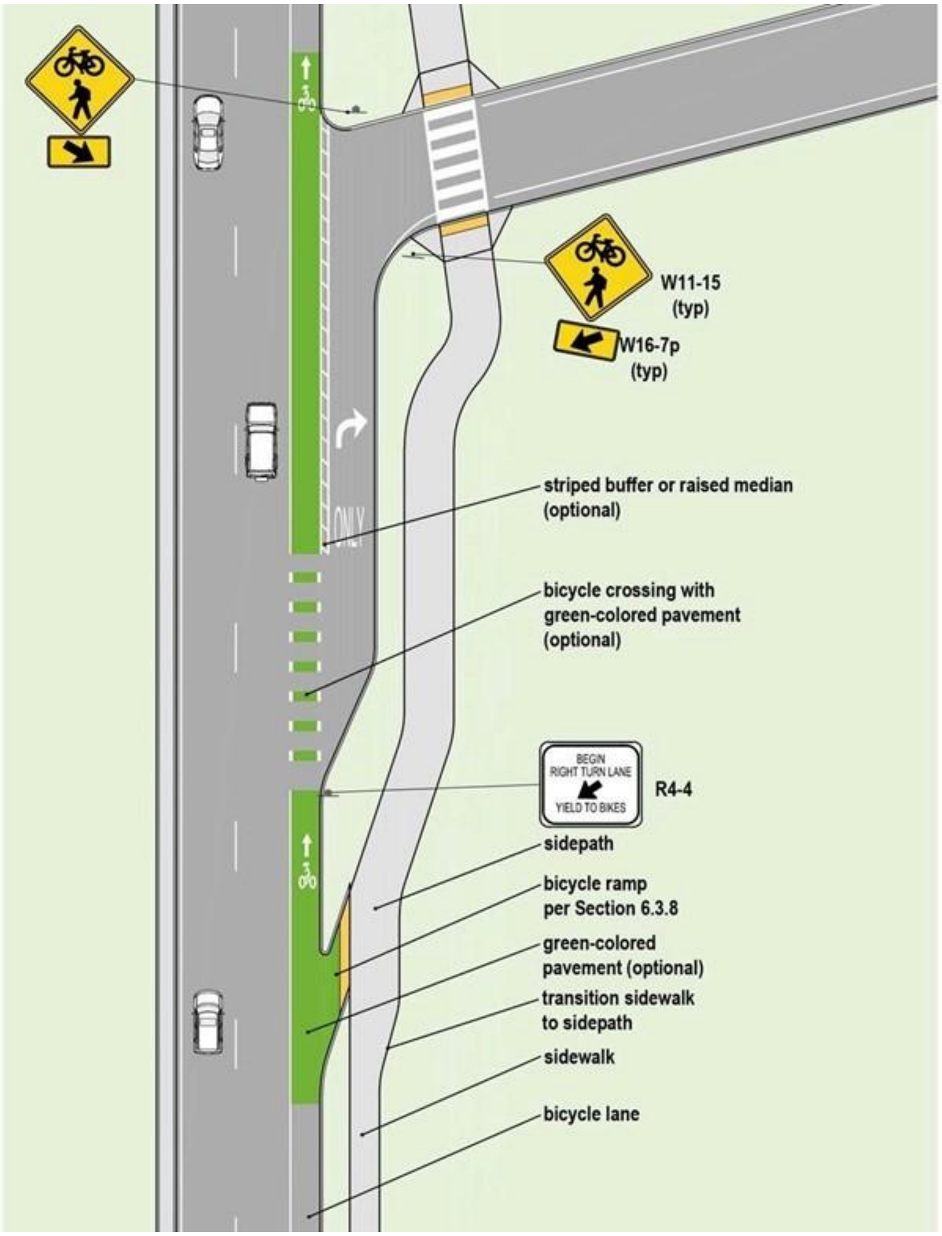
Multi-lane right turns should be prohibited unless signalization is provided to eliminate the potential for the "multiple threat" scenario where one vehicle blocks the pedestrian from the sight line of a second approaching vehicle. Ensuring the crossing location is within the approach line of sight for drivers and meets stopping and intersection sight distance criteria is also critical to confirming pedestrians within the crossing are visible to approaching vehicles. Figure 9-1 illustrates some of these treatments for on-ramps, but similar treatments for lower-speed design can be used at off-ramps.

## Bicycle Considerations

Providing clearly marked bicycle facilities through the free-flow merging and diverging areas at the ramp terminals is critical to improving visibility of the bicyclists and reducing exposure to vehicles exiting and entering the roadway. Designers should stripe entrance and exit ramps so through moving bicyclists do not have to weave across motorists and can continue traveling along the facility while turning motorists are required to yield (see Figure 9-1). This treatment is similar to the striping of on-street bicycle lanes at standard intersections where dedicated right turn movements are present to avoid a right-hook collision. Opportunities for bicyclists to leave on-street facilities and transition to a separated bike lane or shared-use path should be provided. See Section 6.3.8 for guidance on transitioning bicyclists from on-street facilities to sidewalks to shared-use paths. Figure 9-2 provides two striping and signing methods for accommodating bicyclists at exit ramps if the geometry of the ramp is unable to be designed closer to 90 degrees to the intersecting roadway.

**Figure 9-1: Potential Bike and Pedestrian Treatments at Cloverleaf Interchange On-Ramps**

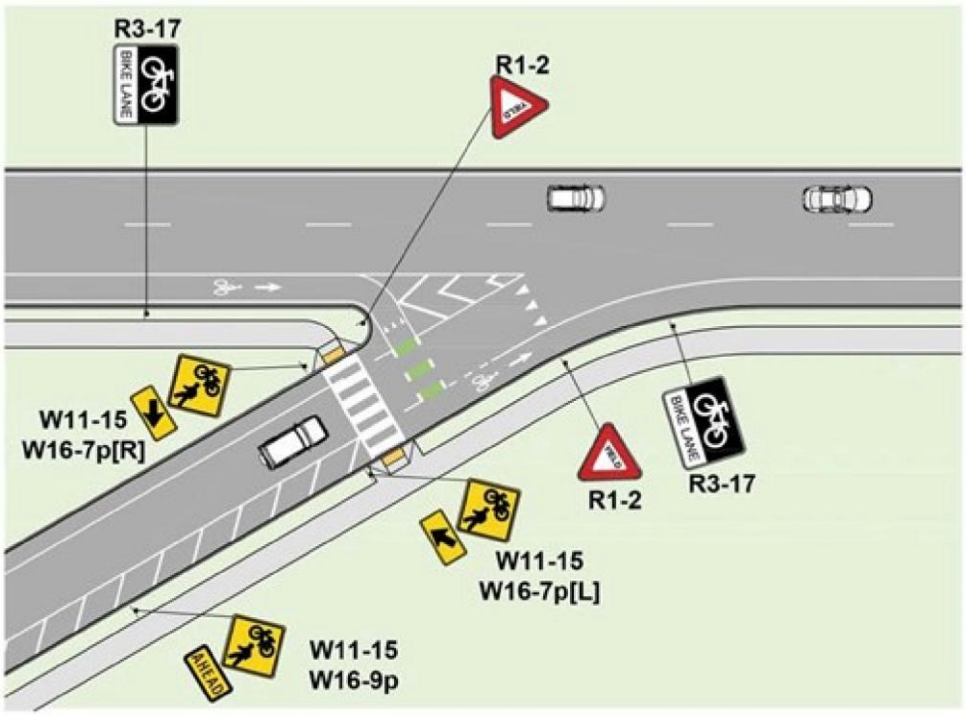


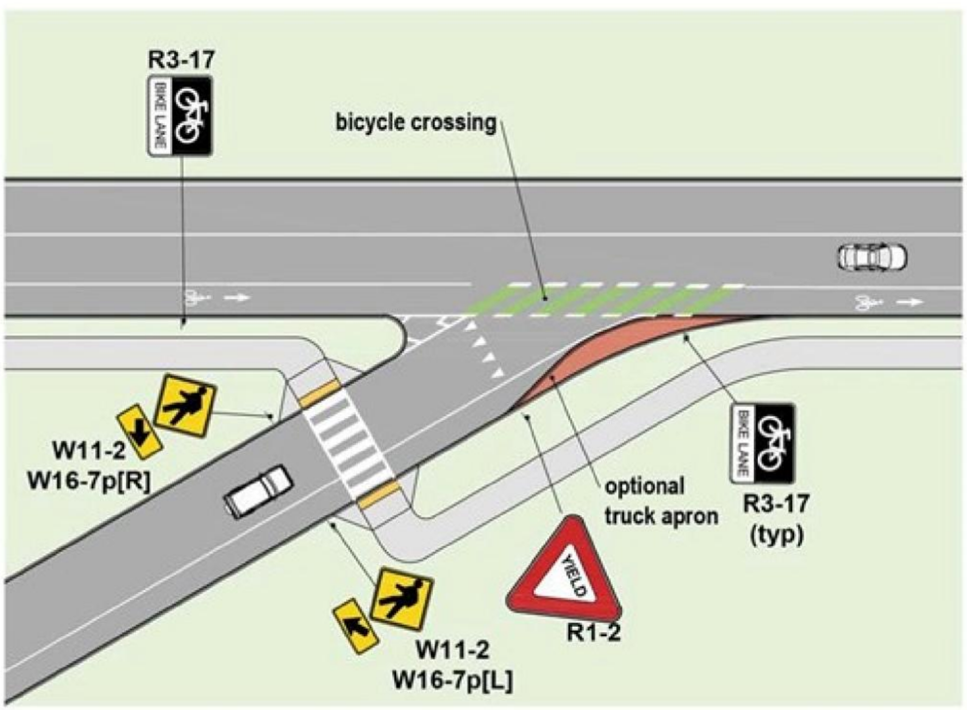

**Commented [JW2]:** Figure to be updated with directional tactile indicators per July 2025 ORE markup.

**Commented [JW3R2]:** Bike symbol needs to be updated per MUTCD.

**Figure 9-2: Bike and Pedestrian accommodations at free-flow exit ramps**

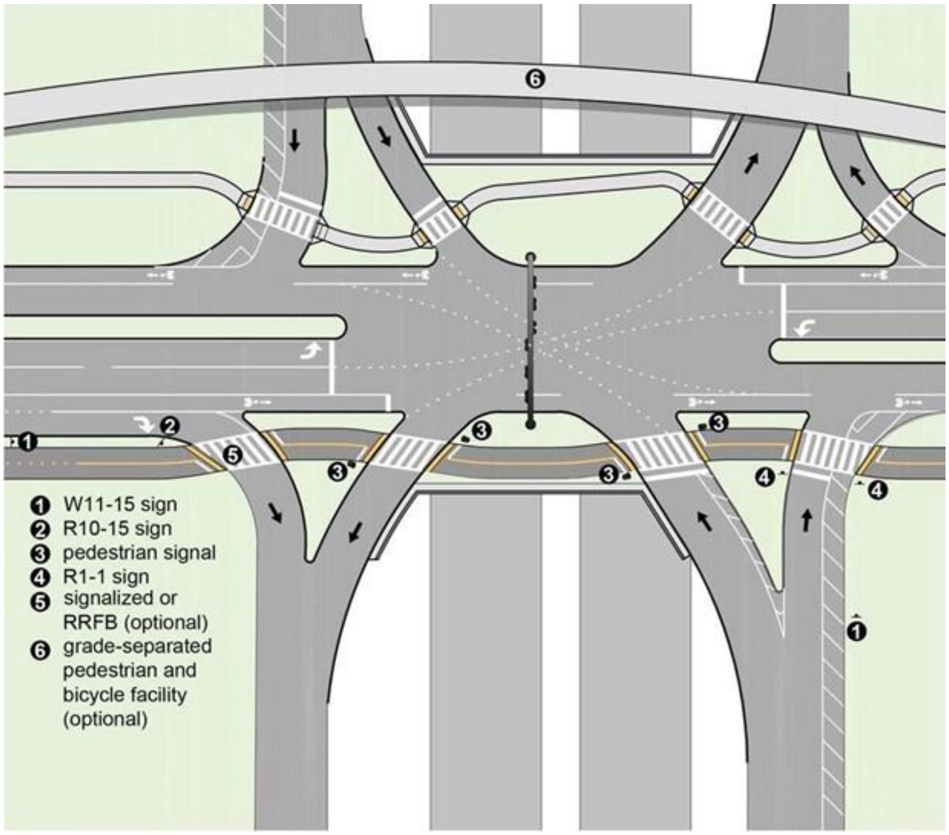
**Commented [JW4]:** Bike symbol to be updated per MUTCD


R3-17
BIKE LANE
R1-2
YIELD
W11-15
W16-7p[R]
BIKE LANE
R1-2
R3-17
W11-15
W16-7p[L]
AHEAD
W11-15
W16-9p


R3-17
BIKE LANE
bicycle crossing
W11-2
W16-7p[R]
BIKE LANE
optional
truck apron
R3-17
(typ)
YIELD
R1-2
W11-2
W16-7p[L]

If the control of ramps is modified, an IOS or IMS must be performed and coordinated with the Office of Roadway Engineering to confirm that the impacts are acceptable. See L&D Manual, Vol. 1, Section 550 for guidance.

**Figure 9-5: Various Bicycle and Pedestrian Treatments at a SPUI**

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## 9.3.4 Diverging Diamond Interchanges (DDI)

DDIs are a variation of the traditional diamond interchange. These interchanges use directional crossover intersections to shift traffic on the minor roadway to the left-hand side of the roadway between the ramp terminals within the limits of the interchange. The crossover eliminates the need for left turn signal phases for

Designers will also need to consider the bicyclist movements when determining cycle lengths for the intersection. Short cycle lengths that allow adequate clearance time are critical for bicyclists. Two-stage left turns or utilizing the pedestrian crossings can be subject to additional delay. Limiting delay will encourage bicyclists to use the facilities as intended. The large footprint of the intersection also means that the designer will need to ensure if the clearance interval is appropriate for bicyclists (see Section 8.4.4).

### 9.4.4 Roundabout Intersections

Roundabouts are generally circular shaped, yield controlled intersections that contain one or more circulating lanes around a central island traveling counter-clockwise. L&D Manual, Volume 1, Section 403 provides guidance on roundabouts. NCHRP Report 1043: Guide for Roundabouts and the Manual on Uniform Traffic Control Devices also provide guidance on roundabouts.

With roundabouts, entering traffic yields to circulating traffic. The circulatory roadway geometry is designed to maintain low vehicular speeds, reducing crash severity for motorists in the intersection. A raised or painted splitter island is provided on all approaches to separate entering and exiting traffic. The curved geometry of the splitter islands aligns traffic with the circulatory road and promotes lower speeds for motorists entering and exiting the roundabout. Roundabouts are generally easier and safer for pedestrians and bicyclists to navigate because motorist speeds are low and the raised splitter islands create a two-stage crossing that allows pedestrians to focus on one direction of traffic at a time while also shortening the crossing length. Where fastest-path analysis shows that motor vehicles may be faster than desired for pedestrian conflicts, designers should consider adjusting the geometry, providing raised crosswalks, and/or provide truck aprons along the right-side of the rightmost lane to encourage slower speeds.

For pedestrians with vision disabilities, the circular geometry of a roundabout can present challenges as they may be unable to decipher the approaching vehicle from the circulating vehicles or know when vehicles have yielded. Bicycle facilities approaching a multilane roundabout also require consideration to provide bicyclists with alternatives to navigate the circulating roadway with minimal conflicts from motor vehicles. Given the challenges that multilane roundabout create for pedestrians and bicyclists, if traffic projections show that multilane roundabouts may be needed in the future, designers should consider constructing single lane roundabouts that would not preclude multilane construction if and when that additional capacity is needed.

## Pedestrian Considerations

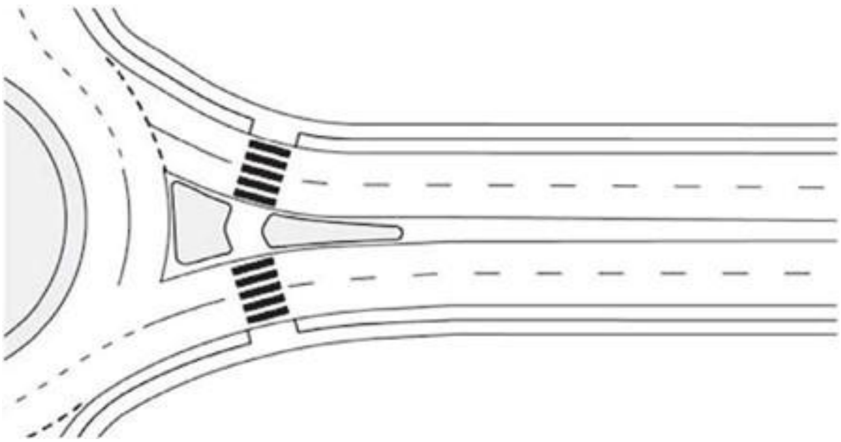
Compared to traditional intersections, roundabouts are generally easier and safer to traverse. Roundabouts break the pedestrian crossing into two stages, providing a refuge in the splitter island. While the navigation of a roundabout may be easier for many pedestrians, pedestrians with vision disabilities may struggle with the non-traditional layout of the roundabout. With a traditional intersection, the sound of a vehicle traveling through the intersection or making a right turn is distinct. Pedestrians with vision disabilities can generally distinguish the direction that approaching vehicles are coming from and how quickly or slowly vehicles may be approaching. With the circular geometry of the roundabout, vehicles passing the exit legs of a roundabout can sound like an approaching vehicle that then turns away. This variation in sound may be hard to distinguish from a vehicle that is actually exiting the roundabout if the pedestrian crossing is too close to the circulatory roadway. To overcome these concerns and to facilitate all pedestrian movements, designers need to ensure good channelization, proper alignment, and careful placement of the crossing.

The pedestrian crossing is placed a minimum of (20 ft.) back from the yield line on the entrance leg of the roundabout. This distance is far enough from the circulating roadway that pedestrians with vision disabilities can focus on the sounds of vehicles approaching or exiting the roundabout rather than the circulating traffic. The crossing should also be placed to maximize sight distances so motorists can see and stop before reaching the crossing when a pedestrian is present (follow the stopping sight distance criteria found in L&D Manual, Volume 1, Section 201.2). When developing the profile for the approach or exit of the roundabout, designers should take care not to place low points within the pedestrian crossing. Low points should be located 15 ft. away from the pedestrian crossing area to reduce the chances for water ponding or freezing in the pedestrian crossing.

The pedestrian route through the splitter island should be a minimum of 6 ft. long and 5 ft. wide to serve as a pedestrian island. The longer and wider the crossing area, the more storage and pedestrian activity that can be accommodated. If bicyclists are expected to also use the crossing, the width should be 10 ft. wide and a length of 10 ft. should be considered to accommodate bicyclists with trailers. The pedestrian refuge through the splitter island should generally be at a similar elevation as the adjacent roadway, as opposed to ramping up and down with conventional curb ramps. The alignment of the pedestrian crossing can be designed three ways: straight, angled, and staggered.

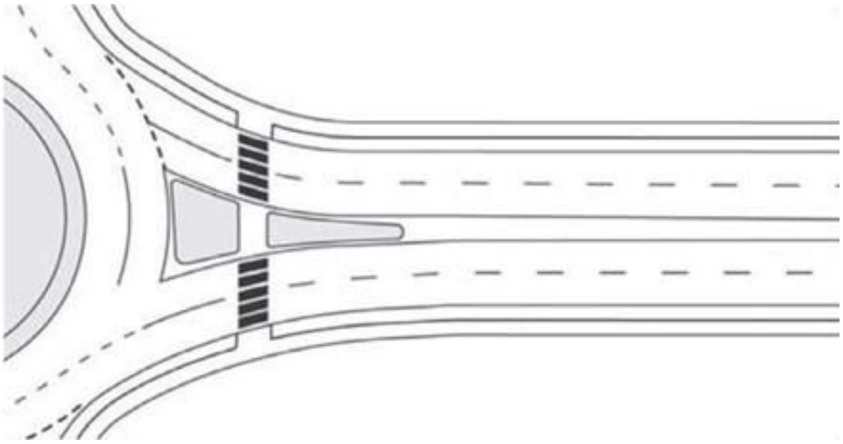
- Angled crossings (see Figure 9-17) are the preferred configuration for pedestrian crossings, especially at higher volume roundabouts. The curb ramps are oriented perpendicular to the curbs, creating an alignment to the sidewalk that is more typical to a standard intersection and providing the shortest crossing distance. For multilane roundabouts, these crossings also better separate potential pedestrian pushbuttons in the splitter island. To help pedestrians better align with the crossing, the angle point within the splitter island should be well defined, as opposed to curved and subtle.

**Figure 9-17: Angled Roundabout Crossing (Source NCHRP 834: Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities)**



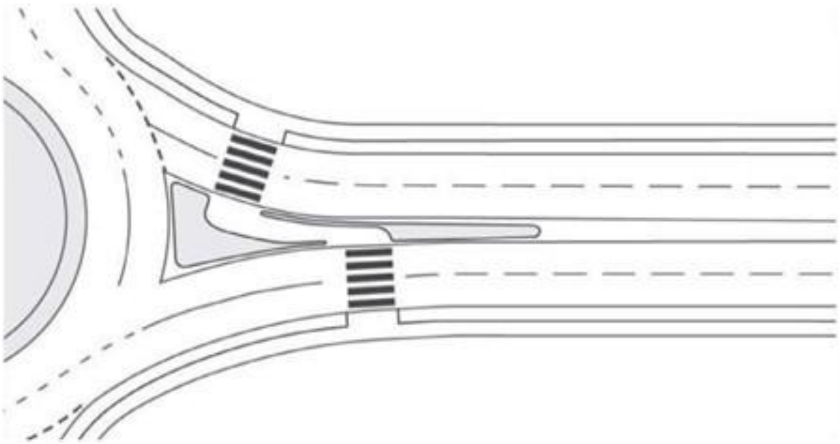
- Straight alignments (see Figure 9-18) typically keep pedestrians aligned in one direction through the entire crossing. This alignment results in longer crossing distances across the travel lanes and requires directional curb ramps (see Section 4.5.9). A straight crossing is also more likely to be treated by a pedestrian as a one-stage crossing (i.e., pedestrians may continue to cross without stopping in the pedestrian refuge.) This design should generally be avoided except in unique circumstances, such as compact roundabouts with narrow splitter islands where it may not be possible to provide a pedestrian refuge.

**Figure 9-18: Straight Crossing at Roundabout (Source NCHRP 834: Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities)**



- Staggered crossing alignments (see Figure 9-19) have different offsets from the circulating roadway on the entry and exit lanes. The pedestrian refuge within the splitter island must be designed with a minimum 5 ft. wide walkway that connects the two crossings, with wider widths necessary in areas of higher pedestrian volumes or where a shared--use path is provided. Staggered crossings indicate to pedestrians that there are two separate stages to the pedestrian crossing. It also provides the most separation between pedestrian pushbuttons and signal heads if Pedestrian Hybrid Beacons are provided. Offset of the crossing on the exit leg should be provided farther from the circulatory roadway to allow for more vehicle storage, reduce the potential for vehicles queuing into the intersection, and provide more stopping distance for motorists to yield. Typically, the offset crossing of the exiting leg is placed 40 to 50 ft. from the circulating roadway. This separation from the circulatory road also benefits pedestrians with low or no vision as they can more easily decipher the sound of a vehicle exiting the roundabout from the circulatory roadway. Channelization with curbs or landscaping may be appropriate to discourage pedestrians from crossing at unexpected locations. These crossing applications are most appropriate at high volume, multilane roundabouts, especially where the splitter islands are wide and can easily accommodate the transitional area between the crossings.

**Figure 9-19: Staggered Roundabout Crossing (Source NCHRP 834: Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities)**



## Accommodating Pedestrians with Vision Disabilities

Visual cues are important factors for pedestrians navigating crossings at a roundabout. Pedestrians are tasked with looking for motorists yielding (or gaps in traffic) that will allow them to cross. This is much more difficult for pedestrians with visual disabilities due to free-flowing traffic and the absence of typical audible and tactile cues. Typically crossing a single lane roundabout does not present significant challenges, but multilane roundabouts are much more difficult to cross.

NCHRP Report 834: Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities presents guidance for accommodating pedestrians with vision disabilities at roundabouts. To accommodate these pedestrians, enhanced facilities need to be constructed to create a crossing that is accessible. This report highlights facilities that may provide equivalent facilitation of crossings consistent with the draft PROWAG accessibility guidance for pedestrians with vision disabilities.

When considering multilane roundabouts as a design alternative, it is vitally important to consider how pedestrians of all abilities will be accommodated. Draft PROWAG R306.4.2 states that at each multilane segment of a roundabout containing a crosswalk, pedestrian crossings will require a pedestrian activated signal, such as a pedestrian hybrid beacon (PHB); a pedestrian actuated rectangular rapid flashing beacon; or a raised crossing. While a pedestrian hybrid beacon (PHB) is an appropriate signalization treatment, they are expensive and if overhead wayfinding signage is provided, a PHB can create additional visual clutter for motorists. Motor vehicle operations should be a consideration when determining if a multilane roundabout with PHB's is an acceptable design solution and should be compared to the motorist operations if instead a single lane roundabout were provided. PHB ~~warrants~~ guidance identified in the ~~OMUTCD~~ 11th Edition of the MUTCD (Chapter ~~4F~~4J) should be followed when determining if a PHB is an appropriate signalization option for the pedestrian crossing. Multilane roundabouts that do not include accessible pedestrian signals should be designed to not preclude the ability to add them in the future.

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Rectangular rapid flashing beacons (RRFB) enhance the accessibility and visibility of pedestrians. For additional information on using RRFBs at roundabouts to improve accessibility designers should refer to FHWA Publication No. FHWA-SA-15-069: Evaluation of Rectangular Rapid-Flashing Beacons (RRFBs) at Multilane Roundabouts. RRFBs are typically mounted on poles on the side of the roadway but can also be mounted overhead.

Additional non-signalized treatments can also be considered to improve accessibility. These treatments include raised crosswalks and speed tables to help reduce the speeds of motor vehicles at pedestrian crossings. Section 7.8.3 provides guidance on the design of speed tables and raised crosswalks. The orientation of these elements in a roundabout should center the pedestrian path on the curb ramp. See Table 9-4 for a summary of potential roundabout crossing enhancements discussed in this guide.

When designing raised crosswalks, the designer will need to consider the geometrics design and grade break alignment of the raised crosswalks, as well as other factors such as drainage impacts.

Raised crosswalks with RRFBs should be used to bring greater attention to pedestrians. Designers should work to reduce visual clutter and only provide necessary signage and markings to bring attention to the crossing. In addition to the design of the pedestrian crossing, designers also need to consider the sidewalk alignment within the intersection and leading to the crossing locations. When pedestrian accommodations at roundabouts are provided, a buffer should be provided between the sidewalk and the curb to help define the crossing locations.

The context of the project location, existing pedestrian accommodations, expected pedestrian activity, land use near the intersection, and community engagement should all factor into how pedestrians of all abilities are accommodated at multilane roundabouts.

**Table 9-4: Roundabout Crossing Enhancements**

| Crossing Treatment | When to Apply | Pro | Con |
|---|---|---|---|
| Raised Crosswalk/ Speed Table | At multilane crossings, crossings where designer wants to bring extra attention to pedestrians | Low cost | Difficulty to implement in a retrofit. Not preferred on routes with significant volumes of emergency services or trucks. |
| PHB | At multilane crossings | PROWAG compliant, enhance visibility of crossing. Less visual clutter at sides of roadway with overhead signal and improve safety for pedestrian crossing | High cost |
| RRFB | At multilane crossings, crossings at locations with heavy pedestrian generators such as school, parks, etc. | Low cost, enhance visibility of crossing | Can add to visual clutter on edges of roadway. |
| Advanced Yield Markings | In advance of crossings | Identifies location for vehicles to stop prior to crossing. Highlights crossing location | Can add to visual clutter at intersection. |

## Bicycle Considerations

Typically, with single lane and compact roundabouts, on-street bike facilities should be merged with motorist traffic so bicyclists travel through the roundabout in a shared-~~-~~lane. Additionally, the ~~OMUTCD~~11th Edition of the MUTCD, Section 9E~~C~~.05~~4~~, states that bike lanes are not to be located within the circulatory roadway of a roundabout. However, the 11th Edition of the MUTCD allows for the installation of separated bike lanes within circular intersections. While Highly Confident and Somewhat Confident Bicyclists may be comfortable traversing a roundabout in a shared-~~-~~lane environment, many bicyclists will not feel comfortable navigating roundabouts with higher motorist volumes, especially multilane roundabouts. For user comfort, roundabouts should also be designed to facilitate bicycle travel outside of the circular roadway on a separated bike lane or shared-~~-~~use path. Where shared-~~-~~lanes or bike lanes are provided on the approach to a multilane roundabout, on-street bicyclists should be transitioned to a separated facility.

This transition from on-road to separated bikeway shall be located as per Chapter~~section~~ ~~OMUTCD 9C~~9E of the 11th Edition of the MUTCD. If on-street bike lanes are present, they shall be terminated in advance of the roundabout at the transition to the separated bikeway. As shown on Figure 9-20, if the elevation of the separated bikeway differs from the on-road facility, a bicycle ramp must be provided to transition between these facility types. The bike lane line should be dotted for 50 to 200 ft. in advance of the taper to provide guidance to bicyclists who wish to travel the roundabout in the shared-~~-~~lane.

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**Figure 9-20: Bicycle Lane Transitions and Striping at a Multilane Roundabout**

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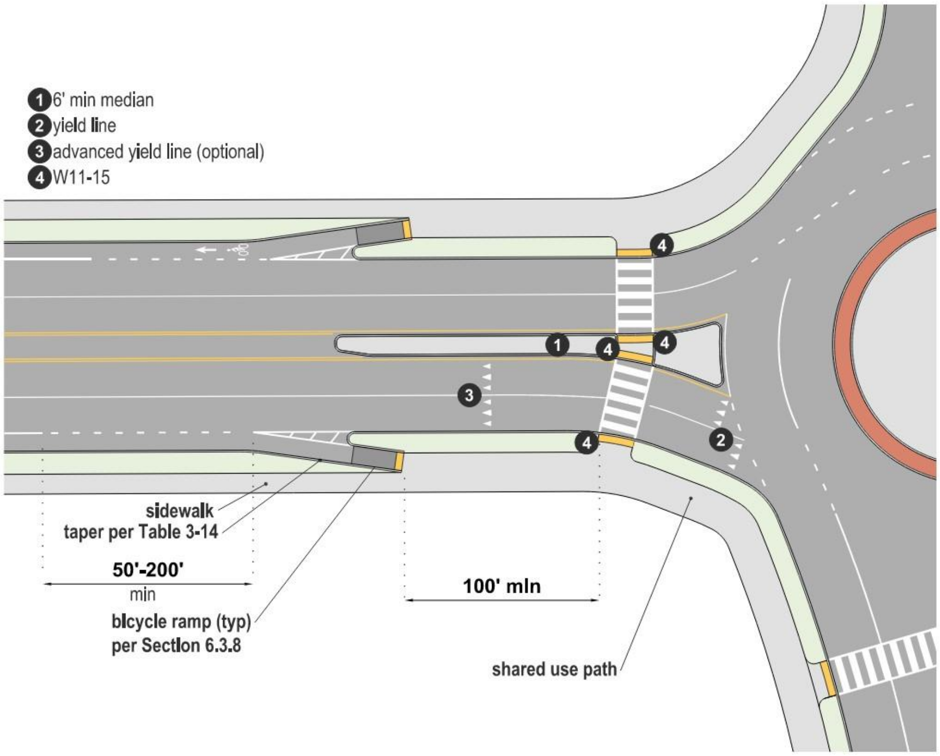
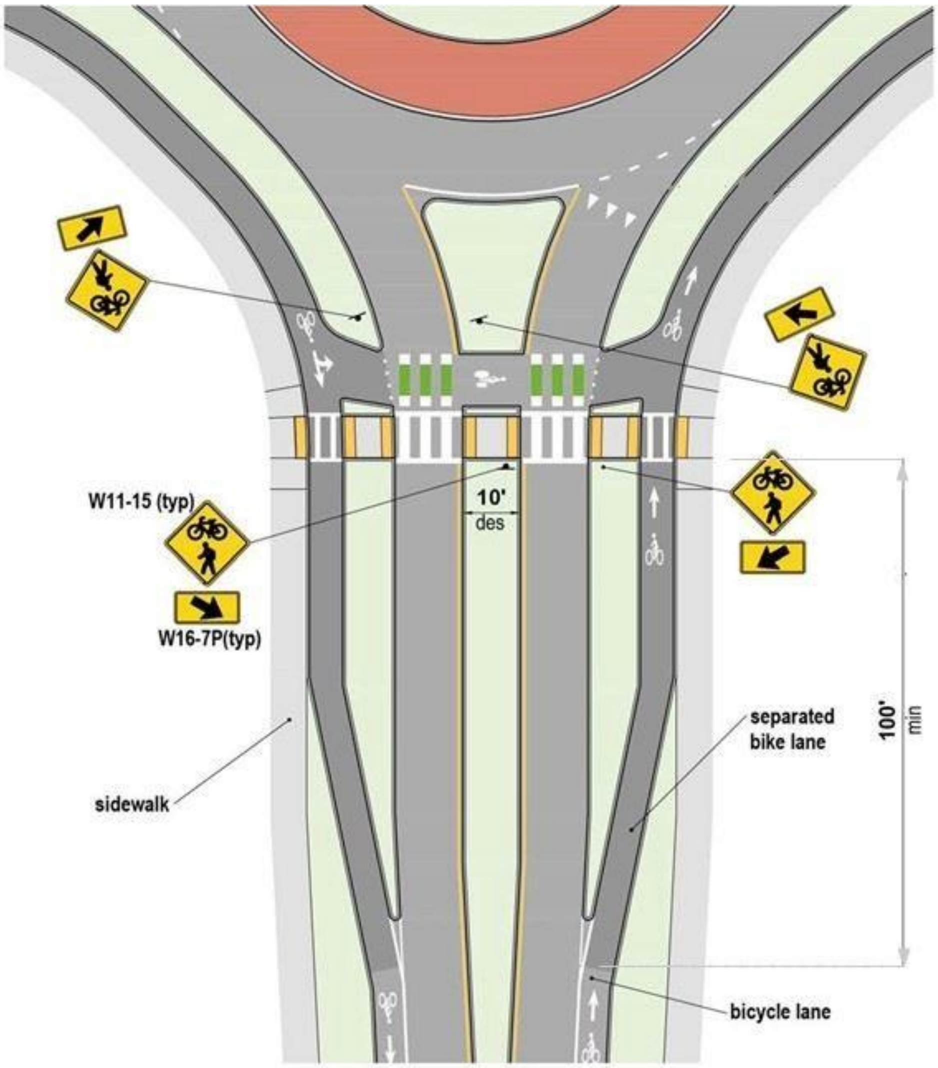



When separated bike lanes are provided on approaches to roundabouts, they may be continued around the intersection to maintain the continuity of the bikeway. When bike lanes are provided on approaches to roundabouts, and if it is desirable to maintain separation between bicyclists and pedestrians, the bike lanes may transition to separated bike lanes around the roundabout. Figure 9-21 provides an example of a separated bike lane at a single lane roundabout.

**Figure 9-21: Bike Lane Transition to Separated Bike Lane at a Roundabout**

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## 10.3.2 Bicycle Access to Transit Stops

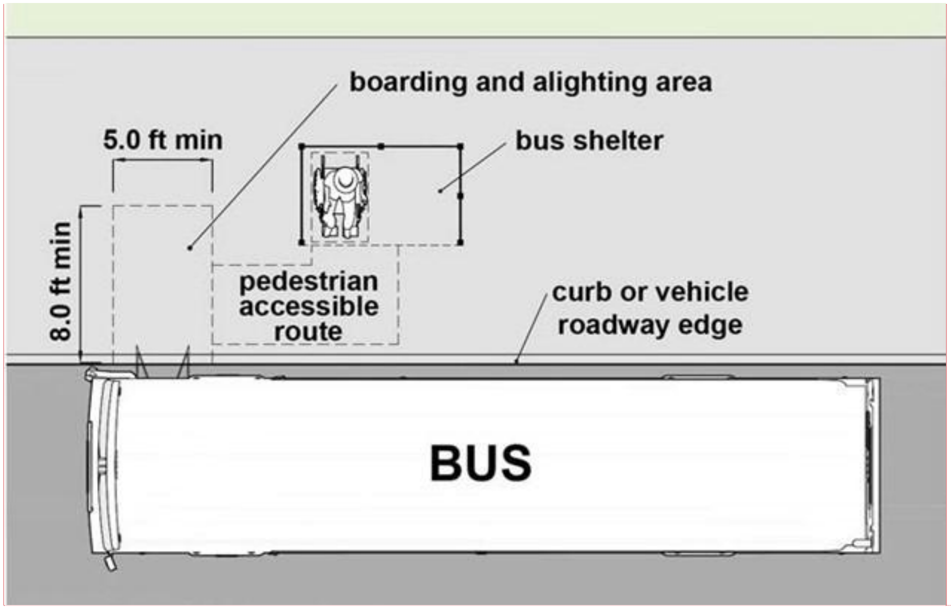
Safe and continuous bicycle facilities can effectively widen the catchment area of transit stops and can support transit trips that begin or end by bike. Some people who access transit by bicycle will need to lock their bikes at the transit stop, while others will bring their bike with them on the transit vehicle. Where access to transit is expected by bicycle, bike racks and/or bikeshare stations should be considered at or near the transit stop, and transit agencies should work to accommodate bikes on buses (see Section 6.3.9).

## 10.3.3 Bus Boarding and Alighting Area Accessibility

An accessible boarding and alighting area is required at every bus stop. Section R308 of PROWAG identifies the dimensions required for pedestrian access and maneuverability at bus stops with a specific focus on people in wheelchairs and using accessibility devices.

An 8 ft. by 5 ft. space is required for transit rider boarding and alighting (see Figure 10-1). This space accommodates the deployment of a ramp from the transit vehicle and the space needed for a pedestrian to access the deployed ramp. If necessary, this boarding and alighting space can overlap with other spaces such as the Pedestrian Through Zone. The 8 ft. x 5 ft. space is required at the accessible boarding and alighting door of the transit vehicle; however, many transit vehicles have more than one door, and different vehicles may have different door spacing and operations (i.e., rear door loading vs front door loading). The different vehicles using the transit stop should be considered when locating and designing the accessible boarding and alighting area, but a firm and stable surface should be provided to accommodate access from all doors of the transit vehicle(s).

The design grade of the boarding and alighting area is 1.56 percent (2.~~0~~ 1 percent max constructed) perpendicular to the curb. Parallel to the curb the grade should match the grade of the roadway to the extent practicable, though 1.56 percent is preferable to serve as a suitable turning area for people in wheelchairs. Additional pedestrian accessibility guidance is provided in Chapter 4. **Figure 10-1: Passenger Boarding and Alighting Area and Accessible Connections**

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An accessible connection must also be provided between the pedestrian waiting area and the boarding and alighting area (Section 10.3.4). Figure 10-1 illustrates a passenger waiting area with a transit shelter that has been sized so that an accessible route is provided between both areas.

### 10.3.4 Passenger Waiting Area

The passenger waiting area is designated for people waiting to board and alight transit vehicles. This space can include shelters, benches, lighting, and other street furniture. Passenger waiting areas are typically situated within the following zones depending on the type of roadway:

Street designs should clearly separate transit passengers from vehicles in travel lanes and provide a comfortable area for waiting and accessing the boarding and alighting area.

The passenger waiting area design must meet accessibility guidelines, and the provided amenities should be based on the land use context, the frequency of transit service, the passenger demand at the stop, and desired facilities. Stops in more densely populated areas, with greater frequency and volume of use, and at major destinations are likely to need a larger footprint to accommodate the desired amenities, whereas stops that are used less frequently might only meet the basic requirements. The following sections provide considerations for some common context types.

The design grade of the waiting area is 1.56 percent (2.~~0~~1 percent max constructed) perpendicular to the curb. Along the roadway, the grade of the roadway can be used to the extent practicable. **Table 10-3: Typical Location of Bus Stop Waiting Areas**

| **Roadway** | **Location within Cross-section Type** |
|---|---|
| Curbed Roadways | Buffer zone – the space between the curb and the Pedestrian Through Zone often accommodates the waiting area and stop amenities. In some constrained areas, the bus stop waiting area may be located along the back of the sidewalk behind the Pedestrian Through Zone. |
| Uncurbed Roadways | Shoulder area – the space starting at the edge of the travel lane is used as a bus stop and space beyond the edge of shoulder may serve as a passenger waiting area. |

## Frequent Bus Stop

### Wide Pedestrian Zone

In contexts with increased pedestrian activity and frequently used bus stops, the Pedestrian Through Zone and passenger waiting areas should be separated as much as possible and maximized in dimensions. This context is typically encountered in urban business districts or within town centers of municipalities. This type of stop may also be used in contexts with major activity centers such as schools, community centers, or health facilities. Where the pedestrian zone available is wider than 12-15 ft., the passenger waiting area can be placed in the buffer space in between the curb and the Pedestrian Through Zone.

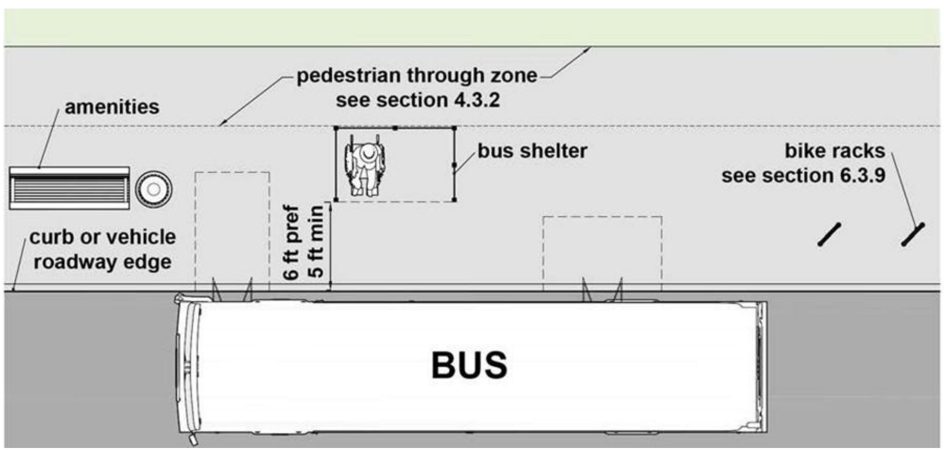
A passenger waiting area that is 10 ft. wide perpendicular to the curb can accommodate a 4 ft. deep shelter facing towards the curb and a 6 ft. buffer in between the shelter and curb. A 5 ft. buffer is the minimum needed to accommodate the pedestrian access route and an ADA accessible turning space. The design should ensure that 5 ft. of space is also provided behind the shelter (waiting area) to accommodate the Pedestrian

Through Zone, although wider is preferred given the context and higher pedestrian volumes (see Section 4.3.2).

A passenger waiting area that is 8 ft. wide perpendicular to the curb can accommodate the minimum requirements for the boarding and alighting area at the accessible transit door. A shelter can be accommodated if it either faces away from the curb or if it uses shelters with either limited or no sides to the shelter, though these designs must be coordinated with the transit operator.

The length of the passenger waiting area should be equal to the distance from the front of the bus to the end of the rear door of the bus. For a standard 40 ft. bus, this distance is typically around 30 ft. For a 60 ft. articulated bus, the length of the passenger waiting area should typically be around 50 ft. In all cases, these distances should be coordinated with the transit operator(s) to understand their vehicle fleet. Figure 10-2 shows an example of a Frequent Bus Stop waiting area with a wide pedestrian zone.

**Figure 10-2: Frequent Bus Stop Waiting Area - Wide Pedestrian Zone**




## Constrained Pedestrian Zone

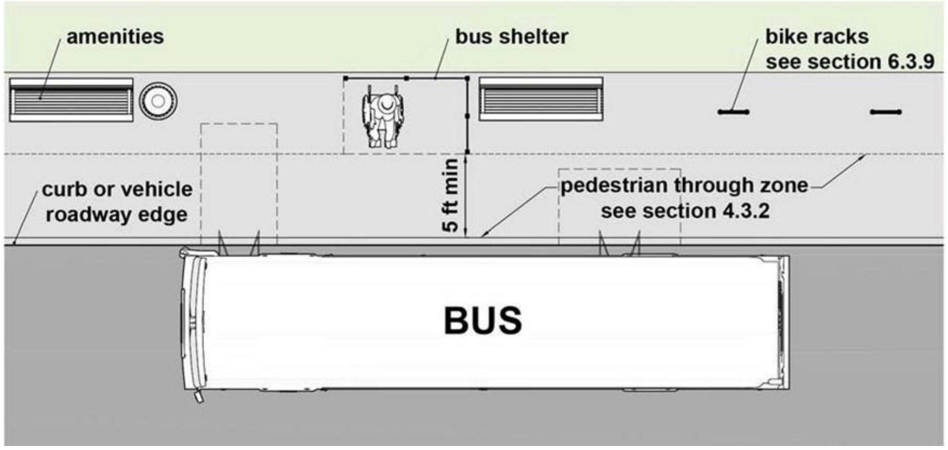
In contexts with high usage stops located where the width of the pedestrian zone is constrained, typically narrower than 12 ft., elements of the passenger waiting area can overlap with the Pedestrian Through Zone as long as accessible widths are maintained.

The Pedestrian Through Zone can be situated adjacent to the curb and should be a minimum of 5 ft. in width (4 ft., if appropriate passing areas and accessible turning areas are provided), although in areas with high volumes of pedestrian activity these minimum widths are likely to be inadequate (see Section 4.3.2). The 8 ft. by 5 ft. boarding and alighting area is likely to overlap with the Pedestrian Through Zone in this scenario.

Passenger amenities can be situated between the Pedestrian Through Zone and the right-of-way line. This arrangement will lead to increased interactions between bus passengers and pedestrians within the Pedestrian Through Zone and should only be used within constrained areas and retrofit situations.

The length of the passenger waiting area should be equal to the distance from the front of the bus to the end of the rear door of the bus. For a standard 40 ft. bus, this distance is equal to 30 ft. For a 60 ft. articulated bus, the length of the passenger waiting area should be 50 ft. Figure 10-3 shows an example of a bus stop waiting area in a constrained environment.

**Figure 10-3: Frequent Bus Stop Waiting Area - Constrained Pedestrian Zone**




## Basic Bus Stop with Amenities

Where bus stop usage is low or moderate, the stop infrastructure footprint may be smaller, but it can still be desirable to provide amenities to improve the comfort of transit riders. In situations where amenities such as shelters or benches are appropriate, they can be placed either within the buffer space (as shown in Figure 10-4) or behind the sidewalk (as shown in Figure 10-5).

Coordinate the design and placement of amenities with the need to provide intersection and driveway sight distances. This assessment may require shelters to be constructed without side, or with transparent sides, to maintain sight distances.

Figure 10-4: Basic Bus Stop Waiting Area with Amenities – Separated Sidewalk

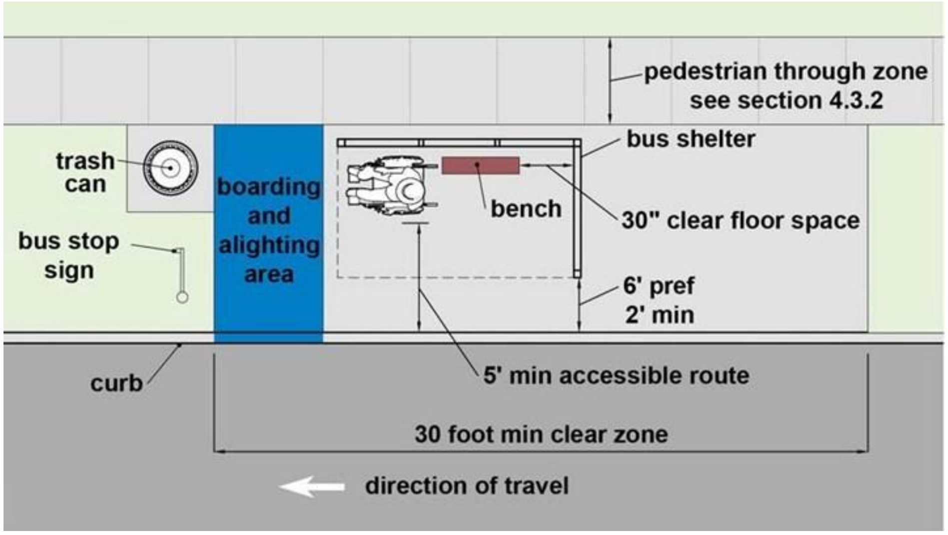
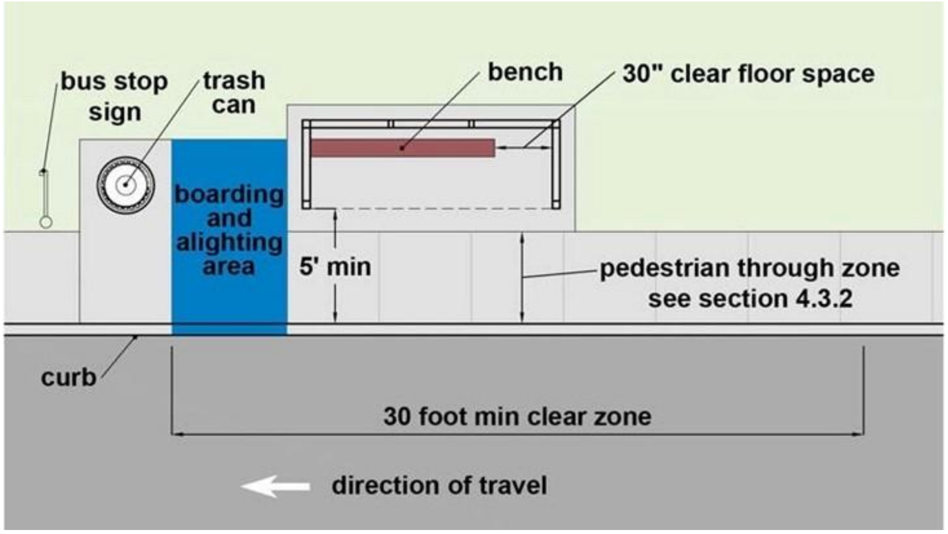



Figure 10-5: Basic Bus Stop Waiting Area with Amenities – Sidewalk Adjacent to Curb




## Basic Bus Stop

Where bus stop usage is low or moderate and shelter amenities are not desired, or where the footprint of the project area cannot accommodate a shelter, the stop design still needs an accessible boarding and alighting area and a bus stop sign. Figure 10-6 illustrates the scenario where the sidewalk is separated from the curb by a buffer space and the boarding and alighting area overlaps with the sidewalk. Designers should note the need for a second concrete pad at the rear door so that passengers alighting can step onto a firm and stable surface.

Figure 10-7 illustrates the scenario where the Pedestrian Through Zone is located adjacent to the curb and an extended boarding and alighting area is provided behind the sidewalk.

**Figure 10-6: Basic Bus Stop Waiting Area - Separated Sidewalk**

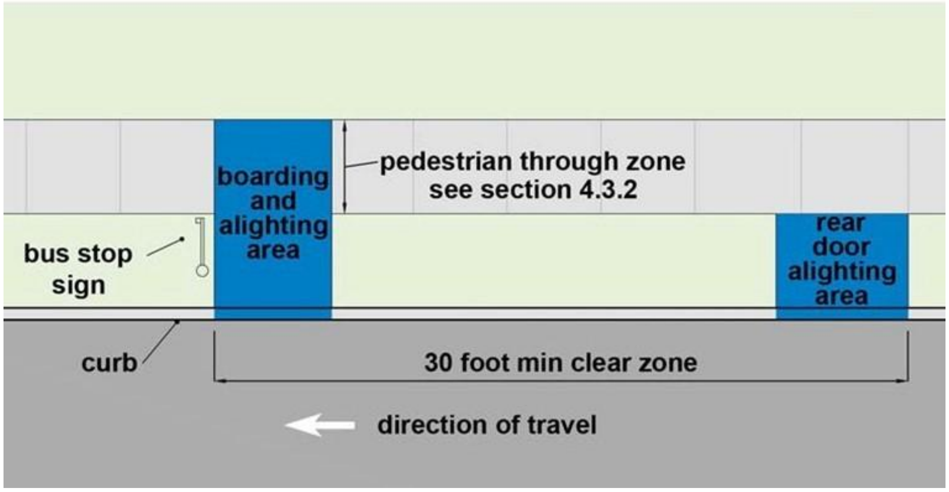
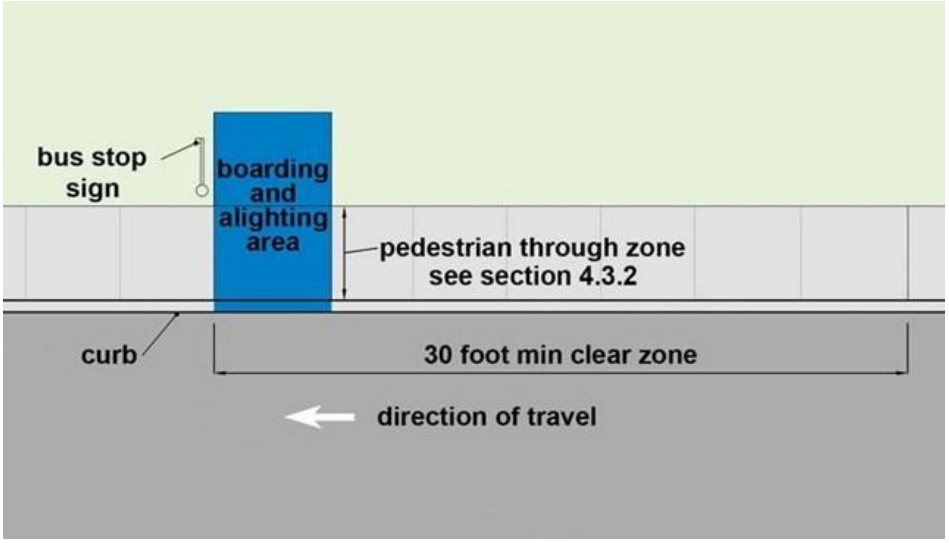



**Figure 10-7: Basic Bus Stop Waiting Area – Sidewalk Adjacent to**



### Uncurbed Roadway

Bus stops on uncurbed roadways can be located within the roadside with flat obstruction-free connections for pedestrians. An 8 ft. by 5 ft. boarding and alighting area is still needed to facilitate accessible access and additional space can be desirable to serve as the waiting area, particularly along higher speed roads.

In some cases it may be desirable to provide a 6 inch high concrete pad in the shoulder as a raised transit stop to better accommodate boarding and alighting, to improve the comfort of waiting transit riders, and to avoid having pedestrians standing in an area of shoulder used for drainage conveyance. The preferred dimensions of a raised transit stop should be a minimum of 8 ft. by 30 ft. exclusive of pedestrian ramps for changing elevations. A pedestrian ramp is needed on both sides of the raised transit stop to connect the platform to the shoulder elevation. These pedestrian ramps should not include detectable warning surfaces because the bottom of ramp facilitate a vertical transition in the Pedestrian Through Zone and not a roadway crossing. Designers should consider the speed of the road, the offset between the edge of travel lane and the raised transit platform, and the design of the approach ends of the platform to avoid introducing an unexpected vertical obstruction close to the travel lane. Ensure that curbs are appropriately tapered to avoid blunt edges and provide right clearance markers, if appropriate, to guide motorists away from the raised transit platform.

## 10.3.5 Bus Stop Amenities

The passenger waiting experience is impacted by which amenities are provided at a bus stop. The following table provides a list of common amenities and design considerations for each. The selection of each amenity depends on the context of the stop and usage. Some guidance on the selection process is provided within the Waiting Requirements section.

Table 10-4: List of Bus Stop Amenities

### 10.5.1 Floating Bus Stop

In this scenario a transit platform is provided between the general purpose lane and the bike lane. It is referred to as a floating bus stop because the boarding and alighting area is separated from the rest of the sidewalk area by the bike lane. This scenario is preferred for bicyclists and transit operators because it effectively eliminates the conflicts between bicyclists and transit vehicles that are typical at conventional transit stop designs. This design also helps to maintain the Pedestrian Through Zone by separating the space for passenger boarding and alighting from the sidewalk area. This design is most typically used where separated bike lanes are provided along a street but can also be used with other bike lane configurations to eliminate the bus-bike conflict when the boarding and alighting volumes or volumes of bicyclists are high.

**Figure 10-12: Far-side Floating Bus Stop with Intermediate-Level Two-Way Separated Bike Lanes**

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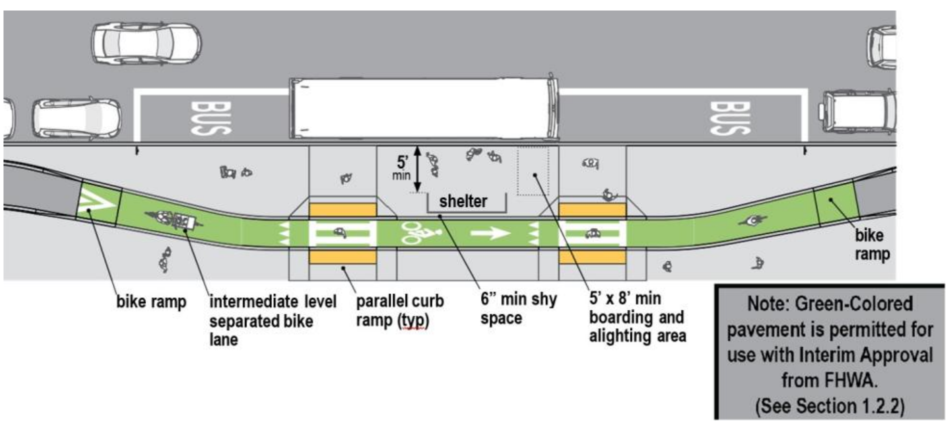
The bike lane behind a floating bus stop is a separated bike lane and should be designed according to the principles of Section 6.3.7. The elevation of the bike lane (at street-level, sidewalk-level, or intermediate level) will affect the design of curb ramps, the sidewalk, and floating bus stop platform to provide pedestrian access and meet accessibility guidelines. To address pedestrian desire lines, a curb ramp should be provided at each end of the floating bus stop, and where possible railings should be provided between the bus stop and bike lane to guide pedestrians to the intended crossing areas (see Shy Distance – Section 3.7.2). For floating bus stops at intersections, one of the pedestrian access points should be integrated into the intersection curb ramp design if practicable; Figure 10-12 shows an example of this configuration.

The floating bus stop area must be wide enough to accommodate the 8 ft. by 5 ft. wide boarding and alighting area, and the designer must carefully consider the placement of curb ramps, railings, and shelters to ensure this space is maintained. The bike lane alignment may shift farther from the roadway (as shown in Figure 10-13) in order to provide the necessary boarding and alighting area width. The bus stop must also be long enough to provide access for the front and rear doors of the bus. See DWG 10-1.1 and DWG 10-1-4 for additional design details.

Where a bus shelter is provided on a floating bus stop, sightlines between pedestrians and bicyclists must be maintained to ensure that bus passengers alighting the bus are visible prior to approaching the crosswalk across the bike lane. This often means providing shelters with transparent sides to help ensure that sightlines are maintained. Shy distances between the bike lane and shelter must also be considered (see Section 3.6.2).

Optional BIKES YIELD TO PEDESTRIANS sign (R9-6) and yield lines may be installed at the approach to uncontrolled crosswalks across the bike lane to reinforce that pedestrians have the right-of-way at the crosswalks. Engagement with pedestrians with disabilities should be done during the design process to discuss how the floating bus stop is intended to operate and discuss other design elements that can make the transit stop easier to locate and access.

**Figure 10-13: Mid-block Floating Bus Stop with Intermediate-Level One-Way Separated Bike Lane**




**Commented [JW3]:** Bike symbol needs to be updated per the MUTCD. Remove note referring to IA.

**Commented [JY4R3]:** Note: Right Bike Ramp missing symbol facility. This situation should be discouraged in cases where bus headways are 15 minutes or less. A dotted white lane line should be provided along the length of the pull-in taper, stop area, and pull-out taper. BUS and bike lane or shared-lane pavement markings may be considered for use within this shared space to communicate to transit drivers and to bicyclists that this is a shared space. At locations with high volumes of bicyclists, green-colored pavement may be considered. See Figure 10-14.

In a Pull-Out Bus Stop configuration, the bus may pull through the bike lane to access the bus stop area. In these situations, the bike lane lines should be dashed for the total length of the stop area and the pull-in and pull-out tapers (see Section 10.4.2); however, if boarding and alighting volumes are very low, the bike lane lines may remain solid through the bus stop.

**Figure 10-14: Bicycle Facility Between Travel Lane and Bus Stop**

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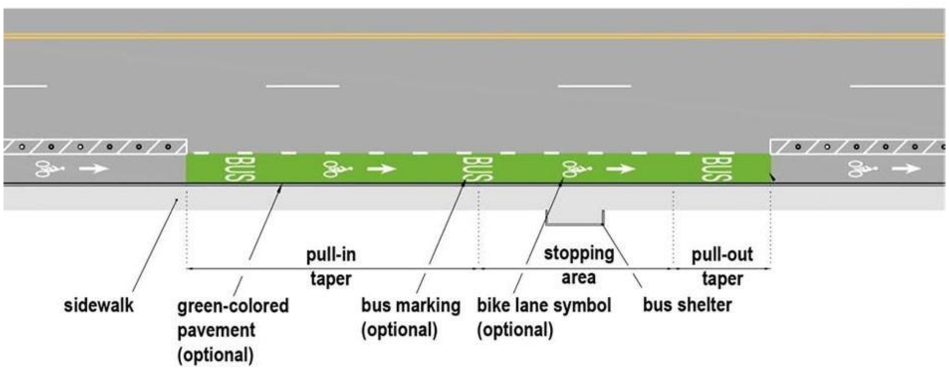


## 10.6 Bus-Only Lanes

Bus-only lanes designate the use of a travel lane for exclusive bus use. Bus lanes can improve transit speeds significantly by separating buses from general purpose traffic. Travel lanes reserved exclusively for buses should be 11-12 ft. wide.

Bus-only lanes should be accompanied with a BUS LANE sign (R3-5gP). The sign may also be designated as an R3-11d (part time buses), R3-11e (full-time buses), R3-11f (Shoulder buses), or R3-11g (Shoulder bus + right turns). The sign may be side- mounted or overhead-mounted where possible.

**Commented [JW6]:** Sign may be designated as an R3-11d (part time buses), R3-11e (full-time buses), R3-11f (Shoulder buses), or R3-11g (Shoulder bus + right turns)

A Bus Only pavement marking shall be positioned laterally in the center of the bus lane (~~OMUTCD~~ Section ~~3D~~3E.~~01~~03, 11th Edition MUTCD). The markings may be spaced as close as 80 ft. apart on city streets or as far apart as 1,000 ft. on freeways.

The lane marking requirements for bus-only lanes are described in ~~the~~ ~~OMUTCD in Section~~Chapter 3E, 11th Edition MUTCD~~D.02~~. ~~Table 10-10 provides a summary for bus-only lanes on the right or left side of the roadway or general purpose lanes.~~ Also see MUTCD Table 3E-1.

In some instances, the bus lane may allow for right-turns (or left-turns if bus lane is on left side of a one-way street) to be made from the bus lane. When this occurs, non-bus vehicles are typically restricted to only turning movements and cannot travel for an extended length in the bus lane. Signage and pavement markings should be used to communicate this operation to vehicles and the bus lane paint may be dashed rather than solid in areas where other vehicles are permitted.

If a bus-only lane is provided on a street that does not include other bicycle facilities, it will likely be used by bicyclists because there are typically fewer motor vehicles using this lane. Because the bus-only lane is for the exclusive use of transit vehicles, if the bus-bike operation is expected and desired, designers should instead consider a bus-bike lane (see Bus-Bike Lane section below).

~~**Table 10-10: Standard Edge Line and Lane Line Markings for Preferential Lanes**~~

| ~~**Type of Preferential Lane**~~ | ~~**Left Edge Line**~~ | ~~**Right Edge Line**~~ |
|---|---|---|
| ~~Barrier-Separated, Non-Reversible~~ | ~~A normal solid single yellow edge line~~ | ~~A normal solid single white edge line (see Drawing A in Figure 3E-1, 11th Edition MUTCD)~~ |
| ~~Barrier Separated, Reversible~~ | ~~A normal solid single yellow edge line~~ | ~~A normal solid single white edge line (see Drawing B in Figure 3E-1, 11th Edition MUTCD)~~ |

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**Commented [JW8]:** Recommend updating to Chapter 3E of the 11th Edition of the MUTCD. Content is covered in multiple sections.

**Commented [JW9]:** Should this include buffer separated or barrier-separated, as is included in Table 3E-1 of the MUTCD?

| | | |
|---|---|---|
| Buffer Separated, Left-Hand Side | A normal solid single yellow edge line | A wide solid double white line along both edges of the buffer space where crossing is prohibited (see Drawing A in Figure 3E-2, 11th Edition MUTCD)<br>A wide solid single white line along both edges of the buffer space where crossing is discouraged (see Drawing B in Figure 3E-2, 11th Edition MUTCD)<br>A wide broken single white line along both edges of the buffer space, or a wide broken single white line within the buffer space (resulting in wider lanes), where crossing is permitted (see Drawing C in Figure 3E-2, 11th Edition MUTCD) |
| Buffer Separated, Right-Hand Side | A wide solid double white line along both edges of the buffer space where crossing is prohibited, or a wide solid single white line along both edges of the buffer space where crossing is discouraged (see Drawing D in Figure 3E-2, 11th Edition MUTCD)<br>A wide broken single white line along both edges of the buffer space, or a wide broken single white line within the buffer space (resulting in wider lanes), where crossing is permitted (see Drawing D in Figure 3E-2, 11th Edition MUTCD)<br>A wide dotted single white line within the buffer space (resulting in wider lanes) where crossing is permitted for any vehicle to perform a right-turn maneuver (see Drawing D in Figure 3E-2, 11th Edition MUTCD) | A normal solid single white edge line (if warranted). |

| | | |
|---|---|---|
| Contiguous, Left Side | A normal solid yellow line | • A wide solid double white line where crossing is prohibited (Drawing A Figure 3D3E-3, 11th Edition OMMUTCD).<br>• A wide solid single white line where crossing is discouraged (Drawing B Figure 3D3E-3, 11th Edition OMUTCD).<br>• A wide broken single white line where crossing is permitted (Drawing C Figure 3D3E-3, 11th Edition O MUTCD). |
| Contiguous, Right Side | • A wide solid double white line where crossing is prohibited (Figure 3D3E-3, 11th Edition OMUTCD).<br>• A wide solid single white line where crossing is discouraged.<br>• A wide broken single white line where crossing is permitted (Figure 3D3E-3 OMUTCD).<br>• A wide dotted single white line where crossing is permitted for any vehicle to perform a right turn maneuver (Figure 3D3E-3 OMUTCD).<br>• A normal solid double yellow line on one-way streets with a counterflow bus only lane. | A normal solid single white line (if necessary). |

**Commented [JW10]:** Drawing A in Figure 3E-3 of the 11th Edition of the MUTCD

**Commented [JW11]:** Drawing B in Figure 3E-3 of the 11th Edition of the MUTCD

**Commented [JW12]:** Drawing C in Figure 3E-3 of the 11th Edition of the MUTCD

**Commented [JW13]:** Same notes about the 11th Edition of the MUTCD as contiguous left side bus lanes

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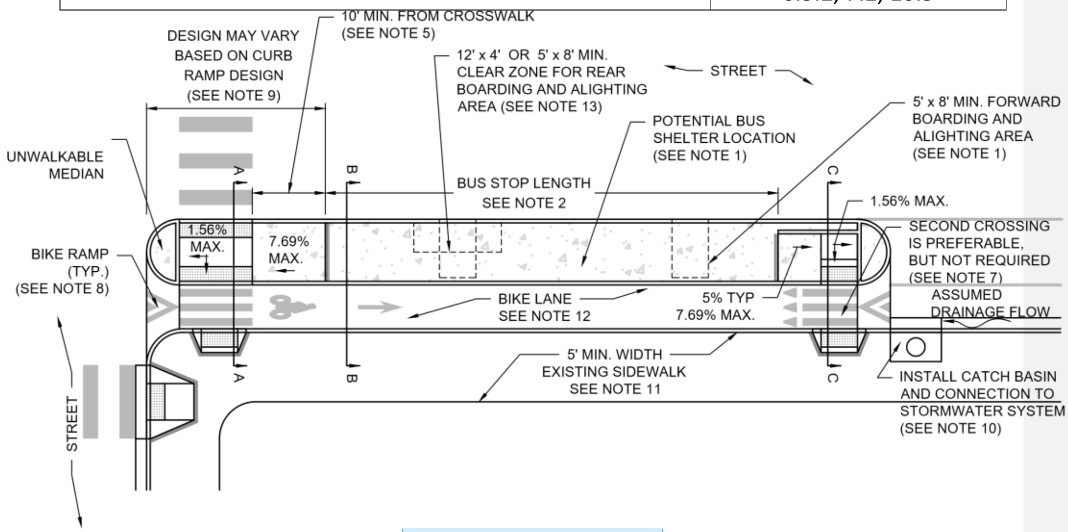
| FLOATING BUS STOP DETAILS | DWG 10-1.1 |
|---|---|
| | REFERENCE SECTIONS 4.5.3, 6.3.7, 6.3.8, 6.5.2, 7.2, 10.5 |




FLOATING BUS STOP

INTERMEDIATE-LEVEL BIKE LANE SHOWN

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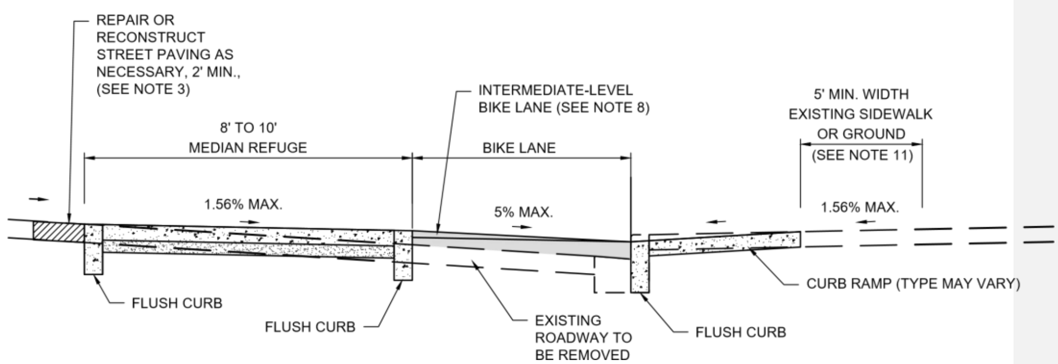
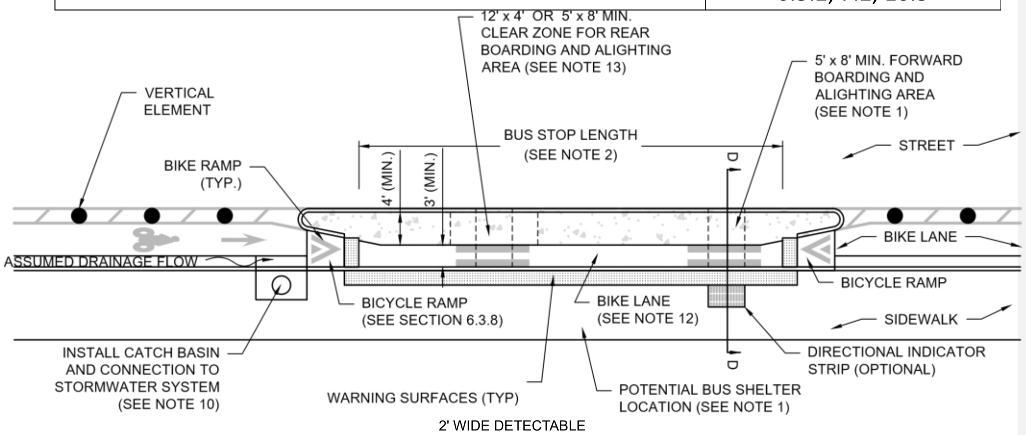
The speed hump marking on the right side of the platform is pointed the wrong direction. It is either not needed, or should be pointed the same direction as the marking on the left side.




SECTION A-A

FLOATING BUS STOP INTERSECTION CROSSWALK

| FLOATING BUS STOP DETAILS | DWG 10-1.5 |
| --- | --- |
| | REFERENCE SECTIONS 4.5.3, 6.3.7, 6.3.8, 6.5.2, 7.2, 10.5 |




FLOATING BUS STOP
CONSTRAINED CONFIGURATION

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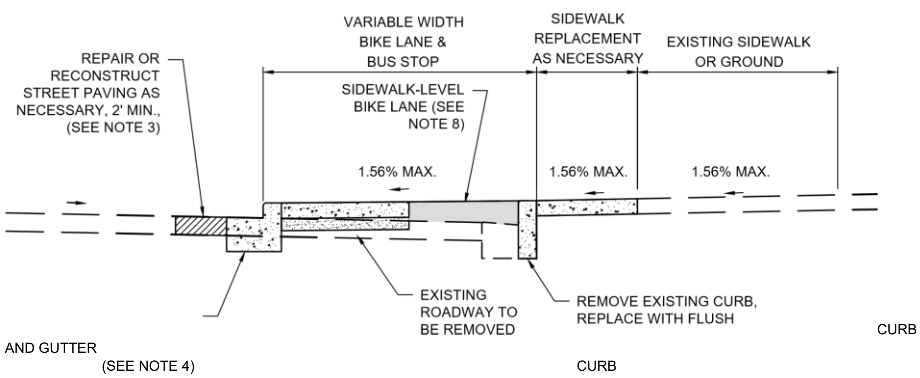
The speed hump marking on the right side of the platform is pointed the wrong direction. It is either not needed, or should be pointed the same direction as the marking on the left side.




SECTION D-D
CONSTRAINED FLOATING BUS STOP

# 11 - Rail Crossings

Published: January 17, 2025

Rail crossings can present unique challenges to non-motorized traffic. Inadequate traffic control devices may lead to confusion about how and when it is safe to cross the tracks. Additionally, crossing tracks for railroads, trolleys, streetcars, etc. can pose a physical challenge as the flangeway gaps may be a tripping hazard for a person walking and may entrap wheelchair casters or a bike wheel. This chapter provides guidance to support decision-making related to the identification of appropriate traffic control devices for walkways and bikeways for at-grade rail crossings where traffic signals are not provided in accordance with Part 8 of the OMUTCD. Designers should refer to Chapter ~~10~~ 8 where highway traffic signals are used as a rail crossing's primary control. The geometric design guidance provided in Section 11.1 is independent of traffic control devices and is therefore ~~potentially~~ applicable to all at-grade rail crossings.

## Railroad and Highway Right-of-Way

Tracks that are not continuously within the roadway (e.g., not a trolley or streetcar) typically have independent right-of-way that typically supersedes the highway right-of-way at a crossing. In most cases, the owners of the railroad right-of-way are responsible for the maintenance of anything in the right-of-way. This chapter is intended to facilitate discussions with rail owners, but the rail owners ultimately have jurisdiction over any work that occurs within their right-of-way. Any design that occurs within the railroad right-of-way must be coordinated with the owner of the railroad right-of-way. If ODOT funding is used, the Ohio Rail Development Commission (ORDC) should also be consulted, and the ORDC may provide conceptual or preliminary reviews before submission to the railroad owner. The coordination process can take an extended period of time, the coordination should begin as early as possible so the design team and railroad owner can determine the preferred treatment and ensure it can be accommodated within the anticipated project schedule and contract documents.

Where work extends outside of the railroad right-of-way, designers should assess if the highway right-of-way is sufficient for the preferred treatment. Acquiring additional right-of-way can be costly and may affect the project schedule. Any right-of-way issues should be identified and resolved as early as possible to ensure the treatment(s) can be built as intended.

### Design Considerations

Designers should consider the following five topics during the design of at-grade rail crossings to accommodate pedestrians and bicyclists:

1. Provision of Access and Design for Pedestrians and Bicyclists (Section 11.1).
2. Evaluate Available Sight Distance (Section 11.2).
3. Evaluate Primary Control for Pedestrians and Bicyclists (Section 11.3).
4. Assessing Pedestrian and Bicyclist Crash Risks and Volumes (Section 11.4).
5. Traffic Control Devices and Treatments for Pedestrians and Bicyclists (Section 11.5).

**Contents**

11.1 Provision of Access and Design for Pedestrians and Bicyclists

11.2 Evaluate Available Sight Distance

11.3 Evaluate Primary Control for Pedestrians and Bicyclists

11.4 Assessing Pedestrian and Bicyclist Crash Risks and Volumes

11.5 Traffic Control Devices and Treatments for Pedestrians and Bicyclists

11.6 Additional Resources

## 11.1 Provision of Access and Design for Pedestrians and Bicyclists

In general, it is preferable to provide people walking or bicycling their own facility to operate outside the path of motorized traffic—sidewalks, shared--use paths or designated bike lanes. ~~Section 5.1.3 discusses the provision of pedestrian facilities based on context and~~ Section 3.3.~~1~~ identifies the appropriate bikeway type based on relevant criteria, such as the design user, land use context, operating speed, and motor vehicle volume. The following section describes accessible and geometric design for pedestrian and bicycle facilities at rail crossings.

### 11.1.1 Accessible Design at Rail Crossings

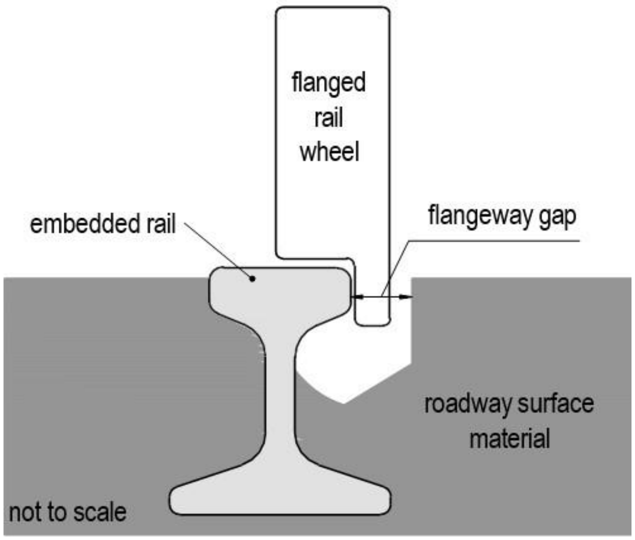
All crossing surfaces, traffic control devices, and any additional treatments provided shall meet applicable accessibility guidelines. The following is a summary of accessibility guidelines detailed in Chapter R3 of the PROWAG.

#### Pedestrian Access Route and Accessible Ramps

Pedestrian access route widths, grades, cross slopes, and surface treatments across at-grade rail crossings should follow the same design requirements discussed throughout this guide, and at a minimum shall be compliant with ADA accessibility guidelines. A curb ramp may be necessary if the at-grade crossing and the pedestrian access route are at different elevations. The design of the pedestrian access route and curb ramps as described in Chapter 4 apply at rail crossing locations.

As shown in Figure 11-1, flangeway gaps shall be a maximum of 2.5 inches on non-freight rail track and 3 inches on freight rail track. To minimize hazards posed by the flangeway gap, crossings should be as close to 90 degrees as possible (see Section 11.1.2 or section 8E.02, paragraph 4 in the OMUTCD).

**Figure 11-1: Illustration of a Rail and Flangeway Gap**




## Detectable Warnings

Detectable warning surfaces are required at approaches of all crossings where a sidewalk or shared-~~-~~use path is provided and at locations where a shoulder is intended for pedestrian travel (PROWAG R208.1). Bicycle lanes and separated bike lanes should not include detectable warning surfaces, as they are only intended for bicycle travel.

The detectable warning surface ~~shall~~ should be placed so that the edge nearest the rail crossing is ~~6~~12-15 ft. from the nearest rail. If a gate is present, the detectable warning surface should be located a minimum of 2 ft. from the projection of any gates which extend across the path (placed on the side of the gate opposite the tracks). See ~~Figure 11-2~~OMUTCD 8E.04 ~~8E-04~~.

Detectable warning surfaces shall be a minimum of 24 inches deep in the direction of pedestrian travel and shall extend the full width of any area in the pedestrian way where there is a level transition between the pedestrian way and the tracks. Where the distance between the ~~centerlines of two tracks~~two nearest tracks exceeds ~~38~~ 30 ft., additional detectable warnings designating the limits of a pedestrian crossing island (which shall be minimum length of 6 ft.) should be used at sidewalk or path grade crossings.

~~Figure 11-2: Placement of Detectable Warnings~~

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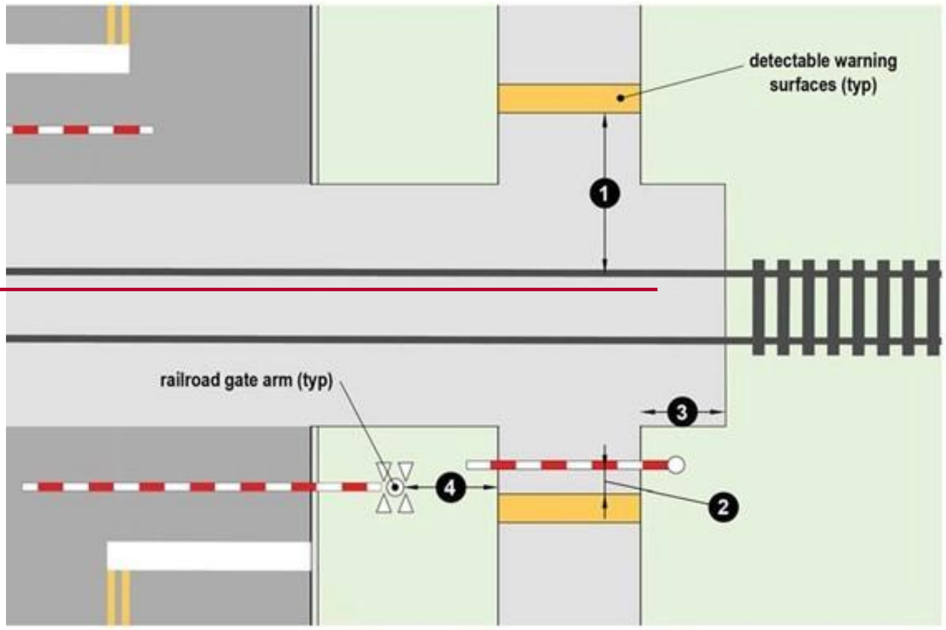


1. Nearest edge of detectable warning surfaces shall be placed 6 ft. minimum to 15 ft. maximum from the nearest rail. For skewed railways, in no instance shall the detectable warning be closer than 6 ft. measured perpendicular to the nearest rail.
2. When pedestrian gates are provided, detectable warning surfaces shall be placed on the side of the gates opposite the rail, 2 ft. from the approaching side of the gate arm. This criteria governs over Note 1 .
3. Crossing surface should extend 2' minimum past the outside edge of walk or shared use path.
4. Ensure that gate arm counterweight does not overlap with sidewalk when gate arm is extended.

### 11.1.2 Geometric Design for Rail Crossings

Railroad and streetcar tracks that interface with pedestrian and bicycle facilities can be hazardous to nonmotorized users. The following design considerations are important for pedestrian and bicycle facilities located near tracks:

- Design the crossing of the tracks to be between 60 and 90 degrees, with closer to 90 degrees preferred.
- Provide firm, stable, and slip-resistant pavement near tracks.

- Provide clear delineation of crossings with pavement markings that indicates to users where they should travel to cross rail tracks at an optimal location and angle.
- Provide warning signs to alert users of the crossing
- Provide adequate sight distances for approaching users to see the crossing ahead.

Generally, there are two configurations of pedestrian and bicycle facilities and rail interfaces: tracks located parallel to the facility, and tracks crossing the facility.

### Parallel Tracks

Tracks that are parallel to a pedestrian/bicycle facility may be located in the street (e.g., streetcar) or adjacent to the roadway. These tracks are potentially hazardous to non-motorized users, both when traveling parallel to the track and when crossing over the track.

While traveling parallel to the track, a bicyclist's wheel, a wheelchair's caster, or a pedestrian's skate may fall into the flangeway if they travel too close to the track. This may be particularly noteworthy where pedestrian and bicycle facilities are located in the street but can also occur near some shared-~~-~~use paths. In this case, the facility should be clearly delineated, and the distance between the facility and the track should be maximized.

Pedestrians or bicyclists may need to cross parallel tracks when turning onto or off a corridor. When turning, users should be encouraged (through the use of pavement markings) to cross the track at an angle between 60 and 90 degrees. This reduces the chance of a wheel falling into the flangeway and the chance of a user slipping on the rail. Figure 11-3 shows the design of a bikeway crossing parallel tracks.

### Crossing Tracks

Rail tracks that cross a street typically cross at an angle near 90 degrees which is relatively easy for a pedestrian or bicyclist to cross. Where the crossing angle is skewed, the pedestrian/bicycle facility alignment should be adjusted to cross as close as possible to 90 degrees and should be no less than 60 degrees. Figure 11-~~3~~ 2 shows an example of a bikeway alignment altered to cross skewed railroad tracks.

**Figure 11-~~3~~2: Rail Crossing Geometry Examples**

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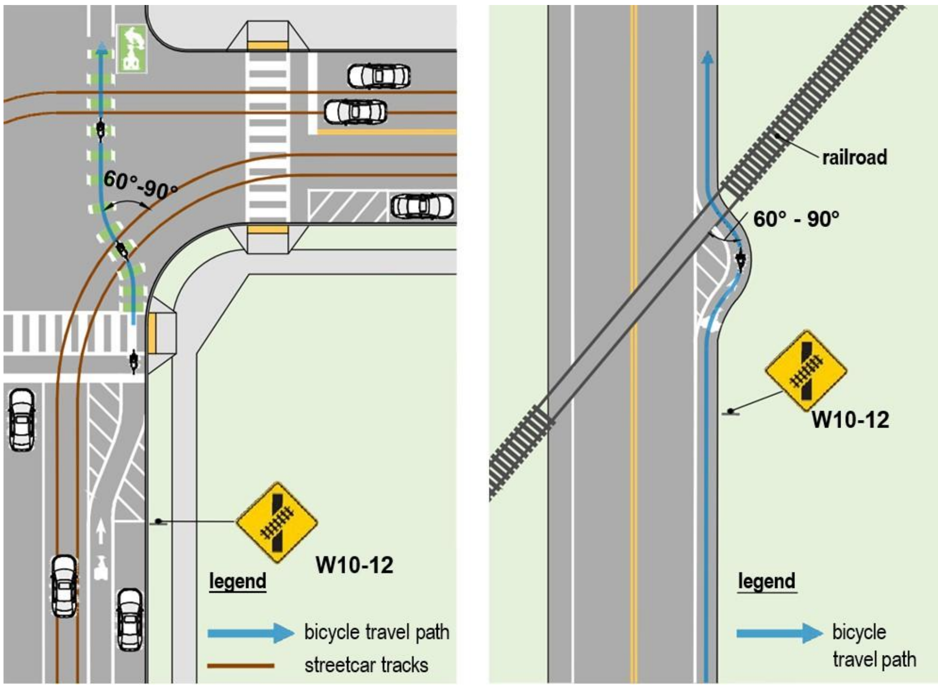


## 11.2 Evaluate Available Sight Distance

Where the crossing of tracks is not controlled by gate arms, Table 11-1[1] provides the necessary sight distance for perpendicular crossings of rail tracks on level ground. Where the clearing sight distance does not meet the values in this table, a crossing does not provide sufficient sight distance and active traffic control devices should be provided.

In non-standard cases, the following formula may be used to calculate a bicycle minimum crossing time from a stop position:

$$G_{min} = t + \frac{1.47V}{2a} + \frac{D+L}{1.47v}$$

*Where:*

$G_{min}$ = bicycle minimum crossing time (seconds)

t = perception reaction time (assumed 2.0 seconds)

v = attained bicycle crossing speed (assumed 8 mph)

a = bicycle acceleration (assumed 2.5 ft./second2)

D = crossing distance from stop, assumed to be 10 ft prior to centerline of nearest set of tracks to 10 ft past centerline of furthest set of tracks

L = length of bicycle (assumed 6 ft.)

The assumed values for the above variables may be adjusted based on site conditions and engineering judgement.

**Table 11-1: Clearing Sight Distance from Stop Position**

| | Clearing Sight Distance from Stop Position (ft) * | | | | | |
|---|---|---|---|---|---|---|
| | Crossing of 1 Track | | Crossing 2 Tracks | | Crossing 3 Tracks | |
| Train Speed (mph) | Pedestrian[1] | Bicyclist[2] | Pedestrian[1] | Bicyclist[2] | Pedestrian[1] | Bicyclist[2] |
| 10 | 120 | 100 | 180 | 120 | 240 | 140 |
| 20 | 230 | 200 | 360 | 240 | 480 | 270 |
| 25 | 290 | 250 | 450 | 290 | 600 | 340 |
| 30 | 350 | 290 | 530 | 350 | 720 | 410 |
| 40 | 460 | 390 | 710 | 470 | 960 | 540 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 50 | 570 | 490 | 890 | 580 | 1200 | 670 |
| 60 | 690 | 580 | 1060 | 700 | 1440 | 810 |
| 70 | 800 | 680 | 1240 | 810 | 1680 | 940 |
| 80 | 910 | 780 | 1420 | 930 | 1920 | 1080 |
| 90 | 1030 | 870 | 1590 | 1040 | 2160 | 1210 |

Notes:

* For far-side stops, the rear buffer should be measured from the nearest edge of crosswalk to the rear of the bus when it is stopped in the stopping area.

[1]Walking 3.5 ft per second across tracks 15 ft. apart, with a 2 second reaction time to reach a decision point 10 ft. before the centerline of the first track, and clearing 10 ft. beyond the centerline of the farthest set of tracks.

[2]Bicycling 8 miles per hour across tracks 15 ft. apart, from a stopped position 10 ft. before the centerline of the first track with an acceleration of 2.5 ft. per second, and clearing 10 ft. beyond the centerline of the farthest set of tracks on a bike of 6 ft. length.

Sight distance can also be restricted at locations with multiple tracks where a stopped train blocks the view of another approaching train. At locations where stopped or slow-moving trains regularly block the view of trains approaching crossings on an adjacent track, the sight distance should be considered restricted and active traffic control devices should be provided.

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## 11.3 Evaluate Primary Control for Pedestrians and Bicyclists

The primary control at a crossing is typically a combination of signs, pavement markings and/or physical barriers that direct the user's attention to the crossing and aid in identifying the appropriate action to take. Treatments vary based on site geometry, traffic volumes and characteristics (of non- motorized users, vehicles, and trains), or site-specific conditions. All traffic control devices and any additional treatments provided shall meet applicable accessibility guidelines.

The first step is to determine if pedestrians and bicyclists can share the traffic control provided for the roadway or if separate primary or supplementary traffic control devices are required. Typically, pedestrians and bicycles may use the roadway signage and signals if the facility is parallel to the roadway and 25 ft. or less from the edge of pavement (measured from the edge of traveled way of the roadway to the outside edge of the separated facility). The primary control may be supplemented by treatments described in Section 11.5.4.

### 11.3.1 Grade Crossings 25 Ft. or Less from a Parallel Roadway

Where pedestrians and bicyclists share the roadway with motorized traffic or are on a separated facility that is 25 ft. or less from a parallel roadway, any signage or signals applied to the roadway crossing also applies to people walking or bicycling. If pedestrians and bicyclists are provided a separate facility, it is recommended to maintain that facility through the crossing rather than to redirect the pedestrian or bicyclist facility immediately adjacent to motorized traffic. ~~In instances where automatic gates are installed, a gate or gates shall be provided such that the pedestrian, bicycle, and roadway facilities are all controlled by a gate arm (see Section 11.5.3).~~

It is not the intent of this chapter to provide guidance on roadway signage or markings. If it is elected that people walking and biking are to follow the roadway traffic control, the designer should ensure that all traffic control devices required by OMUTCD Chapter ~~8B~~ 8D are present and visible from the pedestrian and bicycle facilities. Separated facilities should be provided their own pavement markings (if used), but additional signage and/or signals may not be necessary unless the traffic control applied to the roadway is not visible to people on the separated facility. The primary control may be supplemented by treatments described in Section 11.5.4.

## Considerations for Two-Way Separated Bicycle Lanes

Although two-way separated bicycle lanes are always within 25 ft. or less of the roadway, one direction of travel on the bike lane will be opposing the direction of the nearest roadway travel lane. The following discusses traffic control placement and gate arm design for two-way separated bicycle lanes.

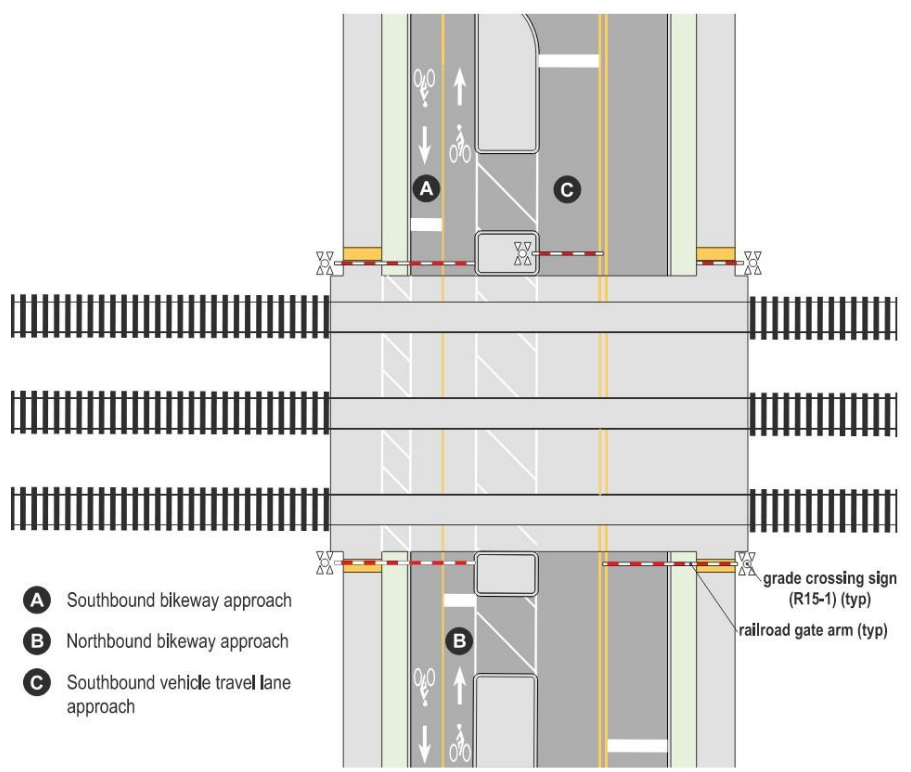
## Sign Placement for Two-Way Separated Bicycle Lanes

Regulatory and warning signage must be provided for each ~~bicycle approach~~direction of travel on the bikeway. Refer to Figure 11-~~4~~ 3 for reference on the preferable sign placements for a two-way bike lane.

- Signage for bikeway approach A and roadway approach C may be combined. It is preferable to place signage to the right of the bikeway. Depending on site conditions and roadway width, it may be appropriate to place signage within the buffer area if buffer widths are sufficient to accommodate signage while meeting shy distances.

When a raised buffer is used and is sufficiently wide to accommodate signage and shy distances, railroad signage for bikeway approach B should be placed to the right of the bikeway and within the buffer. Where ~~narrow buffers exist,~~ signage cannot physically be installed on the right, it may be placed to the left of the bikeway.

**Figure 11-~~4~~3: Two-Way Separated Bike Lane Rail Crossing**




**Commented [JB3]:** ODOT to consider revising this figure. The gates are shown wrong in this illustration for the two-way separated bike lane. They should only extend across the approach lane, not the other bike lane as they would trap bicyclists on the track doing this. The paragraph below this figure explains this as well.

**Commented [DH4R3]:** ODOT Team agreed that updating gate configuration in figure is needed.

## Automatic Gates for Two-Way Separated Bicycle Lanes

If automatic gates are used on a two-way separated bike lane, a gate arm shall be provided for each approach and should extend to cover the entire width of the approaching bike lane. A centerline raised median or flexible delineators may be used to prevent bicyclists from bypassing the gate.

Where the gate arm for the bike lane and roadway is combined, the gate arm should extend across the entire width of the bike lane. In these instances, ~~the gate should be located far enough from the nearest rail to accommodate a bicyclist with a trailer who may be trapped between the gate and rails~~refer to 11.5.3 for more details on preventing entrapment along the tracks.

### 11.3.2 Grade Crossings Greater Than 25 Ft. from a Parallel Roadway

At locations where sidewalks, separated bike lanes, or shared-use paths are greater than 25 ft. away from a parallel roadway—or where the roadway traffic control is not visible to users of these facilities—separate traffic control devices must be provided for pedestrians and bicyclists in accordance with ~~O~~MUTCD Chapter ~~8D~~8E. This is typical for grade crossings with shared-use paths that have their own alignment independent from a roadway.

#### Passive Traffic Control

Traffic control at passive crossings consists of signing and pavement markings that generally provide static messaging. At a minimum, a CROSSBUCK sign (R15-1) and a STOP sign2 (R1-1) are required at all passive crossings unless the crossing has been declared exempt as defined in the Ohio Revised Code. Designers should also review signing and marking treatments that may be required in addition to the primary traffic control devices discussed in Section 11.5.1.

#### Active Traffic Control

Active traffic control gives visual and audible warning of the approach of a train. Active devices require power service and are activated by the train, which means users will only interact with them when a train is present. All active traffic control devices at rail crossings include flashing-light signals with an audible warning and a CROSSBUCK sign (R15-1). Designers should also review signing and marking treatments that may be required in addition to the primary traffic control devices discussed in Section 11.5.1.

Where rail operation frequency is more than 4 trains per day, train operating speeds increase beyond 35 mph, or sight distance (as described in Section 11.2) is restricted, active traffic control devices should be considered for at-grade pedestrian and bicyclist rail crossings. Active control systems shall be used where LRT speeds exceed 25 mph. It may also be desirable to include supplemental traffic control devices (see Section 11.5.4).

In certain conditions, automatic gates are also provided at rail crossing. For the design and implementation of automatic gates, see Section 11.5.3. Flashing signals with automatic gates should be installed in any of the following cases:

- Any crossing with train operating speeds above 79 mph.
- Any LRT crossing with train operating speeds above 40 mph.
- Any crossing with train operating speeds 35 mph or greater where an engineering study or diagnostic review has determined that the sight distance is not sufficient for pedestrians and bicyclists to complete their crossing prior to the arrival of the train at the crossing.
- Any crossing with train operating speeds below 79 mph and either of the following conditions exist:
  - An engineering study or diagnostic review determines pedestrians and bicyclists are exhibiting risky crossing behavior (see "Risky Behavior or Crash History" in Section 11.4).
  - There is a high volume of pedestrians or bicyclists crossing per hour any peak hour in the week (see "High Pedestrian and Bicycle Volume" in Section 11.4).

## 11.4 Assessing Pedestrian and Bicyclist Crash Risks and Volumes

In addition to the basic controls previously discussed, it may be desirable to provide additional traffic control devices or treatments at locations which have any of the following conditions present:

- Restricted Sight Distance – see Section 11.2.
- Risky Behavior or Crash History – Risky behavior is defined as the observation of pedestrians or bicyclists:
- Ignoring traffic control devices or bypassing traffic control devices.
- Failing to observe approaching trains.
- Attempting to cross in front of approaching trains, placing the individual at risk of being struck by the train.
- Crossing through a stopped train by stepping between cars or rolling under a car.
- Waiting too close to crossing trains.
- A history of crashes that have the potential to be corrected by engineering measures.

This behavior should be documented through an engineering study or diagnostic review that demonstrates an existing safety problem.

- High Pedestrian and Bicycle Volumes – High pedestrian and bicycle volumes are relative to the surrounding population and land uses. Designers should consider the context of the crossing location. In urban areas, the minimum value might be 60 pedestrians/bicyclists per hour; however, in some suburban or rural contexts, the minimum value may be lower. Crossings near major pedestrian generators such as stadiums, parks, transit or passenger transfer stations, schools, or other activities can create pedestrian and/or bicyclist surges during specific times. Designers should be aware of the influence of these activity-generators and special events when evaluating user volumes and crossing behaviors.
- Quiet Zone – In an area designated as a quiet zone, trains may not sound their horn when approaching a crossing. In these locations, additional treatments should be considered to mitigate the increased risk caused by the absence of a horn.

# 11.5 Traffic Control Devices and Treatments for Pedestrians and Bicyclists

Other than grade crossing CROSSBUCK signs (R15-1) that are required at all rail crossings, the decision to provide additional traffic control devices is dependent on a variety of factors. The following describes traffic control devices most often used at rail crossings as well as the design and implementation of primary traffic control devices. Figure 11-~~5~~ 4 provides guidance for selecting the traffic control devices and treatments to address specific site conditions and train speeds.

## 11.5.1 Signing and Markings

### Stop Lines

Stop lines indicate a location where bicyclists should stop at rail crossings. Stop lines should be provided at all shared-~~-~~use path, shoulder, separated bike lane, and bike lane crossings to ensure bicyclists are waiting outside the dynamic envelop of a train. They should also be used at all locations with a gate to ensure bicyclists stop prior to a gate. Stop lines may extend across the full width of the bikeway and should be:

- 12 inch – 24 inch wide white lines. Although stop lines of 24 inches are most common for roadways, 12 inch lines may be considered on bikeways (see OMUTCD 3B.19).
- Located no less than 15 ft. nor more than 50 ft. in advance of the nearest rail

- Located a minimum of 2 ft. from the projection of any gates, flashing light signals, and crossbuck signs which extend across a path, placed prior to the approach to the gate. If stop lines are co-located with roadway stop lines, they should be located a minimum of 8 ft. from the gate ~~(~~see OMUTCD ~~8D~~8C.034).

## Path Delineation

Path delineation defines the path a pedestrian or bicyclist should take to safely and efficiently navigate an at-grade rail crossing. People should not have to make decisions as to the appropriate direction of travel after entering the grade crossing. Due to the irregular shape of the rails, a longitudinal bar or double-bar style crosswalk should not be used.

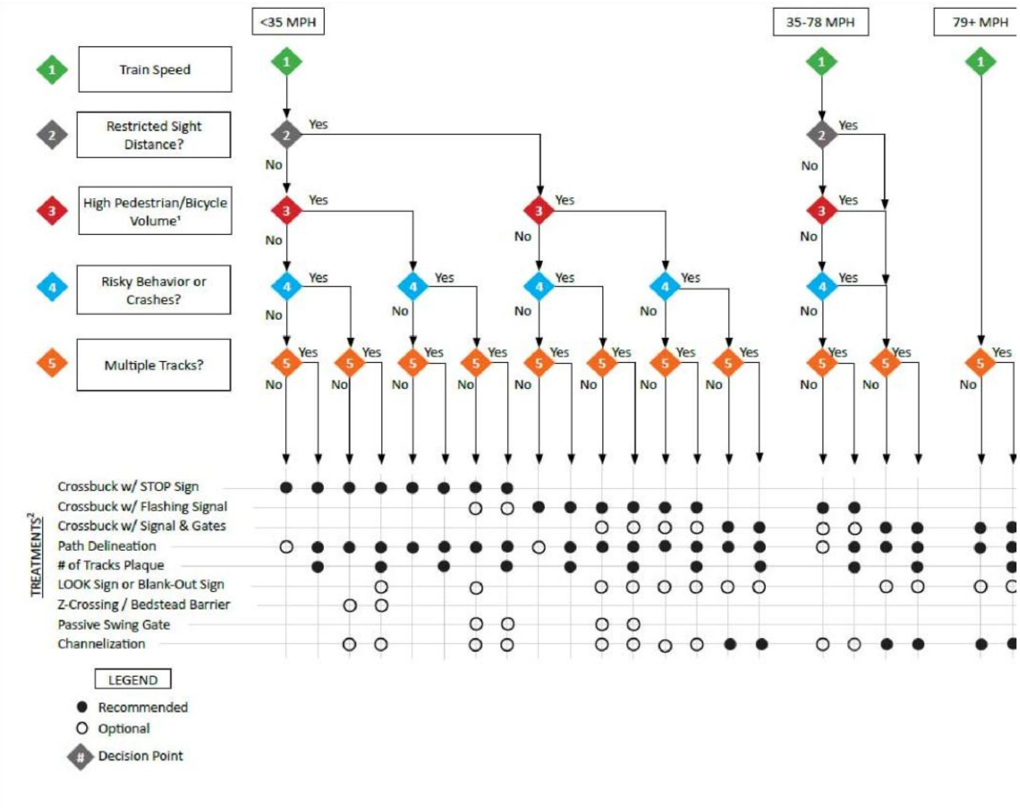
Where pedestrians are expected to cross, path delineation should be provided by either or both of the following:

- Pavement markings (minimum 4-inch white edge lines or crosswalks).
- 6-12 inch lines may be used to add emphasis to the crossing location and assist people with visual disabilities to identify the edge of the path (section 3B.09 of the OMUTCD).
- Color/texture differences which provide visual contrast from the surrounding area

Path delineation should be used at any crossing where one or more of the following conditions exist:

- Crossing length exceeds 40 ft. (such as at skewed crossings).
- Locations with more than 1 track.
- Where the pedestrian or bike path is immediately adjacent to a vehicular traveled way.

**Figure 11-54: Decision Tree for Selecting Traffic Control Devices & Treatments for Pedestrian and Bicycle Rail Crossings**




## Dynamic Envelope Markings

Dynamic envelope markings are a type of pavement marking that identifies the physical boundary of a train as it travels through a crossing. Dynamic envelope marking guidance can be found in OMUTCD 8C.06 and TEM 802-3. See also Figure 11-5. should be used at all crossings that include gates where a person may be located between a gate and the tracks. They should be:

A minimum of 4 inch width white pavement markings.

Located to create a buffer that is 6 ft. minimum from the nearest rail.

**Figure 11-65: Reserved for Future UseExample Dynamic Envelope Markings with Cross-Hatching with Optional Supplemental "Do Not Block Intersection" Markings (Source: Federal Railroad Administration)**

### Skewed Crossing Sign (W10-12)

A crossing angle of less than 60 degrees from perpendicular should not be used (see Section 11.1.2). When a crossing angle less than 60 degrees cannot be avoided, a SKEWED CROSSING sign (W10-12) may should be used wherever bicyclists must cross tracks at an angle between 30 and 60 degrees from perpendicular, as they have an increased likelihood of a crash due to a wheel being caught in a rail flangeway.

### Grade Crossing (CROSSBUCK) Sign (R15-1)

A CROSSBUCK sign (R15-1) is required at all rail grade crossings. The sign shall should be installed on the right-hand side of facilities, although it may be located to the left-hand side where restricted sight distance or unfavorable highway geometry existis, or where there is a one-way multi-lane approach. if the facility is using the roadway signage.

### Number of Tracks Plaque

A NUMBER OF TRACKS plaque (R15-2P) supplements a CROSSBUCK sign (R15-1) and shall be provided at all crossings where automatic gates are not present and there are two or more tracks at a grade crossing. When automatic gates are present, a NUMBER OF TRACKS Plaque (R15-2P) may still help inform non-motorized users of the crossing distance and avoid leaving them trapped between the gates.

### LOOK Sign (R15-8)

The LOOK sign (R15-8) should may be mounted as a supplemental plaque at all locations where trains operate in two directions and where one of the following conditions occurs:

- An engineering study or diagnostic review has determined that the sight distance is not sufficient for pedestrians and bicyclists to complete their crossing prior to the arrival of the train at the crossing (see Section 11.2).
- An engineering study or diagnostic review determines that pedestrians and bicyclists are exhibiting risky crossing behavior (see Section 11.4, "Risky Behavior or Crash History").
- Locations with passive pedestrian swing gates.
- There are not high pedestrian volumes (see Section 11.4, "High Pedestrian and Bicycle Volumes").

The LOOK Sign (R15-8) should not be used where blank out signs or automatic gates are present over the pedestrian facility.

### Blank-Out Warning Sign

A Blank-Out Warning sign, such as the LIGHT RAIL TRANSIT APPROACHING-Activated Blank- Out Warning Sign (W10-7), may be posted at locations where it is desired to provide additional emphasis in place of the LOOK Sign (R15-8) or at locations with multiple tracks where stopped or slow-moving trains block the view of trains approaching on an adjacent track.

Blank-Out Warning signs may also be used when a vehicular movement is only prohibited when a train or streetcar is present, such as a turning movement that crosses tracks.

## 11.5.2 Flashing-Light Signals

### Flashing-Light Signals with Audible Warning Device

Flashing light signals consist of two light units arranged horizontally that flash in an alternating pattern.

They may be mounted on assemblies next to the roadway or path, overhead, or both, based on site visibility. Flashing-lights shall be accompanied by a CROSSBUCK sign (R15-1) on the mounting assembly and an audible warning device. A supplemental Number of Tracks sign (R15-2P) shall be included where there is more than one track.

### Pedestrian Signals and Audible Pedestrian Signals

At crossing locations controlled by highway traffic signals, pedestrian signals are required. All pedestrian at grade crossings with active controls must should provide supplemental bells or other audible warning devices. Locations controlled by traffic signals which include Accessible Pedestrian Signal (APS) equipment do not require supplemental bells or audible devices as they may diminish the effectiveness of the APS equipment.

## 11.5.3 Automatic Gates

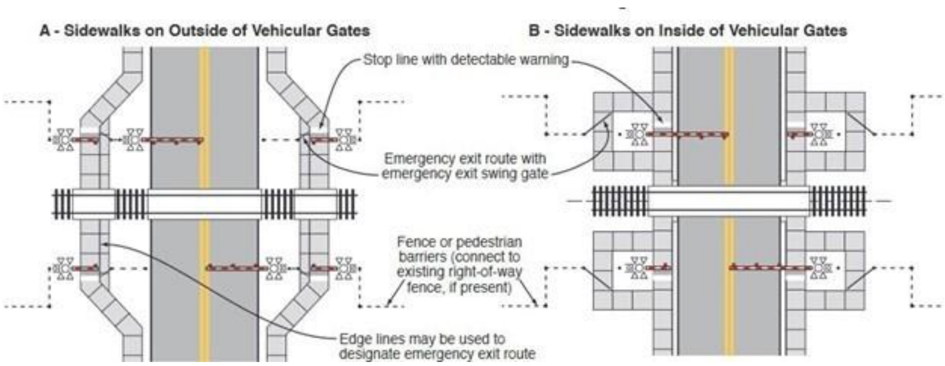
Automatic gates lower when a train is approaching to create a physical barrier between the pedestrian or bicyclist and the tracks. Automatic gates are may be installed in addition to flashing-light signals in order to enhance visibility and inform pedestrians and bicyclists when it is safe to cross. If trains are permitted to travel at 40 mph or more, the crossing shall be equipped with a system of automatic pedestrian gates and an escape area. If a separate pedestrian or shared--use path gate is provided, the need for a separate CROSSBUCK sign, audible device, and flashing-light signal should be determined based on site-specific conditions such as the proximity of the sidewalk or shared--use path to the roadway grade crossing devices, see Section 11.3.

Automatic gate arms shall extend the full width of the sidewalk or shared--use path. The sidewalk or shared-use path gate may be combined with adjacent vehicular gates (if pedestrians and bicyclists are following the roadway traffic control), or a separate gate may be provided as shown in Figures 8C-5 8E-9 and 8C-6 of the OMUTCD, and Figure 11-7 6 below. There should be a minimum of 2 ft. between the edge of sidewalk or path and any protrusions from the gate arm and counterweights while in its raised position or any portion of the flashing-light signal assembly.

Where automatic gates are installed, channelizing fence and gate skirts may be used to prevent bicyclist and pedestrians from bypassing the gates. A clear zone should be provided between the train's dynamic envelope and the pedestrian gates that is a sufficient width for the anticipated users, including bicyclists with trailers. The dynamic envelope of the train should be marked. An emergency escape route with an emergency exit swing gate must allow pedestrians to exit the refuge area so that they do not become trapped on the trackway when the automated gates are activated. This will require the use of a separate gate arm for sidewalks and shared use paths. Each of these treatments are discussed in the subsequent sections.

**Figure 11-76: Automatic Gates - Separate from Vehicular Gates (Left) & Combined with Vehicular Gates (Right)**

Commented [JB5]: There is a new version of this graphic in the OMUTCD and it's slightly different. Consider replacing with this figure with the new OMUTCD Figure 8E-9.




## Channelizing Fencing

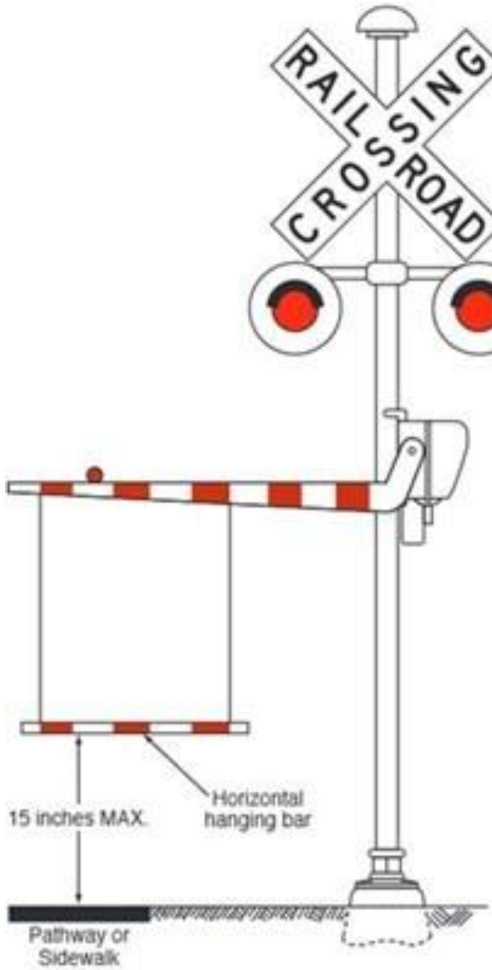
Fencing may be installed to direct pathway users to the grade crossing used to discourage pedestrians from crossing tracks at random by preventing and prevent them from bypassing the gate. Fencing should extend parallel to the tracks a minimum of 50 ft. back from designated pedestrian crossings to direct pedestrians to the crossing. Where fencing is used, the height should be a maximum of 3.5 ft. within 100 ft. of the crossing to avoid restricting sight distances. Alternatives to fencing less likely to impede sight distance include bollards, short posts with chains, or low landscaping. Maze fencing and pedestrian barriers need to be designed to permit the passage of wheelchairs, power-assisted mobility devices, and bicycles.

## Gate Skirts

Crossing gate skirts may be constructed across pedestrian facilities by attaching a horizontal hanging bar to the gate arm (see Figure 11-87) and have been shown to be effective at reducing the likelihood that pedestrians, in particular children, will violate a lowered crossing gate. Gate skirts should be provided where pedestrian traffic is likely.

**Figure 11-~~8~~7: Automatic Gate Arm with Gate Skirt**

Commented [JB6]: Recommend replacing this with Figure 8E-12 in 11th Edition.




## Entrapment and Emergency Swing Gates

Individual users on bikes or walking will require a broad range of times to complete a crossing. As such, it may not be possible or practical to time the gate arms so that all users can clear the tracks before the arms lower. This may leave some slower-moving users trapped between the tracks and the gate as a train approaches. A refuge area clear of obstructions should be provided between the train's dynamic envelope and the pedestrian gates that is of sufficient width for the anticipated users, including bicyclists. Gates located a minimum of 14 ft. from the nearest rail would accommodate a typical bicyclist, and a minimum of 18 ft. from the nearest rail to accommodate a bicyclist with a trailer. These minimums assume a dynamic envelope of 6 ft. and should be enlarged if directed by the rail operator. The dynamic envelope should be marked so that any entrapped users are aware of what space may be safely occupied.

In locations where entrapment is possible, an emergency swing gate (see Figure 11-~~9~~8) shall be provided that allows users to exit the refuge area. Emergency swing gates shall open away from the tracks and should have a latch that only permits the gate to be opened from the track side of the gate. Swing gates shall automatically return to the closed position after each use. Swing gates should be equipped with a PUSH TO EXIT (I13-2) sign on the track side of the gate and DO NOT ENTER (R5-1) sign on the side of the gate facing away from the tracks. See also OMUTCD Figure 8E-10.

**Figure 11-~~9~~8: Automatic Gate for Pedestrian Facilities with an Emergency Swing Gate (Source: Los Angeles County Metropolitan Transportation Authority)**


The design of the emergency swing gate shall permit the passage of wheelchairs, power-assisted mobility devices, and bicycles (where allowed). The design should permit bicyclists to traverse the gate by dismounting and walking the bicycle through the gated area. If the emergency swing gate is at a different elevation than a bike lane (for example, the bike lane is street level and the gate is on a sidewalk), then a ramp should be provided to allow bicyclists to access the emergency swing gate. Swing gates shall be designed in compliance with current ADA requirements. The gate should be retroreflective.

### 11.5.4 Supplemental Treatments

The following supplemental treatments are optional treatments that may support the primary and other required traffic control devices when certain conditions are present.

#### Z-Crossing or Bedstead Barrier Channelization

Z-crossing or Bedstead Barrier channelization requires approaching pedestrians and bicyclists to deviate from their approach path in advance of the crossing. They may be considered for use at crossings where:

- There are not high pedestrian or bicyclist volumes (see Section 11.4, "High Pedestrian and Bicycle Volumes").
- Sight distance meets requirements for pedestrians and bicyclists (see Section 11.2).
- An engineering study or diagnostic review determines people exhibit risky crossing behavior (see Section 11.4, "Risky Behavior or Crash History").
- Location does not allow for bicyclists or pedestrians to easily bypass the Z-crossing or Bedstead Barrier.

The design of these crossings needs to permit the passage of wheelchairs and power-assisted mobility devices. The design should also permit bicyclists to traverse the barriers at low speed without dismounting and accommodate the physical lengths of longer bicycles (e.g., cargo bikes, bikes with trailers).

The use of Bedstead Barriers should be limited to locations with a documented risky behavior or crash problem that is caused by bicyclists not stopping at railroad crossing. Bedstead Barriers present a fixed object safety hazard to bicyclists and can impede passage for bicyclists and pedestrians exiting a railroad crossing by slowing the exit if/when groups cross, potentially trapping people within the crossing area.

#### ~~Pedestrian Swing Gates~~

~~Pedestrian swing gates are movable barriers that pedestrians and bicyclists must open manually to cross the tracks. The pedestrian swing gate differs from the emergency swing gate discussed in Section 11.5.3 because pedestrian swing gates are opened to begin a rail crossing whereas emergency swing gates are opened to complete a rail crossing and prevent entrapment. Pedestrian swing gates may be used where:~~

- ~~There are high pedestrian or bicyclist volumes (see Section 11.4, "High Pedestrian and Bicycle Volumes").~~
- ~~Sight distance does not meet requirements for pedestrians and bicyclists (see Section 11.2).~~

**Commented [JB7]:** The MUTCD 11th Edition does not include any discussion of pedestrian swing gates. Recommend removing this section.

- An engineering study or diagnostic review determines people exhibit risky crossing behavior (see Section 11.4, "Risky Behavior or Crash History").
- Location does not allow for bicyclists or pedestrians to easily bypass the swing gate.

Pedestrian swing gates shall open away from the tracks and should be able to be easily opened from either side of the gate. Swing gates shall automatically return to the closed position after each use.

The design of the pedestrian swing gate shall permit the passage of wheelchairs, power-assisted mobility devices, and bicycles (where allowed). The design should permit bicyclists to traverse the gate by dismounting and walking the bicycle through the gated area. Swing gates shall be designed in compliance with current ADA requirements, and a detectable warning shall be placed in advance of the gate (see Section 11.1.1). The gate should be retroreflective.

Since swing gates present a fixed object safety hazard to bicyclists, their use should be limited to locations with a documented risky behavior or crash problem that is caused by bicyclists or pedestrians not stopping at railroad crossings. The LOOK sign (R15-8) should be mounted as a supplemental plaque at all locations where trains operate in two directions and a pedestrian swing gate is used.

### Channelization

Channelization strategies may be used to guide people to the rail crossing and encourage them to take the desired path through the crossing. It can consist of rough surfaces designed to be unwalkable/rideable, fences, or other similar barriers. Where fencing or barriers are used, the ends should be retro-reflectorized and sufficient lighting should be provided to ensure the crossing area is visible to approaching bicyclists and pedestrians to reduce the potential for a crash.

### Supplemental Illumination

Supplemental illumination should be considered to enhance visibility of the crossing and traffic control treatments where one or more of the following conditions occur:

- Road users have trouble seeing trains or traffic control devices during hours of darkness
- A substantial amount of railroad operations occur at night (greater than 4 trains per evening)
- Locations with frequent operation of low speed trains (greater than 4 trains per day)
- Grade crossings are blocked for extended periods of time at night (such as near switching yards)
- A crash history indicating that people fail to detect trains or traffic control devices at night
- Locations with restricted sight distance to the crossing on the approach
- Locations where long dark trains, such as unit coal trains, operate at night

## 11.6 Additional Resources

The following resources provide information about the design of rail crossings to accommodate people walking and biking:

- Ohio Manual of Uniform Traffic Control Devices (OMUTCD), Part 8. Ohio Department of Transportation, Columbus, Ohio, 2012.
- Traffic Engineering Manual (TEM), Part 8. Ohio Department of Transportation, Columbus, Ohio.
- Highway-Rail Crossing Handbook, 3rd Edition. Federal Highway Administration, U.S. Department of Transportation, Washington DC, 2019.
- Engineering Design for Pedestrian Safety at Highway-Rail Grade Crossings. Federal Highway Administration, U.S. Department of Transportation, Washington DC, 2016.
- Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way (PROWAG), Chapter R3. United States Access Board, Washington DC, 2011.

### ~~Chapter 11 Endnotes~~

~~1. This table incorporates the values from Table 41 in the Railroad-Highway Grade Crossing Handbook, Revised 2nd Edition, 2007.~~

~~2.~~1. ~~A STOP sign is required by ORC 4511.61, which was revised after the publication of the 2012 OMUTCD. See Traffic Engineering Manual (TEM) Section 801-2.~~