Federal Highway Administration

SEPARATED BIKE LANE PLANNING AND DESIGN GUIDE

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Any traffic control devices that are used for separated bike lanes must comply with the Manual on Uniform Traffic Control Devices (MUTCD). The MUTCD is incorporated by reference in 23 Code of Federal Regulations, Part 655, Subpart F, and is approved as the national standard for designing, applying, and planning traffic control devices installed on any street, highway, or bikeway open to public travel. The FHWA issues the MUTCD, which contains all national design, application, and placement standards, guidance, options, and support provisions for traffic control devices used with separated bike lanes. The jurisdiction implementing the bike lane must ensure that the project complies with the MUTCD. Please note that interim approvals (IAs) have been issued by the FHWA for green colored pavement (IA-14) and bicycle signal faces (IA-17). Agencies who desire to use green colored pavement or bicycle signal faces must request specific approval from the FHWA using the procedure outlined in Paragraphs 14 through 22 of Section 1A.10 of the MUTCD. Please also note that bike boxes and two-stage turn boxes are still experimental. Agencies who desire to experiment with bike boxes or two-stage turn boxes must request approval from the FHWA using the procedure outlined in Paragraphs 8 through 11 of Section 1A.10 of the MUTCD. The FHWA maintains a web page regarding the MUTCD approval status of various bicycle-related treatments at http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/design_guidance/mutcd.

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98 How can accessible parking and loading be accommodated in tandem with a SBL?

102 What factors should be considered when designing intersections along a corridor with a SBL?

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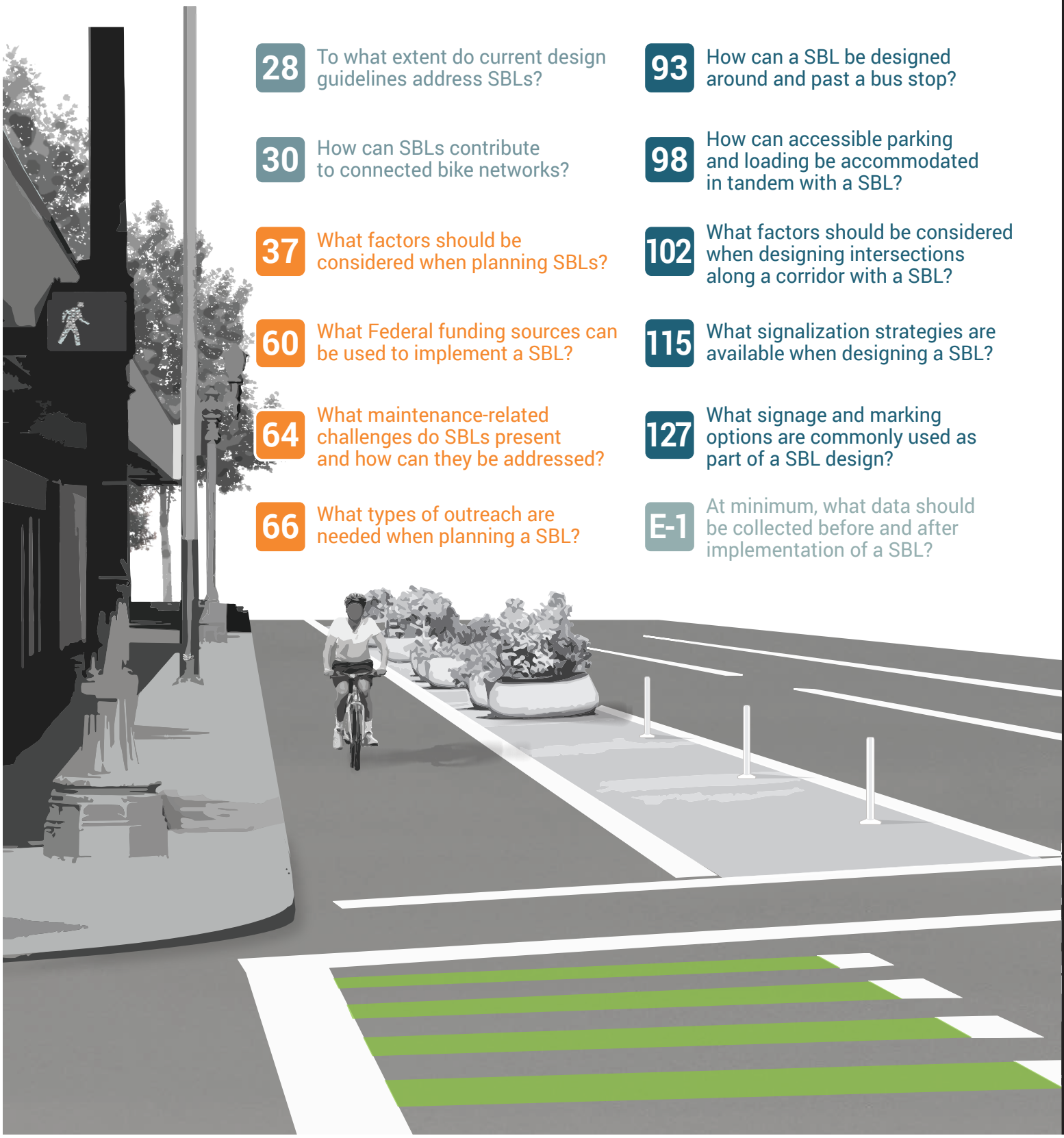
E-1 At minimum, what data should be collected before and after implementation of a SBL?

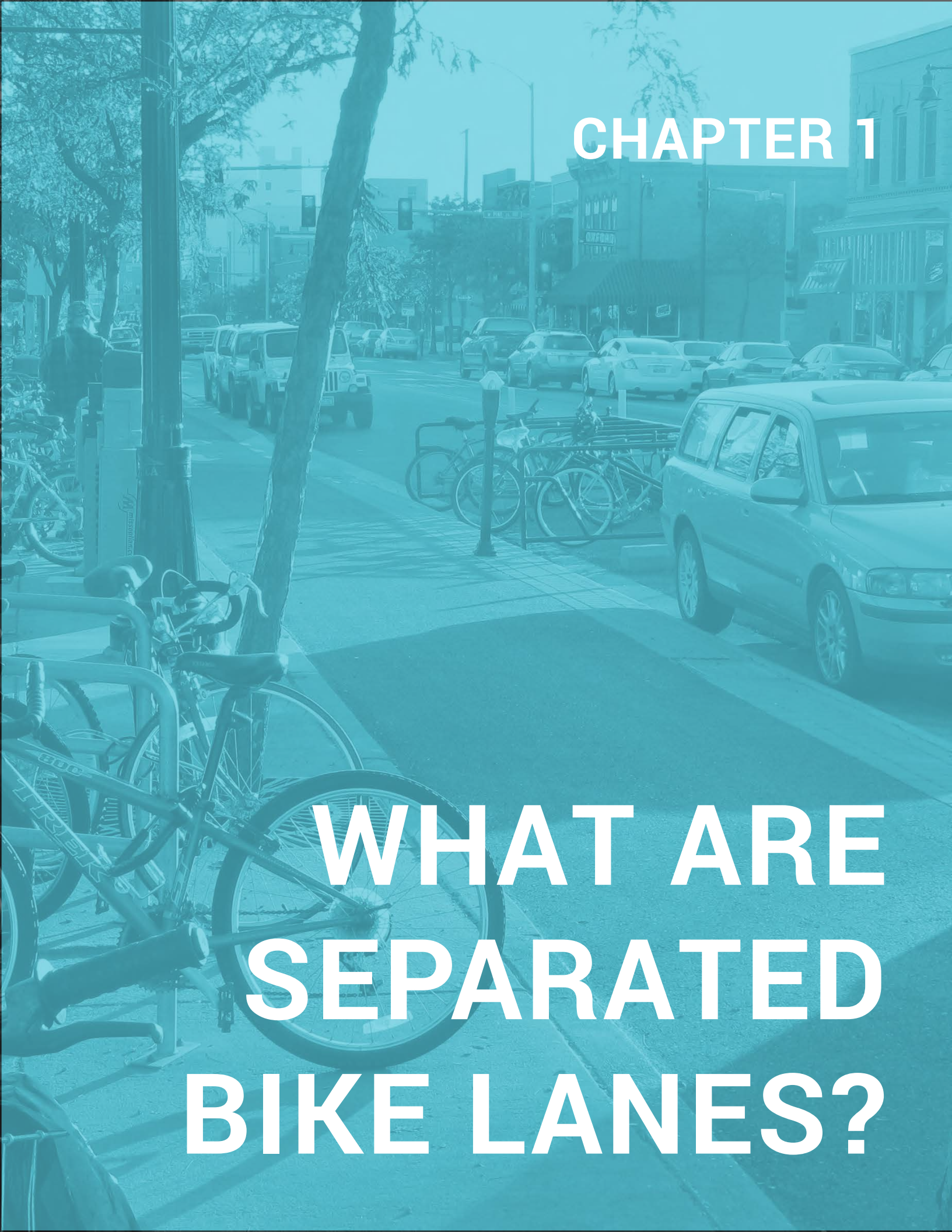


SEPARATED BIKE LANE PLANNING AND DESIGN GUIDE

Figure 1

This *Separated Bike Lane Planning and Design Guide* outlines planning considerations for separated bike lanes (also sometimes called "cycle tracks" or "protected bike lanes") and provides a menu of design options covering typical one and two-way scenarios. It highlights different options for providing separation, while also documenting midblock design considerations for driveways, transit stops, accessible parking, and loading zones. It provides detailed intersection design information covering topics such as turning movement operations, signalization, signage, and on-road markings. Case studies highlight best practices and lessons learned throughout the document.

The Guide consolidates lessons learned from practitioners designing and implementing separated bike lanes throughout the U.S. It attempts to capture the current state of practice, while still recognizing that our understanding of this facility type is still evolving and that there is a need for design flexibility. To encourage continued development and refinement of techniques, the guide identifies specific data elements to collect before and after implementation to enable future analysis across facilities in different communities. It identifies potential future research, highlights the importance of ongoing peer exchange and capacity building, and emphasizes the need to create holistic ways to evaluate the performance of a separated bike lane.



CHAPTER 1

WHAT ARE SEPARATED BIKE LANES?

WHAT ARE SEPARATED BIKE LANES?

Separated Bike Lanes Defined

A separated bike lane is an exclusive facility for bicyclists that is located within or directly adjacent to the roadway and that is physically separated from motor vehicle traffic with a vertical element. Separated bike lanes are differentiated from standard and buffered bike lanes by the vertical element. They are differentiated from shared use paths (and sidepaths) by their more proximate relationship to the adjacent roadway and the fact that they are bike-only facilities. Separated bike lanes are also sometimes called "cycle tracks" or "protected bike lanes."

Within the common elements of separated bike lanes – dedicated space for cyclists that is separated from motor vehicle travel and parking lanes – practitioners have flexibility in choosing specific design elements. Separated bike lanes can operate as one-way or two-way facilities; their designs can integrate with turning automobile traffic at intersections or can be more fully separated; they can be designed at roadway grade, at sidewalk grade or at an intermediate grade; and they can be separated from the adjacent roadway or sidewalk with a variety of treatments including but not limited to on-street parking, raised curbs or medians, bollards, landscaping, or planters.

Higgins Street separated bike lane in downtown Missoula, MT (Source: City of Missoula)

Figure 2 Separated Bike Lanes compared to other bicycle facility types

Least Separation

Signed Routes (No Pavement Markings)

A roadway designated as a preferred route for bicycles.

Shared Lane Markings

A shared roadway with pavement markings providing wayfinding guidance to bicyclists and alerting drivers that bicyclists are likely to be operating in mixed traffic.

On-Street Bike Lanes

An on-road bicycle facility designated by striping, signing, and pavement markings.

On-Street Buffered Bike Lanes

Bike lanes with a painted buffer increase lateral separation between bicyclists and motor vehicles.

Separated Bike Lanes

A separated bike lane is an exclusive facility for bicyclists that is located within or directly adjacent to the roadway and that is physically separated from motor vehicle traffic with a vertical element.

Off Street Trails / Sidepaths

Bicycle facilities physically separated from traffic, but intended for shared use by a variety of groups, including pedestrians, bicyclists, and joggers.

Most Separation

(Photo sources, from top: Nick Foster, Eric Gilliland, Conor Semler, Kevin Lee, Karla Kingsley, Nick Foster)

Separated bike lanes are one of many bicycle facility types that can be used to create connected bicycle networks. FHWA defines a network as *"Interconnected pedestrian and/or bicycle transportation facilities that allow people of all ages and abilities to safely and conveniently get where they want to go."* Connected bicycle networks can include all of the facility types shown in Figure 2.

WHAT ARE SEPARATED BIKE LANES?

Separated Bike Lanes in the United States

Separated bike lanes have existed in the United States since at least the 1970s, but only in the past several years has interest spread outside of a handful of early-adopting cities: an inventory of such facilities found that they have doubled in number since 2011 and may double again by 2016.[1] Separated bike lanes have been a fixture of bicycle networks in many countries with high rates of cycling for decades. Today, interest in separated bike lanes is accelerating in the U.S. and there is a rapidly growing list of planned and implemented separated facilities across the country. The Green Lane Project, a program of the PeopleForBikes organization, maintains an inventory of separated bike lanes in the U.S., which is available at: http://www.peopleforbikes.org/green-lane-project/pages/inventory-of-protected-bike-lanes.

[1] *Inventory of Protected Bike Lanes (PeopleForBikes, 2014)*

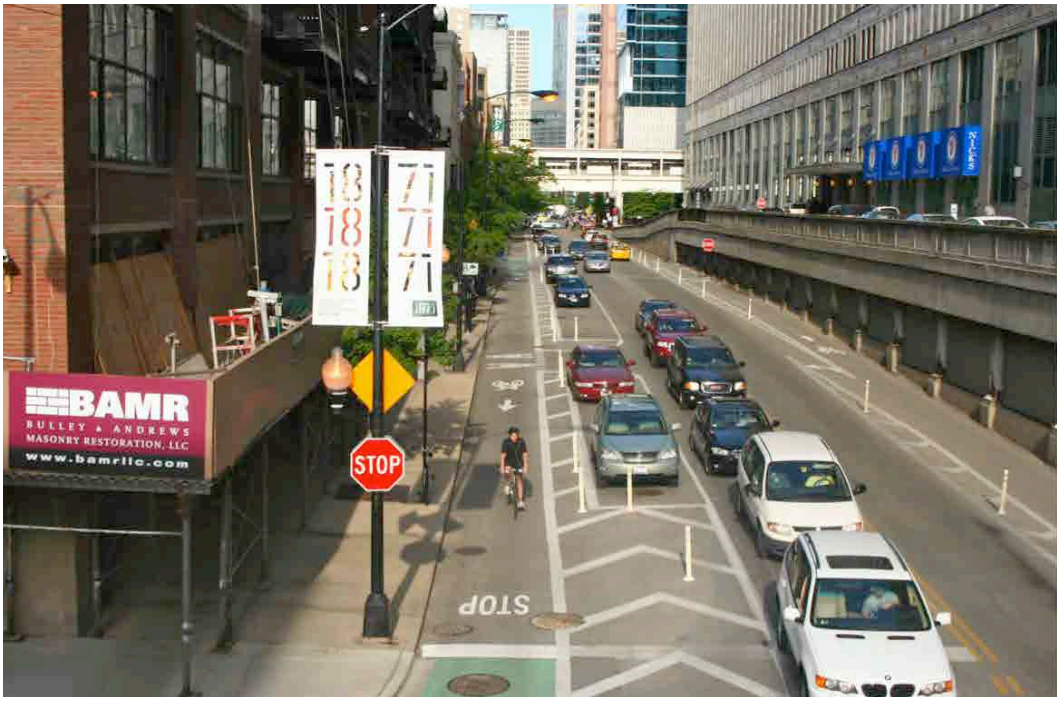
WHAT ARE SEPARATED BIKE LANES?

Separated Bike Lanes in Context

Separated bike lanes have the potential to improve traffic safety for all street users, especially when implemented as part of a "road diet" or other traffic calming project. Separated bike lanes can help to organize all traffic modes, while also reducing pedestrian crossing distances and decreasing "leapfrogging" between buses and bicyclists. Separated bike lanes can contribute to increased bicycling volumes and mode shares, in part by appealing to less confident riders and this could eventually result in a more diverse ridership across age, gender, and ability. Shifting a greater share of commute, errand, or social trips to the bicycle also offers one potential solution for relieving traffic congestion and contributing to other public policy goals.

Separated bike lanes are one of many bicycle facility types and they exist within a broader context shaped by demographic and land use changes and influenced by interrelated transportation, public health, environmental, and economic factors. In many communities there is an aging population maintaining an independent lifestyle later in life and at the same time a generation of younger adults that is driving less and riding transit more than previous generations. Separated bike lanes can speak to both of these demographic trends, while also contributing to a community's health and economic goals, as noted below.

As the linkages between the built environment and public health – in particular, the obesity epidemic – have become clear, creating more opportunities for residents to incorporate "active transportation" modes such as walking and bicycling into their daily lives has been identified as one strategy to encourage healthier lifestyles [(2)]. Research has also suggested that the creation of bicycle-friendly streets can be a boon to business, encouraging greater patronage of local retail [(3)]. Cities like New York City and Chicago have framed strategic infrastructure investments, such as separated bike lanes, as an element of their economic development strategies.



On Kinzie Street in Chicago, parked cars and flexible delineator posts on both sides of the street separate the bike lanes from traffic. (Source: City of Chicago)

Separated Bike Lanes and the Community

As with all transportation investments, there are important equity considerations associated with separated bike lanes. Separated bike lanes can contribute to greater mobility at low cost to lower-income populations, providing a "last mile" link to transit, and expanding access to employment opportunities. Providing opportunities for public input throughout the planning and design process can build local support for separated bike lanes, while also ensuring that community concerns are addressed.

Chapter 4 of this document emphasizes the importance of providing opportunities for early and ongoing public engagement in proposed separated bike lane projects because a strong public involvement program will ensure that social, economic, and environmental issues are fully considered. Practitioners must also ensure that their professional actions do not impose "disproportionately high and adverse effects" on low-income and minority populations, as specified by the DOT Order 5610.2(a), Title VI of the Civil Rights Act of 1964, and the Environmental Justice Executive Order 12898.

For more information on public involvement requirements, see:

https://www.fhwa.dot.gov/planning/public_involvement/orders/#a11

Refer specifically to *Part 450: Planning Assistance and Standards, Subpart B: Statewide Transportation Planning and Programming, 23 CFR 450.210: Interested parties, public involvement, and consultation* and *Part 450: Planning Assistance and Standards, Subpart C: Metropolitan Transportation Planning and Programming, 23 CFR 450.316: Interested parties, participation, and consultation.*

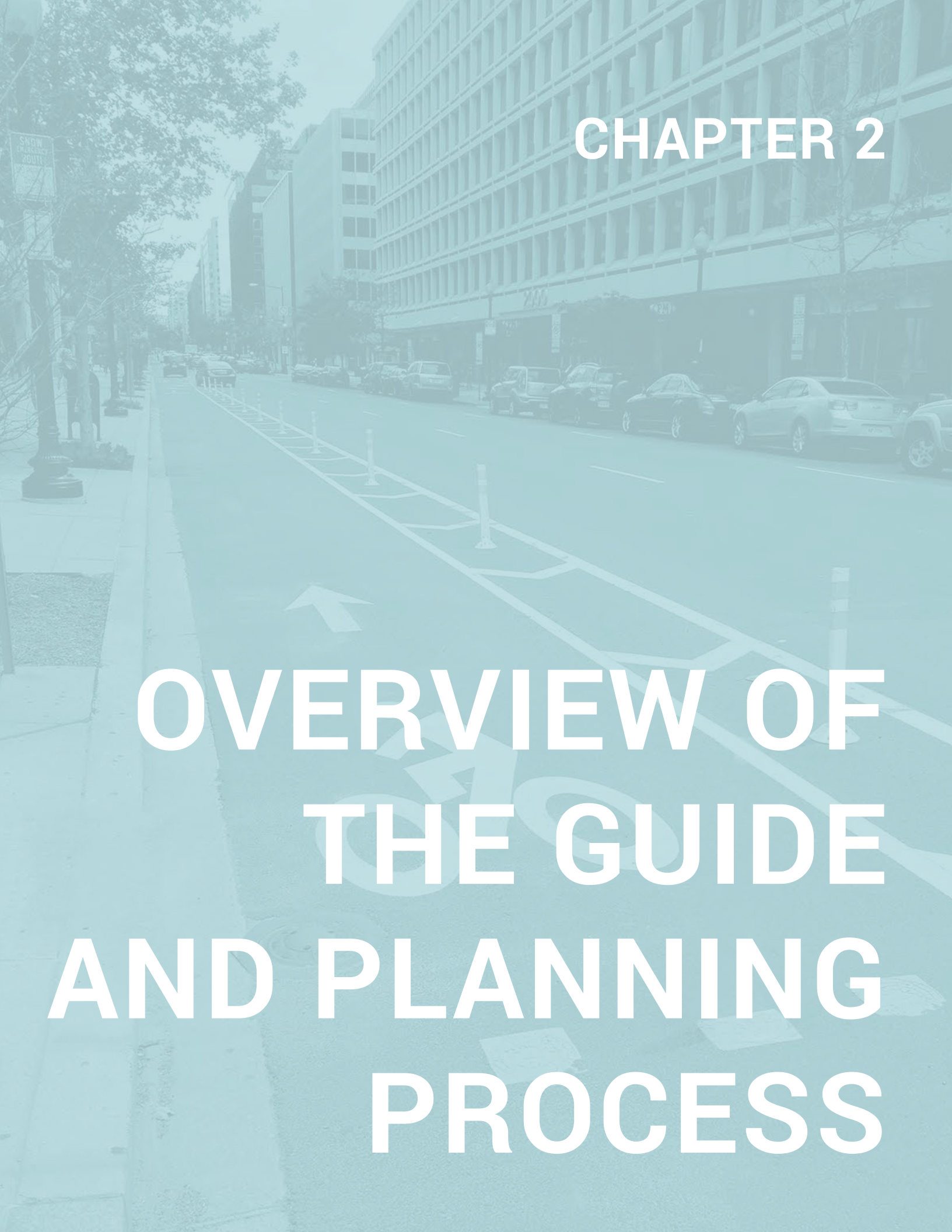
Additional resources and tools for engaging the public and building community support for walking and bicycling are available on the Pedestrian and Bicycle Information Center (PBIC) website at *http://www.pedbikeinfo.org*.

The League of American Bicyclists (LAB) has adopted equity as one of its top priorities and established an Equity Initiative and an Equity Advisory Council. Through these and other efforts, LAB "engages leaders from traditionally underrepresented demographics and bridges the current gap between diverse communities and bicycle advocates." For more information, visit: *http://bikeleague.org/equity*. LAB has also developed resources focusing specifically on equity and bicycle transportation, including the following:

The New Majority: Pedaling Towards Equity
http://bikeleague.org/sites/default/files/equity_report.pdf

Integrating Equity in Bike Advocacy
http://bikeleague.org/sites/default/files/League_internal_equity_web.pdf

[2] Anna Goodman, Shannon Sahlqvist, and David Ogilvie. (2014). New Walking and Cycling Routes and Increased Physical Activity: One- and 2-Year Findings From the UK iConnect Study. American Journal of Public Health. [3] New York City Department of Transportation. (2013).



CHAPTER 2

OVERVIEW OF THE GUIDE AND PLANNING PROCESS

OVERVIEW OF THE GUIDE AND PLANNING PROCESS

Structure of the Guide

This guide is structured in four primary sections:

- Introduction chapters describing what a Separated Bike Lane is and providing an overview of the Guide, planning process and other relevant context;
- A broad review of separated bike lane planning considerations;
- A flexible menu of design recommendations; and
- A Moving Forward section outlines next steps for separated bike lane development.

In addition, detailed reports on the literature review, lessons learned interviews, and safety analysis, along with project evaluation and data collection worksheets designed for practitioners, are included as appendices. This guide provides an overview of planning considerations and a menu of design options for Separated Bike Lanes. These sections of the document are described in more detail below.

Planning Considerations

The Planning Separated Bike Lanes chapter provides information on the process of determining appropriate locations, taking into account factors such as existing and potential users, creating connections as part of a bicycle network, street and land use contexts, and opportunities available for installation. It also touches on other planning issues including funding, maintenance, public outreach, and project evaluation.

Menu of Design Recommendations

The Design Recommendations chapter forms the heart of the guide, laying out in detail recommended design approaches based on currently understood best practices. The recommendations are organized around four primary design areas: directional and width characteristics, intersection considerations, type of separation, and midblock considerations. Also covered are general strategies for related topics such as signalization, signage, and markings. A series of hypothetical design scenarios are also provided, complete with suggested dimensions and traffic controls, to illustrate the various recommendations put into practice. It is important to note that separated bike lane design is a quickly evolving subject and therefore this guide does not prohibit designs that are not included – *a flexible design approach is encouraged*. (For further information on FHWA's position on design flexibility, refer to the August 2013 memo "Bicycle and Pedestrian Facility Design Flexibility", available at the following address:

http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/design_guidance/design_flexibility.cfm

OVERVIEW OF THE GUIDE AND PLANNING PROCESS

Overview of the Planning Process

The recommendations in this guide were developed based on a comprehensive review of the state of the practice of separated bike lane planning and design in the United States. This effort was comprised of four parts:

- An in-depth literature review;
- "Lessons learned" interviews with practitioners;
- A safety analysis of implemented projects; and
- Ongoing input from a Technical Work Group.

Literature Review

A review of national and international literature on separated bike lanes and related issues was conducted to establish a baseline of the current state of the practice, including studies, design guides, and other pertinent publications. This review informed and served as a foundation for the first-hand information collected during the subsequent phases of work (refer to Appendix A).

Lessons Learned Interviews

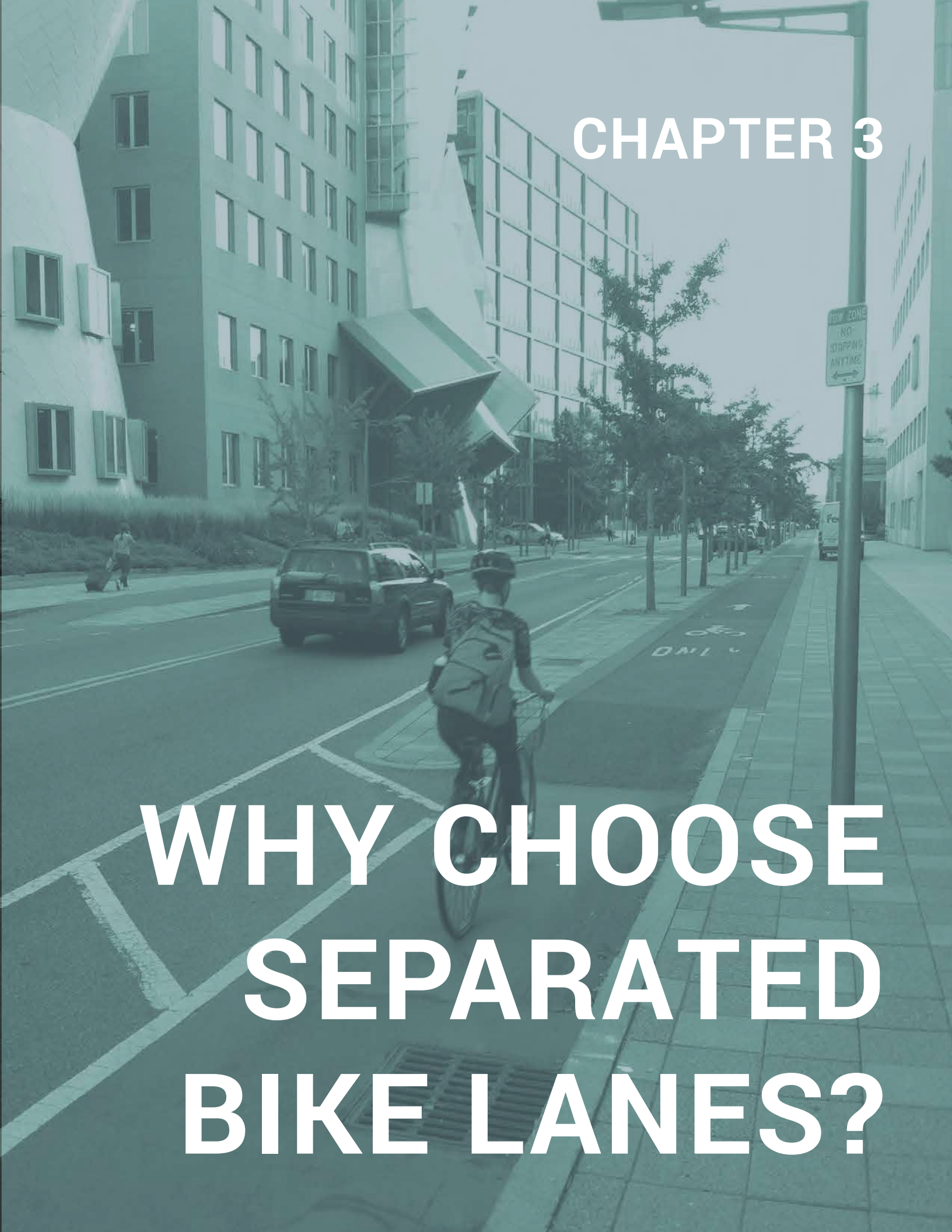
Structured interviews were conducted with municipalities that have designed and constructed separated bike lanes, those that are planning to implement separated bike lanes, and those that have considered separated bike lanes but determined them to not be the appropriate treatment. Over 35 cities, towns, and counties were interviewed, and the results have been incorporated throughout this document (refer to Appendix B).

Safety Analysis

An in-depth analysis of crash and ridership data from implemented separated bike lanes in the U.S was completed to evaluate safety outcomes and inform the recommendations of this guide. While the bicycle collision and volume data that exist for most implemented projects is not yet sufficient to draw broad-based conclusions concerning the overall safety of separated bike lanes, the analysis did uncover useful insights to build upon in future analyses (refer to Appendix C). Future research will become more robust as data collection efforts improve, and municipalities consider more holistic evaluations of separated bike lane projects to measure impacts on mobility, economic vitality, and quality of life. To help municipalities collect robust data for evaluation, a project evaluation checklist and data collection information guide are provided as appendices (refer to Appendix D and Appendix E, respectively).

Technical Work Group Guidance

Finally, a Technical Work Group was convened to provide guidance, input, and critical review throughout the project planning process. Comprised of representatives from the Institute of Transportation Engineers (ITE), American Association of State Highway and Transportation Officials (AASHTO), National Association of City Transportation Officials (NACTO), League of American Bicyclists (LAB) and nearly a dozen geographically diverse State and city transportation departments, the Technical Work Group helped ensure that the information, analysis, and recommendations contained herein are not only accurate but responsive to the concerns and experiences of practitioners across the transportation discipline.



CHAPTER 3

WHY CHOOSE SEPARATED BIKE LANES?

WHY CHOOSE SEPARATED BIKE LANES?

Implementing Separated Bike Lanes Using a Flexible Approach

Separated bike lanes are a relatively new treatment in most American municipalities. The current design process for separated bike lanes is loosely based on a mixture of existing best practices, local roadway conditions, context, and constraints, and some design element guidance in existing national resources. A common lesson learned from municipalities that have implemented or are planning to implement separated bike lanes is the desire for more concrete design guidance, while still allowing for flexibility in the planning and design process.

For separated bike lanes to be successful, a flexible design process taking into account all available resources is needed. This guide provides a menu of design options that may be used in tandem as required by specific site conditions and project goals.

A memo on this topic is available at: *http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/design_guidance/design_flexibility.cfm*

Additional questions and answers related to FHWA's position on NACTO's Urban Street Design Guide are available at: *http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/design_guidance/design_flexibility_qa.cfm*

Many of the different resources that inform the planning and design process provide **flexible** options on the use of different elements and a range of dimensions on designs. These resources cover a range of contexts, philosophies, audiences, and goals, while also presenting various levels of flexibility. A selection of the most prominent and widely used resources, with a summary of key separated bike lane design elements presented within each resource and the degree to which flexibility in design is encouraged, is provided in the table on the following page. In most cases, separated bike lanes are not addressed as a facility but design elements used in SBL are included.

The Manual on Uniform Traffic Control Devices is adopted by reference in accordance with Title 23, United States Code, Section 109(d) and Title 23, Code of Federal Regulations, Section 655.601(d) and 655.603(a), and is approved as the national standard for designing, applying, and planning traffic control devices installed on any street, highway, or bikeway open to public travel. The FHWA publishes the MUTCD, which contains all national design, application, and placement standards, guidance, options, and support provisions for traffic control devices used with separated bike lanes.

While certain portions of the design information in this guide (see Chapter 6) are based on information from these resources, practitioners need not limit their designs to what is presented in that chapter. The following table and the menu of design options in Chapter 6 is intended to help designers navigate through the different resources; additional flexibility beyond the existing resources and what is included in this guide may be needed, especially in comparison to typical street design. *The practice of designing separated bike lanes is still evolving and until various configurations have been implemented and thoroughly evaluated on a consistent basis, design flexibility will remain a priority.* FHWA encourages the use of all appropriate design resources as well as continued experimentation and modifications of designs, in order to develop safe, comfortable, and predictable separated bike lane treatments that fit unique site conditions and needs for each project. Design modifications following separated bike lane implementation should be expected and welcomed; they are not an indication of failed design.

Resources for Bicycle Design Elements

The table below highlights the extent to which existing design resources published by FHWA, AASHTO, NACTO, and ITE address elements of Separated Bike Lane planning and design. Key design resources are noted at the top of each column and specific planning and design considerations are noted in the rows. This table should be used as a high-level reference point for practitioners and the resources should be consulted directly for further guidance.

Table 1

		Manual on Uniform Traffic Control Devices FHWA		**Guide for the Development of Bicycle Facilities AASHTO** (2012)	
		Level of Detail Addressed	*SBL- Specific Level of Detail Addressed*	*Level of Detail Addressed*	*SBL- Specific Level of Detail Addressed*
1	Bicycle specific signs and pavement markings (including green colored pavement[1], markings through intersections)	**High**	**None**	**High**	**None** [3]
2	Intersection approach treatments and combined bicycle lanes / vehicle lanes (i.e. mixing zones)	**High**	**None**	**Medium**	**None** [3]
3	Bicycle signalization (bicycle signal heads[1], signal timing for clearances, bicycle detection, bicycle push buttons)	**Medium**	**None**	**High**	**None** [3]
4	Bicycle turning treatments (2-stage queue boxes, bicycle boxes)	**Low** [2]	**None**	**Low**	**None** [3]
5	Bicycle facilities on one-way streets (left or right side)	**None**	**None**	**Medium**	**None** [3]
6	Contraflow or two-way bicycle facilities	**Low**	**None**	**Medium**	**None** [3]
7	Bicycle facilities and on-street parking (parallel or diagonal)	**Low**	**None**	**High**	**None** [3]
8	Transit stop interaction treatments	**Low**	**None**	**Low**	**None** [3]

Urban Bikeway Design Guide NACTO (2014)		Urban Street Design Guide NACTO (2013)		Traffic Control Devices Handbook ITE (2012)	
Level of Detail Addressed	*SBL- Specific Level of Detail Addressed*	*Level of Detail Addressed*	*SBL- Specific Level of Detail Addressed*	*Level of Detail Addressed*	*SBL- Specific Level of Detail Addressed*
Medium	**Medium**	**Low** [(4)]	**Low** [(4)]	**Medium**	**None**
High	**High**	**Medium** [(4)]	**Low** [(4)]	**Medium**	**None**
High	**Medium**	**Low** [(4)]	**None** [(4)]	**Medium**	**None**
High	**Medium**	**Low** [(4)]	**None** [(4)]	**None**	**None**
Medium	**Low**	**Low** [(4)]	**None** [(4)]	**Medium**	**None**
High	**Medium**	**Low** [(4)]	**None** [(4)]	**Medium**	**None**
Low	**Low**	**None**	**None**	**Medium**	**None**
Low	**Low**	**None**	**None**	**None**	**None**

[1]Interim Approval Status

[2]Experimental status

[3]Separated bike lanes are not discussed in AASHTO's Guide for the Development of Bicycle Facilities, although some elements are covered in the context of shared use paths and sidepaths. As defined in this report, Separated Bike Lanes are located within or immediately adjacent to the roadway and are intended for bicyclist use only; AASHTO's shared use path facility type generally refers to off-street facilities with their own rights-of-way, and that may be used by pedestrians, joggers, and other users.

[4]NACTO's Urban Street Design Guide provides broader context for Separated Bike Lanes. More comprehensive design information on these facilities is provided in NACTO's Urban Bikeway Design Guide.

Separated Bike Lanes and Connected Low-Stress Bicycle Networks

Separated Bike Lanes and Connected Bicycle Networks

Separated bike lanes are one of many bicycle facility types that can be used to create bicycle *networks*, which are interconnected bicycle transportation facilities that allow bicyclists to safely and conveniently get where they want to go. Well-planned and designed separated bike lanes can complement or connect to other facilities such as on-street bike lanes and shared use paths. Separated bike lanes can appeal to a broad range of people and in doing so contribute to increases in bicycling volumes and rates. A June 2014 National Institute for Transportation and Communities report entitled "Lessons from the Green Lanes: Evaluating Protected Bike Lanes in the U.S.." observed that ridership on all facilities increased after the installation of separated facilities. Survey data showed that 10% of current riders switched from other modes and that over a quarter of riders are bicycling more in general because of the separated bike lanes. This report is available at:

http://otrec.us/project/583

As part of a connected bicycle network, separated bike lanes can:

- Provide a more comfortable experience for less-skilled riders;
- Improve access to destinations such as schools, jobs, health care facilities, and essential services;
- Enhance access to public transportation, for example by helping to solve the first/last mile challenge;
- Improve access to employment opportunities, especially for those without access to a private automobile; and
- Provide a linkage between regional trail systems.

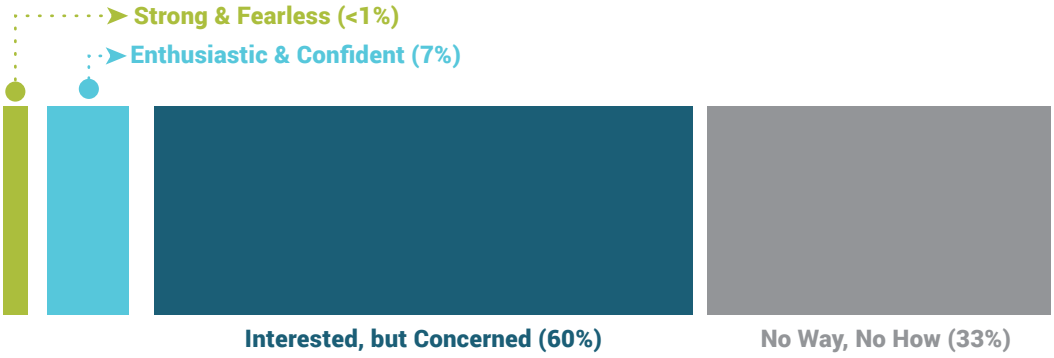
Separated Bike Lanes and Low-Stress Networks

Separated bike lanes have great potential to fill needs in creating low-stress bicycle networks (generally separated from heavy vehicular traffic or sharing the road with motorists only on very low-volume residential streets). Many potential cyclists (including children and the elderly) may avoid on-street cycling if no physical separation from vehicular traffic is provided. This cohort falls into the "Interested, but Concerned" category as noted in Figure 3. To encourage this group to use cycling as a transportation option for short to moderate length trips, many municipalities are focusing on creating a connected bicycle network that "Interested, but Concerned" riders will confidently use. Examples of two municipalities that are leading the push in creating low-stress bicycle networks are presented in a case study on page 46.

Figure 3

Four Types of Transportation Cyclists in Portland

By Proportion of Population

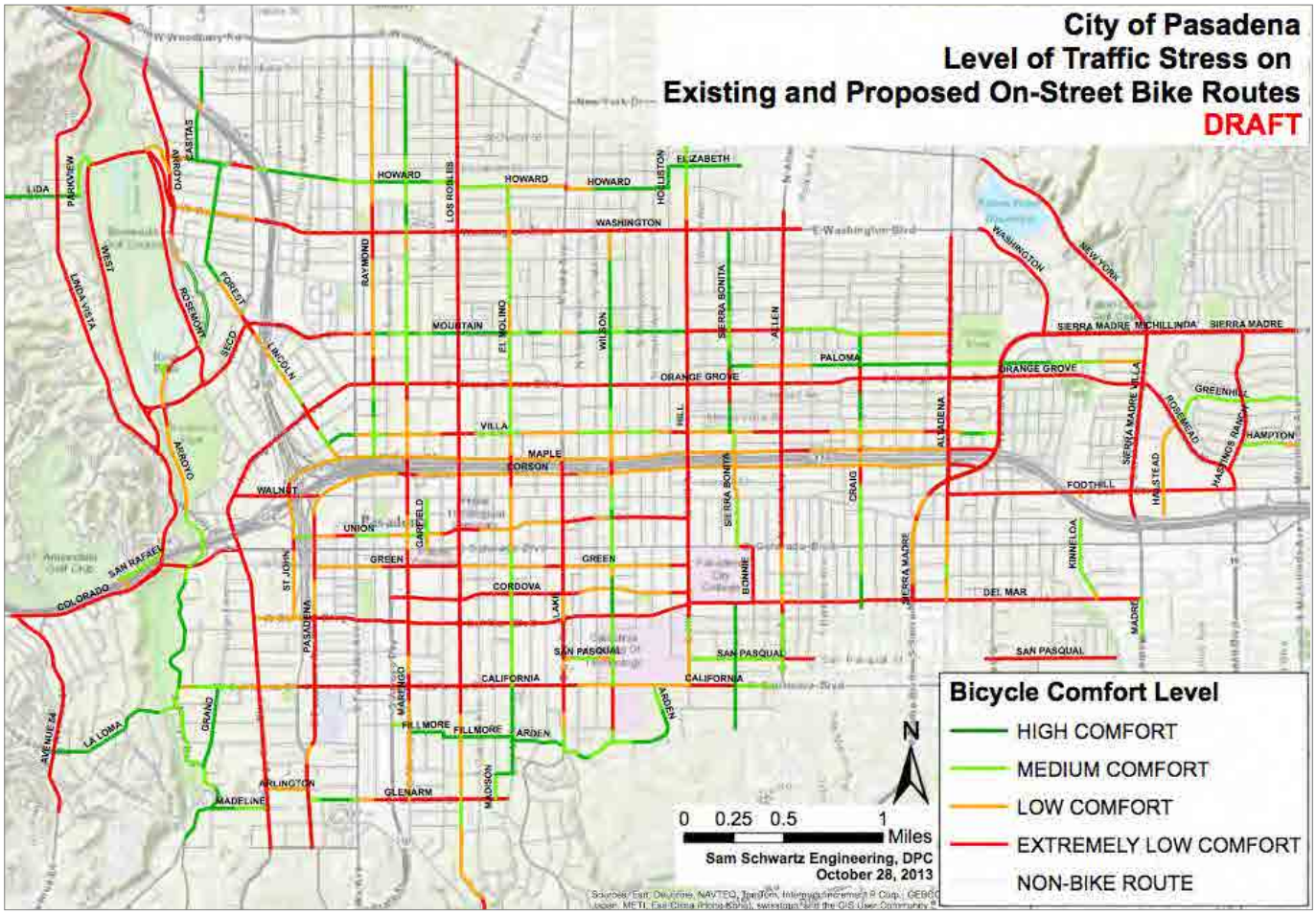


Graphic based on: Geller, R. (2006). Four types of Cyclists. Portland Office of Transportation.

Many municipalities may already have a comprehensive network that – when mapped – appears to adequately cover a large area with multiple intersecting on-street bike lanes or sign-posted bike routes. However, if these facilities are inaccessible to cyclists seeking a low-stress experience then the network may not meet the needs of everyone. Municipalities may implement separated bike lanes as a way to provide a low-stress bicycle network. Such a network might be overlaid on and around – or even replace – an existing bicycle network. It pays particular attention to higher-quality, lower-stress connections, even if this results in some backtracking or extra distance requirements for cyclists using the enhanced network. An example of a planning effort in Pasadena, CA focused on low stress bicycle networks is highlighted on the following page.

The goal of a low-stress network is to create connections that cover a municipality while emphasizing the quality of bicycle facilities over their quantity. Depending upon the context of the corridor (motorist volumes and speeds, roadway alignment, etc.), municipalities may find that separated bike lanes provide substantial benefits in moving towards building out such a network. Additionally, municipalities may find that providing a low-stress bicycle map for public use – with a focus on separated bike lanes, off-street paths, greenways, and neighborhood bike boulevards – will be helpful in defining and promoting the low-stress network. For more information on low-stress networks, refer to the May 2012 Mineta Transportation Institute report, "Low-Stress Bicycling and Network Connectivity" - available at the following address:

http://transweb.sjsu.edu/PDFs/research/1005-low-stress-bicycling-network-connectivity.pdf



Pasadena, CA's bicycle network as mapped based on bicycle comfort, or stress level. Green segments represent low-stress bikeways. (Source: Sam Schwartz Engineering)

Separated Bike Lanes and Bike Share

Bike share systems are growing rapidly in popularity in U.S. cities. Since the first major U.S. bike share scheme launched in Washington, DC, in 2008, the number of bikeshare programs has expanded to 36 cities, with more on the way. Bike share has transformed the way people get around in many cities and provides convenient transportation options to replace short car, walking, taxi, and transit trips. Bike share growth has been accompanied by a jump in bicycle commuting, which increased by over 60% between 2000 (US Census) and 2008-2012 (5-year US Census American Community Survey) – the largest growth in any transportation mode. With its surge in popularity, bike share has consequently attracted many novice riders or those who may only remember bicycling recreationally as children and never in urban traffic. The presence of bike share as part of a city's transportation landscape may spur planners to consider separated bike lanes and other low-stress options to allow for safe and comfortable movement within the street network. For more information on bike share programs, visit:

www.pedbikeinfo.org/bikeshare

From a design perspective, separated bike lanes have potential to complement bike share systems. Siting bike share docking stations adjacent to separated bike lanes – within their physical separation from vehicular traffic – allows for easy and safe

access and egress to docks. At the same time, the physical separation or buffer space may provide ideal locations for the dock locations themselves; by claiming roadway space for the separated bike lane, planners may find they have also simultaneously identified a space within the right-of-way for a docking station. Refer to Chapter 4 for additional ideas on public space opportunities through separated bike lane design.

A listing of current bike share systems in the U.S. is available at:

www.pedbikeinfo.org/bikeshare

A B-Cycle docking station provides physical separation within the buffer space in Austin, TX, between the separated bike lane and vehicle travel lanes. (Source: City of Austin)

WHY USE THIS GUIDE?

Safety Context

Trends in Bicycle Safety

According to the National Highway Traffic Safety Administration, 743 cyclists were killed in the US in 2013 and an additional 48,000 were injured in collisions with motor vehicles. The number of cyclist fatalities represents an increase of 1.2 percent over the previous year; by comparison, the decrease in total motor vehicle crash fatalities from 2012 to 2013 was 3.1 percent. In 2012, sixty-nine percent of cyclist fatalities occurred in urban areas and 60 percent occurred midblock. A variety of efforts at the national, State, and local levels have sought to improve safety for bicyclists using a combined approach that incorporates planning, engineering, education, and enforcement. At the national level, the US Department of Transportation's (USDOT) efforts to improve quality of life include promoting the creation of connected pedestrian and bicycle networks, ensuring that everyone has access to convenient and affordable transportation choices, and encouraging innovations such as road diets that have proven safety benefits.

Separated Bike Lane Safety – Real or Perceived?

Since separated bike lanes are physically separated from vehicular traffic, almost all users (96 percent) feel safer as a result of the separation, which can help attract new riders[4]. However, while cyclists may perceive that separated bike lanes provide increased safety, it has been difficult to identify conclusive safety trends due to a lack of data, especially bicycle volume data before separated bike lane installation. In addition, the relatively small numbers of bicyclist crashes that are reported make it difficult to draw conclusions that may be applied to separated bike lanes on a broad level.

The analysis conducted as part of the preparation of this guide studied data from 17 separated bike lane corridors in 8 States (refer to Appendix C). Based on this analysis, separated bike lanes were generally associated with a decrease in total crashes and an increase in total bicycle crashes, however, when accounting for changes in bicycle volumes on facilities that provided sufficient pre- and post-implementation bicycle volume data, the per capita crash rates for cyclists appeared to decrease in most facilities after separated bike lanes were installed. Additionally, the analysis found that increases in bicycle crashes after separated bike lanes were built were especially pronounced at intersections.

The Future of Separated Bike Lanes and Safety

Separated bike lanes continue to be installed across the country to improve quality of life and efforts to create safer, more complete streets. As this trend continues, it is imperative for communities to collect bicycle and motor vehicle crash and volume data for a sufficient period of time before and after separated bike lane installation. This will improve understanding of safety benefits and design considerations—such as differences between one-way and two-way facilities (Refer to Appendix E for guidance on data collection and Appendix D for a project evaluation checklist).

(4) *"Lessons from the Green Lanes: Evaluating Protected Bike Lanes in the U.S." National Institute for Transportation and Communities (2014).*

CHAPTER 4

PLANNING SEPARATED BIKE LANES

SUMMARY OF PLANNING ELEMENTS

The process of planning for separated bike lane facilities is complex and involves multiple stakeholders with diverse goals. This chapter provides an overview of opportunities and challenges when planning separated bike lanes. It includes representative case studies from municipalities that have addressed common planning issues and provides guidance on how to holistically approach the task of repurposing or reconstructing the street for low-stress bicycling. Planners, designers, and engineers of separated bike lanes can consult this chapter as a reference tool throughout the planning process.

The table below provides a summary of key planning chapter takeaways. For additional case studies and lessons learned on separated bike lanes in a wide range of U.S. cities, refer to Appendix B.

Table 2

1 PLANNING CONSIDERATIONS	
SBLs within a Bike Network	Plan for a separated bike lane in context of a bike network, not as an isolated project. Connect origins and destinations. Develop a low-stress bike network accessible to novice cyclists.
Safety Benefits	Use separated bike lanes to create safety benefits at specific locations or along high-volume corridors. Providing physical separation may improve safety and provides peace of mind to novice cyclists.
Design Flexibility	Strategically deploy separated bike lanes where most needed. Consider context and use design flexibility on separation type, intersection treatments, and other design elements to promote safety and manage traveler expectations.
Existing and Potential Users	Desired bikeway routes may already attract cyclists. Plan for separated bike lanes along corridors that naturally draw cyclists to expand opportunities. Fill unmet needs on busy streets that discourage cycling due to high-traffic volumes.
Local Support	Successful locations start with local support. Choose corridors where residential or business communities have bought in to the idea of encouraging cycling through strategic infrastructure investment.
SBLs and Equity	Use separated bike lanes to promote cycling as an option for commuting to transit-dependent or carless households. Facilities can also improve connections to transit, jobs, schools, and essential services through safer first / last mile trips.

2 ADDITIONAL CONTEXTUAL CONSIDERATIONS

Roadway Capacity Effects	Consider how a separated bike lane affects motor vehicle volumes. Potentially implement a road diet, remove on-street parking, or remove a travel lane. Evaluate capacity effects holistically against mobility benefits of separated bike lanes and potential safety improvements relating to SBL implementation. Perform traffic modeling to measure disbursement of vehicles in road network.
Pedestrian and Other Street User Safety Effects	When locating bicycle facilities on higher-speed or higher-volume facilities, the separation afforded by SBLs may provide increased comfort and safety benefits. Improved organization of motor vehicle travel lanes and turn lanes, as well as reduced crossing distances and potential pedestrian safety islands, all provide benefits related to those found in FHWA's 9 proven pedestrian safety countermeasures.
Transit Corridors	Consider how a separated bike lane shares a corridor with transit services. Design lanes for safe interaction at transit stops or measures that separate bus and bike lanes, such as boarding islands. Consider placing facilities on left-sides of 1-way streets or on parallel, non-transit corridors.
Loading and Unloading	Engage in site-specific research on local loading and unloading requirements when designing separated bike lanes. Commercial corridors may require dedicated loading zones with clear markings. Explore off-street loading options and off-peak loading time incentives.
Accessibility	Ensure that the interface of the SBL with pedestrian facilities at crosswalks, parking spaces, transit stops and other locations is accessible and in compliance with the Americans with Disabilities Act and other local requirements. Consider access to the curb for fire and emergency vehicles.
Parking	Evaluate parking needs holistically and attempt to minimize parking space losses where possible. Educate the public on floating parking regulations. Identify opportunities to provide parking on streets adjacent to separated bike lanes.

3 INSTALLATION OPPORTUNITIES

Pilot Projects	Use "pilot projects" to test reactions to separated bike lane concepts with minimal upfront investment. Evaluate designs, make necessary changes, and transition successful pilots to permanent buildouts where feasible.
Street Retrofits	Using the existing right-of-way, change geometry of the street to accommodate separated bike lanes. Consider changes to number or width of travel lanes and/or presence of on-street parking. Reduce costs by using scheduled resurfacing projects as opportunities for street retrofits.
New Construction or Major Reconstruction	Leverage major capital construction projects and include separated bike lanes in designs. The addition of separated facilities may represent a minimal increase on total construction investment.

4 OTHER PLANNING ISSUES

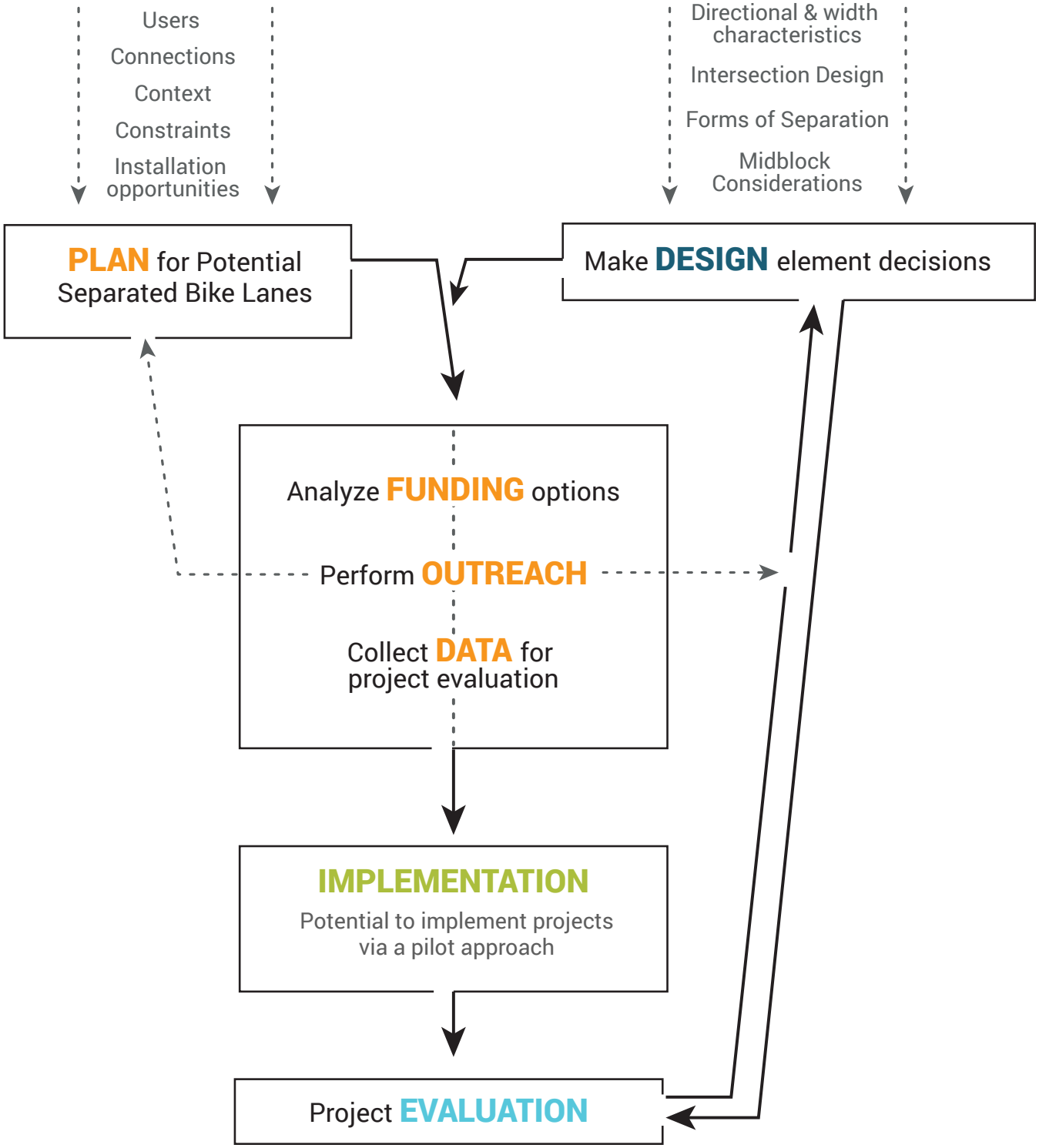
Cost	Few benchmarks exist for separated bike lane costs, which vary extensively due to the wide variety of treatments and materials used. Cheaper materials can save money upfront; however, permanent build-outs may prove more cost-effective in the long term.
Funding	Consider funding through Federal programs, State or local contributions (including dedicated taxes), private sector sources, and nonprofit contributions. Private sector partners can benefit from separated bike lanes; consider value capture strategies.
Maintenance	Plan ahead on how a separated bike lane will be maintained. Consider the width of the facility and evaluate sweeping and plowing capabilities. Forge local partnerships and develop maintenance agreements. Consider repairs for the facility itself (e.g. replacing flexible delineator posts frequently).
Outreach	Perform continuous outreach before, during, and after separated bike lane implementation. Target different groups such as residents, local businesses, advocacy groups, and others. Provide public education on changes to the streetscape.
Agency Coordination	Coordinate with public agencies on traffic safety, enforcement, emergency vehicle access, maintenance, funding, and other issues. Use a combination of design resources to inform the design process.

5 PROJECT EVALUATION

Holistic Evaluation	Evaluate separated bike lanes in a holistic fashion. Consider all street users (pedestrians, cyclists, transit users, and motorists). Measure important changes such as crash (fatality and injury), volume, and speeding data along with indirect benefits such as retail sales growth, public health, and environmental benefits.
Data Collection	Formalize data collection procedures and collect pre- and post-implementation data on all separated bikeway corridors and comparison corridors. Remain consistent on methodology and data collection technology. Use data to communicate the effect of separated bike lanes on all street users.

Planning and Design Process Diagram

Figure 4



CHOOSING LOCATIONS

Identifying a Successful Location

When planning for a separated bike lane, success can be considered within 3 frameworks: network effects, safety improvements, and appropriateness of the solution.

Network Effects

The public may deem a separated bike lane as successful if it is heavily used by cyclists. Cyclists will be more likely to use a bicycle facility, separated or otherwise, if it is part of a comprehensive bicycle network. Successful separated bike lanes will improve service by addressing high-stress areas in the network and provide linkages to expand the portion of a city or town's street grid that is accessible by bike. Separated bike lanes that provide first and last mile connections to other modes, such as transit, and that fill a need in building a low-stress network accessible to cyclists of all abilities will be successful in terms of effects on a bicycle network. Users and ridership both benefit from the improved legibility and network completeness provided by SBLs.

Safety Improvements

Some separated bike lanes will succeed in creating safety improvements at specific locations, such as those adjacent to or passing through major intersections, while others can improve bicycle safety along an entire corridor, such as on a high-volume street. In conjunction with a Complete Streets planning approach, separated bike lanes can be a tool for improving safety outcomes for all street users, including cyclists.

Appropriateness of the Solution

Separated bike lanes will be most successful when deployed strategically. Not every bicycle facility needs to be a separated bike lane, and in certain cases it may be appropriate to vary a facility's separation type or alignment depending on external conditions, such as traffic volumes or adjacent land uses. Planners and engineers should be flexible on designs through a context sensitive approach. For further information on FHWA's support for and encouragement of design flexibility, see the August 2013 memo at the following web address:

http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/design_guidance/design_flexibility.cfm

A Complete Streets retrofit has improved safety outcomes along 1st Avenue in New York City (Source: NYCDOT)

CHOOSING LOCATIONS

Consider: Users of Separated Bike Lanes

Are cyclists already using a corridor?

A separated bike lane may be appropriate if a street or corridor already has bicycle traffic. Streets that naturally draw cyclists, even in the absence of any bicycle facility, are likely to draw even more if a separated bike lane is constructed.

Would potential cyclists use the corridor if a separated facility existed?

Some streets may not currently have high bicycle volumes because they are uncomfortable. Planners should study corridors that could potentially fill an unmet need in expanding their jurisdiction's bicycle network to meet latent demand.

CASE STUDY

Local Support

Alameda, CA

Planners in Alameda found that cyclists were already heavily using its waterfront recreational path along Shoreline Drive – so much so that the need for a new, separate bicycle-only facility had become apparent to accommodate the large number of pedestrians, cyclists and other nonmotorized users of the path. In planning for a separated bike lane along Shoreline Drive, the City received overwhelming calls of support from path users – cyclists and pedestrians alike. Alameda was able to decrease the street capacity in certain segments and to remove on-street parking in others along Shoreline Drive without significant impacts on street or parking availability. As a result, the City will build a two-way buffered bikeway on the beach side of the street with broad public support and a growing community of cyclists that look forward to using the upgraded facility with views westward across the San Francisco Bay.

CHOOSING LOCATIONS

Consider: Connections with Separated Bike Lanes

Could a potential separated bike lane connect origins and destinations?

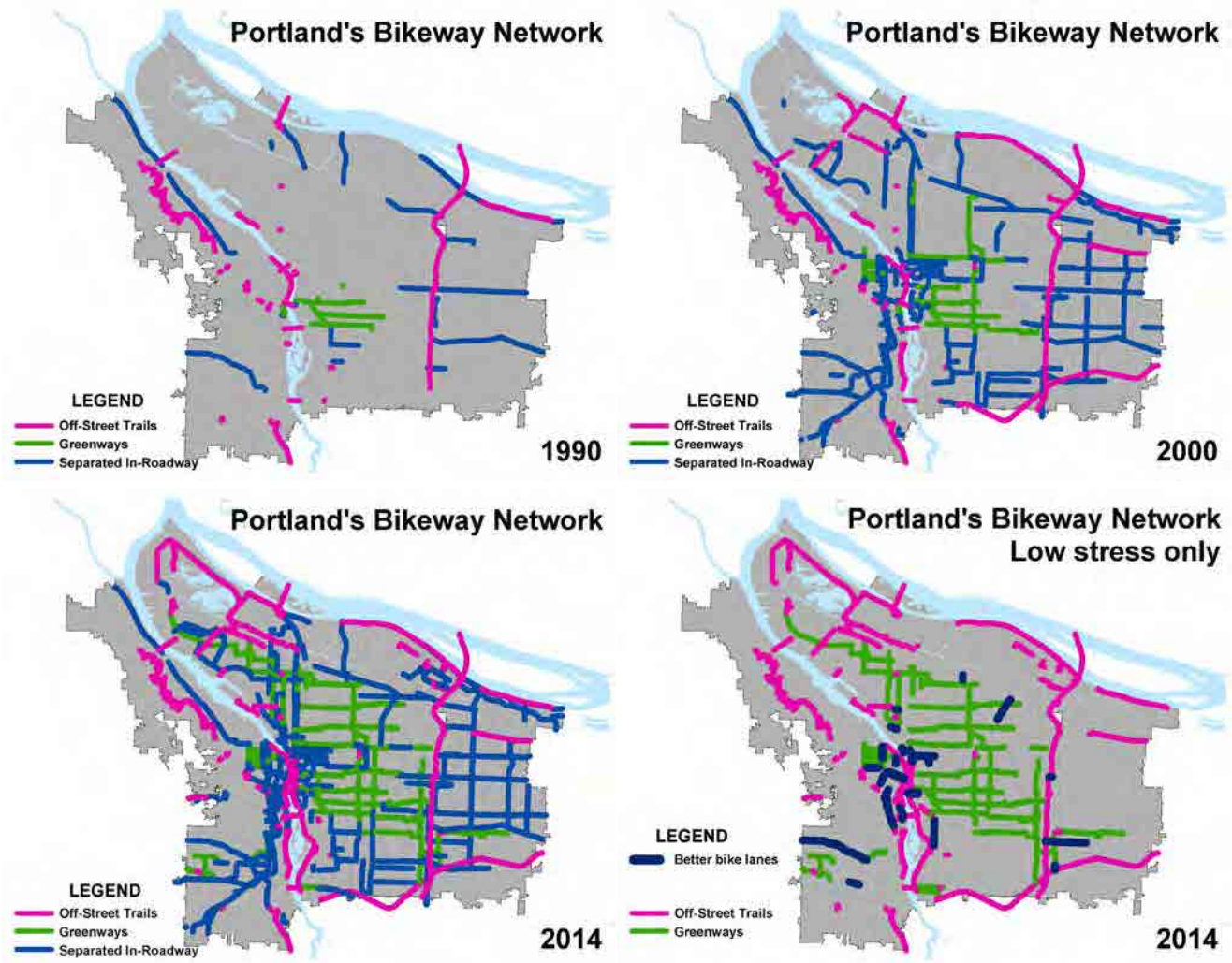
A separated bike lane that improves connections between and among high-demand destinations such as schools, parks, transit stops, commercial areas, residential clusters, and other attractions will better serve a community than if it is located at random without these considerations.

How can a potential separated bike lane help build a low-stress bicycle network?

Physically separated bike lanes can be a primary tool in creating a bicycle network that is accessible for cyclists of all ability levels, including children and inexperienced adult bicyclists. Facilities that provide low-stress, high-quality connections can improve mobility for all users. Along with off-street paths, greenways, and facilities on low-volume residential streets, planners can use separated bike lanes as a tool to build out low-stress networks accessible to all. The table below and the maps on the following page highlight how Portland, OR has integrated the concept of low stress bikeways into its planning process and how its bicycle network is anticipated to be enhanced in the coming years.

Portland's BIKEWAY MILES					PORTLANDERS LIVING NEAR LOW-STRESS BIKEWAYS - Number / (%)	
Year	Neighborhood Greenways	Separated In-roadway	Off-street Trails	Total	Within 1/2 Mile	Within 1/4 Mile
2009	30	175	78	283	277,300 / (51%)	159,700 / (29%)
Existing (March 2011)	46	179	78	303	342,200 / (62%)	212,800 / (39%)
Existing & Funded	71	187	83	341	399,600 / (73%)	268,200 / (49%)
Existing, Funded & In-Planning	149	198	83	430	493,900 / (90%)	390,900 / (71%)

Portland's Bike Plan for 2030 targets an expansion of a low-stress network, which includes separated bike lanes. (Source: One Year Progress Report on Portland Bicycle Plan for 2030, published April 2011)



Portland's Bike Plan for 2030 targets an expansion of a low-stress network, which includes separated bike lanes. (Source: City of Portland)

Could a separated bike lane improve connections for disadvantaged populations?

Beyond facilitating connections between origins and destinations in a low-stress environment, planners should consider separated bike lanes and their relationship with surrounding communities. In many American cities, transit-dependent populations often face long commutes that are exacerbated by limited access to private motorized transport and residences far from convenient public transport options. [5]

[5] http:// ww.peopleforbikes.org/blog/entry/rich-poor-both-know-good-biking-when-they-see-it-new-data-shows

CASE STUDY

Low-Stress Bicycle Networks

Austin, TX and Boulder, CO

Bluebonnet Lane, Austin, TX (Source: City of Austin)

Low-stress bicycle networks – already common in European municipalities – will likely become more widespread in the United States in coming years as bicycling grows as a transportation option and municipalities seek to attract new riders. Low stress network strategies recognize that a significant portion of people interested in riding are not comfortable interacting or sharing a roadway with high-volume motor vehicle traffic. Two municipalities leading the push in creating these networks – and using separated bike facilities as a major component of building them out – are Austin and Boulder.

Austin is combining its paved trails, low-volume streets, and on-street separated bike lanes to create an "all ages and abilities network," or one that provides even novice cyclists, the young, and the old with the ability to travel extensively by bicycle in the city via lower stress facilities. The City's highly popular Bluebonnet Lane separated bike lane runs adjacent to an elementary school and is frequently populated with young children commuting to and from school on two wheels.

Boulder has an extensive network for bicycling that includes on-street bicycle lanes, off-street multi-use paths, and sidepaths, as well as designated bike routes along residential streets. Estimating that a core network of connected bicycle facilities will be complete in the next few years, Boulder is now assessing where it can fine tune the existing network to attract and accommodate a broader range of people who want to make trips by bike; in particular women, older adults, and families with younger children. The City is looking towards creating a low-stress network to provide a connected system of routes accessible for bicyclists of all ages and abilities.

CHOOSING LOCATIONS

Consider: Context of Separated Bike Lanes

How might a separated bike lane affect roadway capacity?

Separated bike lanes cannot be planned in a vacuum. Among the primary concerns when planning a separated facility is determining how much, if any, motor vehicle capacity might be removed due to an installation. The reduction could result from removing a lane of vehicular traffic or altering signal timing such that vehicular throughput is impacted. Many municipalities find the subject of reduced capacity politically challenging. Planners should engage in a comprehensive, multi-modal analysis of the costs and benefits of a separated bike lane in terms of mobility for all street users – cyclists, pedestrians, and transit users, in addition to motorists. Planners should take a flexible approach to separated bike lane construction and engage in robust before and after data collection (refer to Appendix E) in order to holistically evaluate how separated bike lanes can fit into a roadway network. Evaluation should include performing a traffic volume analysis, determining if a corridor has excess capacity, and evaluating whether a separated bike lane design will require removal of roadway capacity. Planning for high-quality separated bike lanes within a dynamic, constrained environment poses considerable challenges and requires careful consideration and analysis.

How do Separated Bike Lanes support USDOT's Bicycle and Pedestrian Safety Initiative?

When locating bicycle facilities on higher-speed or higher-volume facilities, the separation afforded by SBLs may provide increased comfort and safety benefits. The United States Department of Transportation launched a Bicycle and Pedestrian Safety Initiative, and installation of separated bike lanes may provide contextual solutions to bicycle safety concerns.

Separated bike lanes are one of many solutions to consider as communities actively work to improve the comfort and safety of all roadway users. For additional information on USDOT's new initiative, visit the following web address:

http://www.dot.gov/briefing-room/us-transportation-secretary-foxx-announces-new-initiative-enhance-pedestrian-and

How can installing a separated bike lane improve pedestrian safety?

Separated bike lanes in areas with high pedestrian activity can provide safety benefits to groups beyond cyclists themselves. Separated bike lanes can shorten pedestrian crossing distances, and, depending on design, may provide a median refuge for pedestrians. This benefit is especially beneficial for young, elderly, and disabled pedestrians who may need more time to cross. SBLs can reduce the number of bicyclists riding on the sidewalk, thereby reducing pedestrian/bicyclist conflicts. Portland State University's 2014 study of separated bike lanes and data collected from facilities in New York City have both found a reduction in sidewalk riding following installation of separated bike lanes.

Pedestrians wait to cross 1st Avenue in New York City on a median island refuge. (Source: NYCDOT)

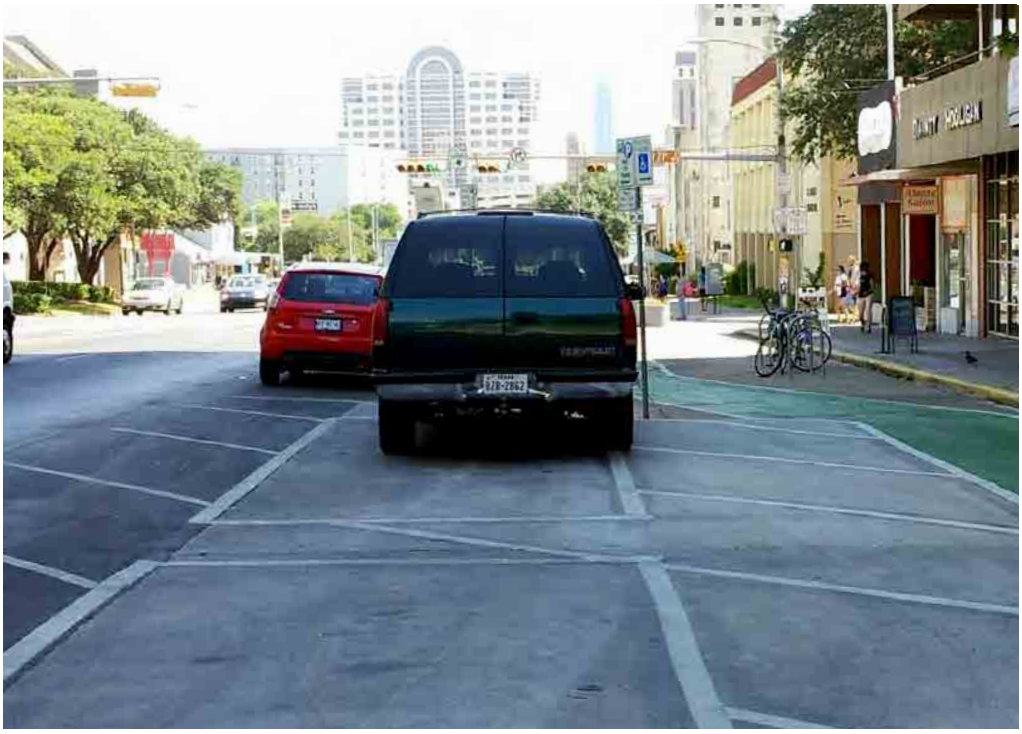
Platform island bus stop and 1st Avenue South separated bike lane in St. Petersburg, FL. (Source: Rory Rowan)

How can a separated bike lane be installed on a transit corridor?

If planners intend to place a separated bike lane on a corridor that also accommodates transit services (such as bus or light rail), additional considerations are required to ensure the separated bike lane functions well with transit operations and stops. Planners should evaluate the context of each corridor, and determine the most appropriate design. Options include installing signs, pavement markings, and/or bus bulbs to provide for shared space, placing a separated bike lane on the left side of a one-way street (out of the way of transit stops along the right side), or choosing to install a separated bike lane on a nearby parallel corridor away from transit to minimize conflicts. There may be a benefit to placing a separated bike lane adjacent to a rail corridor to encourage bicyclists to ride away from in-street rail tracks that may pose a hazard.

How can loading and unloading activities be accommodated with a separated bike lane?

Planning for loading and unloading on streets with separated bike lanes requires site-specific evaluations of local needs. Commercial areas with limited off-street or side-street loading opportunities will require advanced planning and outreach. Dedicated on-street loading space can be provided along a floating parking lane, with highly visible crossings and accessible curb ramps. Other options include off-peak loading time slots or configuring adjacent streets and driveways for loading.



A dedicated accessible parking space in Austin, TX. (Source: Kelly Blume)

How can accessibility issues be handled with a separated bike lane?

Municipalities must take measures to address accessibility and not reduce access as a result of implementing separated bike lanes. Requirements fall under the Americans with Disabilities Act (ADA) but may also include specific supplemental State or local legislation. If not planned carefully, separated bike lane installations can potentially impede access to the curb for alighting motor vehicle passengers or transit users. It is possible to address this curb access issue by installing mid-block curb-ramps and buffers wide enough to accommodate wheelchair lifts. In municipalities with legislation requiring any on-street parking be adjacent to a curb, planners may find it necessary to install a raised curb between the separated bike lane and floating parking lane to

CASE STUDY

Contextual Separated Bike Lane Planning

New York City, NY

A separated bike lane, shorter crossing distances, and a dedicated bus lane along 1st Avenue, New York City (Source: NYCDOT)

To plan for separated bike lanes while accounting for outside context, New York City frames its planning process as part of a more comprehensive effort to transform its streets to promote livability and safety in addition to mobility. The City has found that separated bike lane installations generally improve safety outcomes for all users.

On 1st and 2nd Avenues, the City accounted for context through the following measures:

- Installation of pedestrian islands that shorten crossing distances;
- Placement of its M15 Select Bus Service in dedicated bus lanes on the right sides of one-way streets, with separated bike lanes on the left to minimize bicycle-transit stop conflicts;
- Provision of floating parking throughout the corridors to create physical separation for cyclists; and
- Targeted outreach to merchants along the corridors and creation of dedicated loading zones and times where needed.

achieve compliance. Other municipalities are addressing this legislative challenge by changing local codes to remove such requirements. Likewise, Section 504 of the Rehabilitation Act of 1973 protects individuals with disabilities and governs recipients of USDOT funds. This Section provides for detectable warning surfaces (small truncated domes) indicating the boundary between a pedestrian route and vehicular route where the connection is flush, rather than curbed.

How can a separated bike lane be constructed in the context of on-street parking needs?

Separated bike lanes are often implemented through the removal of a parking lane or by moving the parking lane between the separated bike lane and motor vehicle lanes. Parking impacts are frequently the most contentious issue associated with separated bike lane projects, even in cases where parking removal was relatively minimal. In some cases, it may be appropriate to identify opportunities to replace lost parking by evaluating potential changes to parking regulations on streets adjacent to a proposed separated bike lane.

CHOOSING LOCATIONS

Opportunities for Separated Bike Lane Installation

Use Pilot Projects

Building out a robust separated bike lane using expensive and often permanent materials like raised curbs and dedicated bicycle signals may be challenging. One solution, already employed in numerous US jurisdictions, is to begin with a pilot project. With pilot projects, municipalities might forgo permanent curbs for less costly flexible delineator posts, dedicated bicycle signals for other less costly intersection approach designs (i.e. less prescriptive mixing zone designs), and thermoplastic paint for cheaper but shorter-term marking treatments.

Numerous benefits in addition to lower costs arise from pilot projects:

- Designers have the ability to "tweak" designs once they are implemented and behaviors can be observed. With newer, complex facility types, design tweaks can be expected and are not indicative of a failed design.
- Pursuit of non-permanent installations provides the public assurance that the separated bike lane concept is not being forced upon them, and provides opportunity for public debate (especially important if it is a community's first ever separated bike lane).
- Pilot projects allow a low-risk trial run for a separated bike lane without significant financial commitment, so if a facility fails or is not accepted, the level of investment lost is relatively minimal; implementation processes under pilot projects will be more streamlined than under more formalized capital construction processes.
- A pilot project can be a stepping stone to a more permanent separated bike lane design – many US municipalities have found the "pilot to permanent" route a smart, cost-effective way to familiarize the public with separated bicycle facility design treatments.

Salt Lake City's 300 East separated bike lane was installed using PBPD with inexpensive materials (Source: City of Salt Lake City)

Apply a Performance Based Practical Design Approach

Performance Based Practical Design (PBPD) is an approach grounded in a performance management framework. The approach encourages cost savings by utilizing the flexibility that exists in current design guidance and regulations. These cost savings will enable cities, Metropolitan Planning Organizations (MPOs), and States to deliver a greater number of projects (for example projects that will create or significantly improve connected pedestrian and bicycle networks). The emphasis on flexibility and project value is fully consistent with the planning and design process outlined in Chapters 4 and 5 of this document. The planning and design process for separated bike lanes should consider both short- and long-term project and system goals and should focus on scoping projects to stay within the core purpose and need. In this way, separated bike lane planning, design, and implementation will be fully consistent with the PBPD approach. For more information on Performance Based Practical Design, see http://www.fhwa.dot.gov/design/pbpd.

Install separated bike lanes as part of street retrofits

Most separated bike lanes will come about as a result of a retrofit of a street using its existing right-of-way. Space in the roadway that is required for a separated bike lane can come from one or more of the following, depending on local context and needs:

- Removal of a lane of on-street (usually curbside) parking
- A shift in alignment of existing on-street parking from curbside to floating to create a parking-protected separated bike lane
- A removal of one of more vehicular travel lanes
- A reduction in width of some or all vehicular travel lanes and/or on-street parking lanes.

These actions fall into two groups, those that affect on-street parking and those that affect general travel lanes and roadway capacity. Planners seeking to install a separated bike lane by changing on-street parking should consider undertaking parking utilization studies, pricing on-street parking at market rates, and evaluating a change in regulations on adjacent or intersecting streets to offset parking space losses. As the public becomes more accepting of cycling and the need for infrastructure with physical separation, they may become more likely to accept and even request such changes.

Creating space for separated bike lanes often involves reducing lane widths or eliminating a motor vehicle lane. Planners have found success in promoting such changes to the streetscape through a Complete Streets approach. By framing the loss of roadway vehicle capacity – which in itself might be undesirable – as a way to calm traffic, improve safety outcomes, and enhance mobility for all street users (pedestrians, cyclists, transit users, and motorists alike), the public will be more likely to see a separated bike lane as a part of a comprehensive effort to improve roadway safety. Implementing such a street conversion by adding a separated bicycle facility, along with other Complete Streets elements like landscaped pedestrian refuge islands, enhanced transit stops, changes to signal timing to reduce speeding, and others, can help to ensure that projects are well-received. Furthermore, adding a separated bike lane design to a more wide-ranging Complete Streets retrofit may often represent only a marginal increase in overall investment on a project.

CASE STUDY

Pilot Projects

Boulder, CO

Boulder's Baseline Road separated bike lane was installed through the Living Laboratory program. (Source: Ray Keener)

In 2013, Boulder introduced a Living Laboratory program to introduce and test new bike facility treatments. The goal of the pilot program is to increase trips by enhancing the existing system for bicyclists of all ages and riding abilities. This pilot approach allows city officials to quickly test out infrastructure treatments, including separated bike lanes, and gather public input to guide design refinements and determine which projects should be made permanent. The program benefits the city by minimizing much of the upfront costs for project design. Boulder prides itself on its active community participation in civic projects, and using a pilot approach allows the City to be experimental while still maintaining its responsive reputation before permanent separated bike lane designs are finalized. Boulder's planners use the program to actively identify potentially successful separated bike lanes and test these perceptions in real-time.

CASE STUDY

Street Retrofits and Complete Streets

Boston, MA

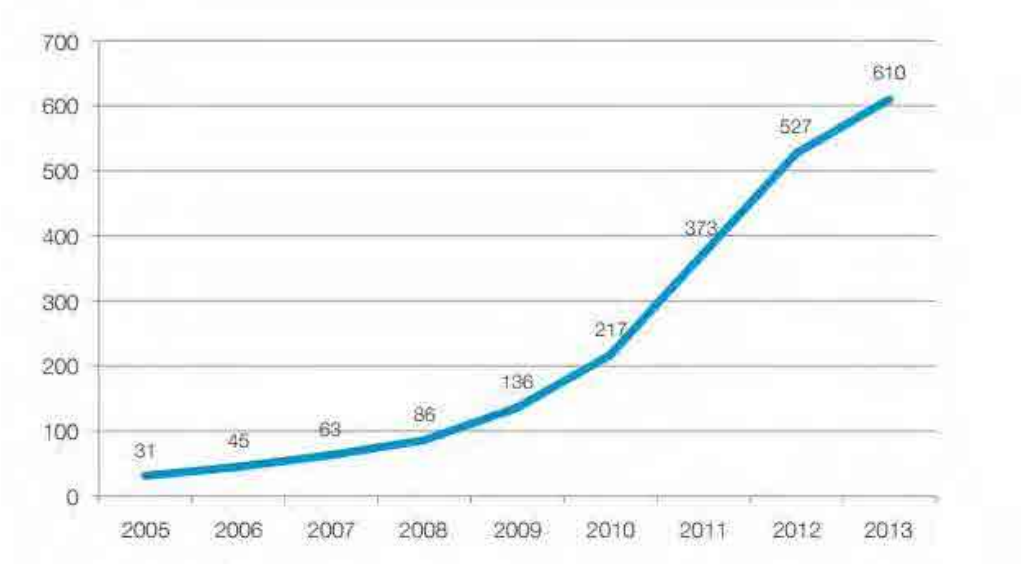
As part of its Connect Historic Boston initiative to link National Park Service and historic sites with transit stations, planners in Boston included a design for a center-running separated bike lane along Causeway Street. It will be part of a network that includes four miles of separated bike lanes along five connected roadways. The City received a Transportation Investment Generating Economic Recovery (TIGER) grant by proposing a wide swath of Complete Streets improvements to several downtown corridors including Causeway Street, which runs adjacent to high-volume pedestrian attractors like North Station, the city's largest transit hub, and the TD Bank Garden arena. The City has decided to use an existing median to build a center-running two-way separated bike lane in this section as part of a major Complete Streets retrofit.

The two-way alignment will allow crossing pedestrians to contend with crossing only one rather than two separate bicycle facilities, and also will reduce pedestrian exposure to motor vehicles in crosswalks. Meanwhile, bicyclists will enjoy the benefit of a separated facility that is well-marked and easily identifiable, with a median that decreases their exposure to motor vehicle traffic. Transit users will also benefit through safer walking and cycling infrastructure, which should help increase transit mode share and support the City's Greenovate Boston (greenhouse gas emission reduction) initiative.

Integrate separated bike lanes into large new construction or major reconstruction projects

Working from a blank or relatively blank slate, planners and engineers should consider possible needs for a separated bike lane from the beginning of the design process. Finding the necessary roadway width to include a separated bike lane in a retrofit can be the most difficult part of the planning process, so planning a separated bike lane from the beginning of a more significant construction project can be highly beneficial to minimize such difficulties years later. Municipalities might consider funding separated bike lanes on new roadways through impact fees on the developer, as separated bike lanes could also bring increased market values to new properties. Municipalities should also take advantage of greater design flexibility in new street construction as part of a Complete Streets approach, especially in States or municipalities that mandate a Complete Streets planning process. Widening an existing roadway can also be an opportunity to produce designs to accommodate adding a separated bike lane. Finally, major reconstruction projects offer opportunities to introduce separated bike lanes to the public as part of a recreational, tourist, or cultural initiative.

Figure 5



610 municipal Complete Streets policies were in effect as of 2013, and more are adopted every year. (Source: Smart Growth America)

CASE STUDY

Reconstruction Projects, Separated Bike Lanes, and Tourism

Indianapolis, IN

Construction of the downtown Cultural Trail in Indianapolis, IN. (Source: Mark H. Zwoyer)

The city of Indianapolis embarked on a comprehensive downtown development effort to create a historic "Cultural Trail" that connects the city's six cultural districts. Officially opened in 2013, the trail includes 8 miles of physically separated bicycle facilities, connects 82 miles of existing on-street bike lanes and over 70 miles of off-street greenway trails, and supports a new public bikeshare system of 250 bikes for use on the facility. The Cultural Trail also features high-quality pedestrian infrastructure, wayfinding and informational signage, public art, and bioswales for stormwater collection and corridor beautification. Constructed with a mix of Federal funds and private donations, Indianapolis has successfully created a new tourist attraction through its downtown that also happens to feature a high-quality separated bike lane that improves bicycle connections for residents and visitors alike.

Completed section of the downtown Cultural Trail in Indianapolis, IN. (Source: Mark H. Zwoyer)

FUNDING, MAINTENANCE, AND OUTREACH

Funding Separated Bike Lanes

Costs for separated bike lanes vary extensively due to the wide variety of treatment types and materials used. One estimate provides a range of $50,000 to $500,000 per mile for facilities in Austin, TX, but the range may be even wider in other localities.[6] Permanent build-outs with raised curbs and/or dedicated bicycle signalization require more labor and material costs than pilot project approaches to separated bike lanes that consist only of flexible delineator posts and moderate amounts of paint and signage. The use of more affordable materials (often as part of a pilot project approach) can help save money upfront on separated bike lane investment.

[6] *Beaudet, Annick, AICP, and Katherine Gregor. "Austin Rides to the Front. "Planning May 2014: 17-19. Print.*

CASE STUDY

Saving Money with Inexpensive Materials

Washington, DC

Inexpensive treatment with flexible delineator posts on L Street, Washington DC (Source: DDOT)

Municipalities often consider more affordable, temporary materials for their flexibility and ease of installation. Washington, DC, built two of its newer separated bike lanes along L and M Streets NW, using flexible delineator posts and reduced use of green paint in order to save money on implementation while addressing neighborhood concerns about design. The District's Department of Transportation estimates that separated bike lane construction costs on L Street may have been reduced by upwards of 50% as a result.

Funding can be acquired from many sources, including Federal, State, and/or local contributions, and monies from private or nonprofit entities. Municipalities have pursued funding through Federal programs such as the Congestion Mitigation and Air Quality Improvement Program (CMAQ), Surface Transportation Program (STP), Transportation Alternatives Program (TAP), Transportation Investment Generating Economic Recovery grants (TIGER), and others. In general, all Federal funding sources can and should be considered in the context of separated bike lane projects. Beyond Federal funds, planners should explore local funding options such as development impact fees and/or local sales tax ordinances to raise money that is dedicated to separated bike lane development.

CASE STUDY

Federal-Aid Funding for Pedestrian and Bicycle Facilities

Nationwide

Bicycle and pedestrian projects, including separated bike lanes, are eligible for Federal-aid highway and transit program funding categories. More information is available at the following web address:

www.fhwa.dot.gov/environment/bicycle_pedestrian/funding/funding_opportunities.cfm

Separated bike lanes can also be funded using private sector sources – a good solution in locations where access to public funds is scarce. Local businesses often have reason to advocate and even pay for separated bike lane investment; some US municipalities are considering or have already received funding for separated bike lanes from local businesses, or groups of businesses through Business Improvement Districts (BIDs), or other private entities that consider investments in bicycle infrastructure to be economically beneficial. A common solution is for a BID to enter a maintenance agreement with a city that has funded separated bike lane construction along a commercial corridor.

Some companies may find a separated bike lane to be such an attractor of potential customers or employees that funding its entire construction can be a worthwhile investment.

Creative funding solutions through value capture financing, in the form of Tax Increment Financing (TIF) mechanisms, infrastructure impact fees, or others, may represent future collaborations between the public and private sectors that treat separated bike lanes like other investments in local transportation infrastructure.

Nonprofit funding such as that from health organizations, can provide the incremental push that a municipality might need to bring a separated bike lane concept from planning and design stages to implementation.

CASE STUDY

BID Support for Separated Bike Lanes

Philadelphia, PA and Miami, FL

The City of Philadelphia and the Center City District temporarily closed one lane (at left) on Market Street to demonstrate the impacts of adding a separated bike lane. (Source: Dylan Semler)

Business districts recognize that vibrant, thriving commercial spaces are characterized by walkability and activity. Philadelphia's Center City BID initiated a traffic calming project to address excess capacity and make street crossings safer on JFK Boulevard and Market Street. The BID worked with the City, neighborhood building owners, and retail tenants, and determined that a separated bike lane design with a landscaped buffer would be the preferred method of calming traffic. During Park(ing) Day, the City enacted a temporary closure of one lane, and showed that traffic would still flow properly even with a lane reduction.

Likewise, the Downtown Development Authority (DDA) in Miami led the planning and concept development of several separated facilities. The DDA is enthusiastic about separated bike lanes because of their ability to attract "interested but concerned" riders and draw potential shoppers to its commercial district. Specifically, the DDA is hoping to attract senior citizens, who often ride on the sidewalk in downtown. In both cases, BIDs in Philadelphia and Miami will assume responsibility for cleaning and regular maintenance of the separated bike lanes and buffers.

CASE STUDY

Corporate Funding for Separated Bike Lanes

Seattle, WA

Rendering of proposed 7th Avenue separated bike lane (Source: Seattle Times)

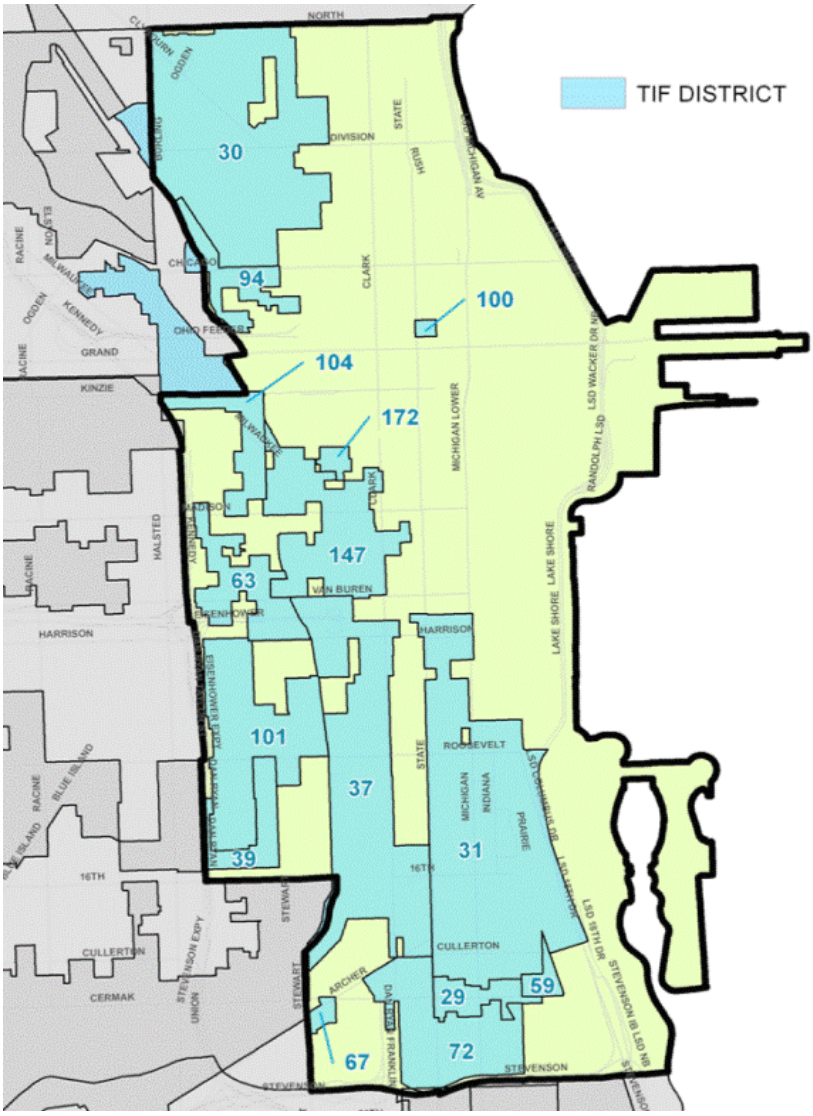
The city of Seattle is planning a separated bike lane along 7th Avenue in the city's South Lake Union neighborhood, and considers this corridor an important element in creating connections in its low-stress bicycle network. Amazon, one of Seattle's largest corporate residents, will pay for construction of the portion of the proposed separated bike lane adjacent to the company's new corporate headquarters. Negotiated as a part of the development review process, both Amazon and the city of Seattle believe safe bicycle access to the workplace will render the location more desirable for potential employees. While such an arrangement may not be common, other municipalities may wish to consider approaching large corporate entities for whom separated bike lane investment could be a win-win situation.

Rendering of proposed Blanchard Street to Westlake Avenue configuration with two one-way separated bike lanes, to be funded by Amazon. (Source: Seattle Times)

CASE STUDY

Funding Separated Bike Lanes with Value Capture

Chicago, IL



TIF districts in central Chicago (Source: City of Chicago)

Value capture financing is defined as the recovery of the increase in property value generated by public infrastructure investments that accrue to private landowners who benefit from the infrastructure. Chicago has used value capture through Tax Increment Financing (TIF) mechanisms, in which portions of increased tax revenue from development rights are used to fund neighborhood improvements such as separated bike lanes. The City also uses TIF funding to expand its popular Divvy bike share program.

MAINTENANCE

Maintaining Separated Bike Lanes

Properly maintaining separated bike lanes involves a set of unique issues that may not be compatible with general street or sidewalk maintenance. When building separated bike lanes, municipalities must consider how they will be swept and, if applicable, plowed during snow events. Consideration should include an inventory of existing maintenance equipment, whether it will fit in the proposed separated bike lane, and alternative options if the equipment will not be compatible. The width of separated bike lanes relative to the width of sanitation vehicles is a particularly important issue to address during planning stages.

Common maintenance problems are the lack of coordination between planning and maintenance agencies and a lack of funding to purchase smaller sanitation equipment to fit the separated bike lane. Plowing and sweeping problems are exacerbated in many municipalities due to their separate departments for planning and maintaining separated bike lanes. When building separated bike lanes to accommodate drainage, planners should consider environmentally friendly options such as bioswales within landscaped medians that can absorb precipitation and also serve as the facility's form of physical separation from vehicular traffic.

Seattle's 2nd Avenue two-way separated bike lane provides adequate width and access for street sweeping vehicles. (Source: Seattle Department of Transportation)

CASE STUDY

Sweeper Selection for Separated Bike Lane Maintenance

Nationwide

Narrow sweepers like this one can fit into most separated bike lanes (Source: PeopleForBikes)

In order to sweep or plow separated bike lanes, many municipalities have realized that traditional maintenance equipment is either too large or small. The Green Lane Project, "a PeopleForBikes program that helps build better bike lanes to create low-stress streets", has published a list on the subject, available at the following web address:

http://www.peopleforbikes.org/blog/entry/tech-talk-the-best-street-sweepers-for-clearing-protected-bike-lanes

As separated bike lanes become more common, the list will likely expand as more products come to market.

Boulder uses a standard plow that fits in its 2-way Baseline Road separated bike lane. (Source: City of Boulder)

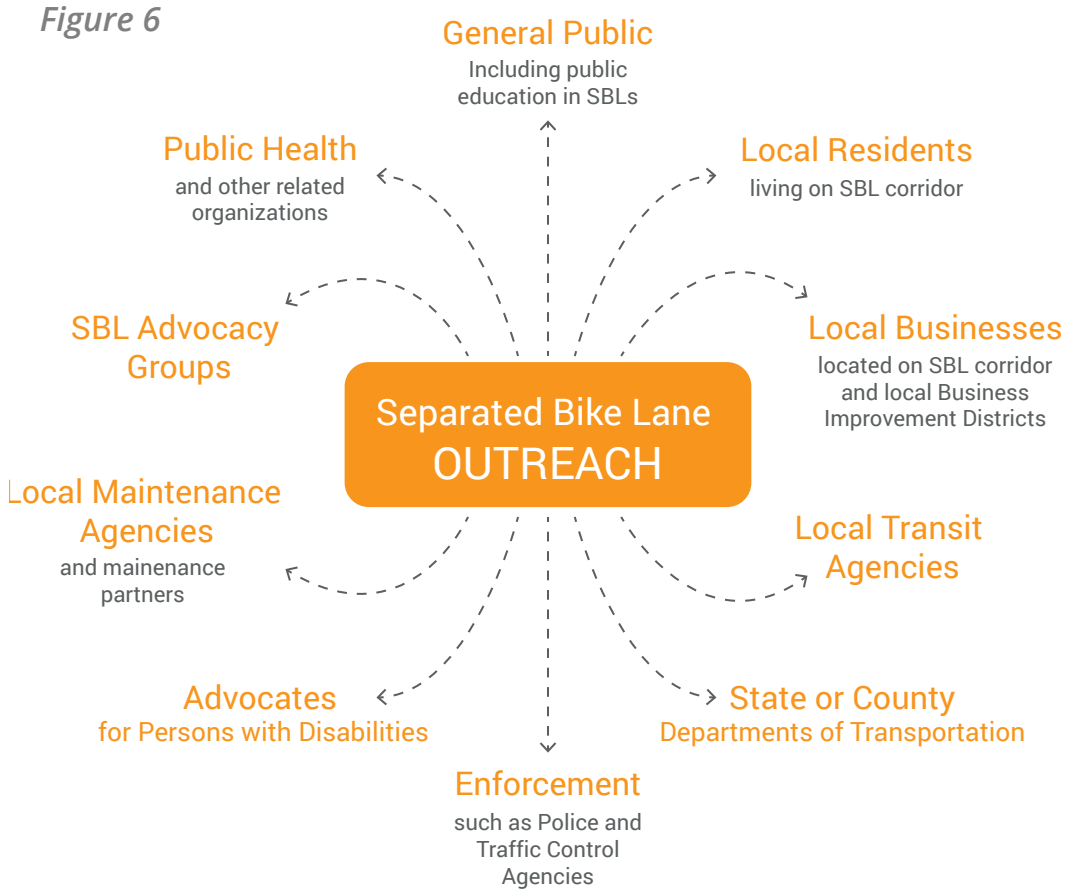
OUTREACH

Outreach on Separated Bike Lanes

Outreach when planning for separated bike lanes is just as critical as working through designs and securing funding. Separated bike lane outreach takes numerous forms, including:

- Outreach to the general public during planning and design stages, including residents along a potential separated bike lane corridor;
- Outreach to the business community along the proposed corridor;
- Coordination with transit agencies that operate service along or intersecting with the proposed corridor;
- Coordination with enforcement and public safety agencies such as police and fire departments;
- Coordination with State and county Departments of Transportation (especially for separated bike lanes along or intersecting with state or county-controlled roads);
- Coordination with maintenance divisions;
- Coordination with other partners such as advocacy groups, public health organizations, and others; and
- Outreach during implementation with a public education focus on how different user groups (cyclists, motorists, pedestrians) should interact with the new facility (especially around conflict areas like intersections and driveways).

Figure 6



CASE STUDY

Business Support for Separated Bike Lanes

Missoula, MT

Higgins Street separated bike lane in downtown Missoula, MT (Source: City of Missoula)

A separated bike lane for Higgins Street in Missoula emerged through a master plan that was conceived of and paid for by the local downtown business improvement association. The plan focused heavily on improving walking and cycling and included separated bicycle facilities. While a few local businesses opposed the project because of losses of curbside parking spots, the vast majority, along with the association's director and the director of the downtown redevelopment agency, supported the project to bring safer cycling activity to downtown Missoula. This support was critical during the public process, and was an important contributor in moving the project forward. Since construction, the downtown BID has assumed responsibility for cleaning and regular maintenance of the separated bike lane. Its activities include snow removal and sweeping, and the BID owns maintenance vehicles that can fit into the separated bike lane.

The most successful outreach is started as early as possible and provides all stakeholders with transparent information on changes that are proposed to the streetscape. Support from the local business community can be critical to the success of a planned separated bike lane, and partnerships with BIDs have been instrumental in advancing separated bike lanes in many municipalities. Separated bike lanes can be marketed to the business community as a tool for traffic calming and generators of increased activity in front of storefronts.

Successful separated bike lane planning is also contingent on cooperation by planners with sister agencies within a municipality along with relevant State or county departments of transportation. The design guidance presented in the following chapter is intended to be a resource for all of these parties, and is meant to aid coordination efforts with these groups.

Perhaps the most important element of separated bike lane outreach involves educating the public on what can be significant changes to the streets in their cities, towns or villages. As separated bike lanes become more popular, the learning curve on these new designs will improve, but today across the country many citizens are interacting with these facilities (as cyclists, as motorists, and as pedestrians) for the first time. As a result, it is critical to consider a messaging campaign, even at a highly localized level, in order to improve awareness of new designs.

CASE STUDY

Public Education on Separated Bike Lanes

Jackson, WY

Rendering of Broadway, a curb separated bike lane in Jackson, WY. (Source: City of Jackson)

Jackson plans to launch a public education campaign associated with its Broadway separated bike lane that will be implemented in 2014 and 2015. The campaign will include a partnership with a local advocacy organization, advertisements in the local newspaper, and temporary signage along the corridor during the initial rollout period. This type of public education effort – rare to date in US municipalities that have constructed separated bike lanes – is encouraged and could serve as a model for education during implementation, especially in municipalities building their first separated facility.

PROJECT EVALUATION

Holistic Evaluation of Separated Bike Lanes

When planning separated bike facilities, practitioners should evaluate projects in a holistic fashion, considering all street users and using evaluation criteria beyond just mobility and safety. The project evaluation process should attempt to measure various effects of separated bike lanes on different groups such as pedestrians, cyclists, transit users and motorists. A detailed project evaluation checklist is provided as Appendix D. This checklist identifies a broad range of measures that can be considered as part of a holistic evaluation of a Separated Bike Lane. This checklist can be used in conjunction with Appendix E, which provides detailed instructions on volume and crash data collection pre- and post-implementation. One of the critical elements in the evaluation is to confirm that all of the traffic control devices are compliant with the provisions in the Manual on Uniform Traffic Control Devices (MUTCD), which is available at *http://mutcd.fhwa.dot.gov*.

It is crucial that any evaluation measure before and after changes in bicycle volumes and bicycle crash and injury data. The collection of high-quality volume and crash data is also important for future research efforts on the mobility and safety effects of separated bike lanes. Meanwhile, the indirect effects on the streetscape, local area quality of life, and safety outcomes for all street users – such as improvements to public spaces, a revival of a retail corridor, shorter crossing distances for pedestrians, and even simplified traffic patterns for motorists – should be emphasized as part of a package of improvements gained through separated bike lane implementation. Using a Complete Streets framework, municipalities can use this holistic approach to project evaluation to achieve support for designs by showing the spillover benefits to populations beyond the local bicycling community.

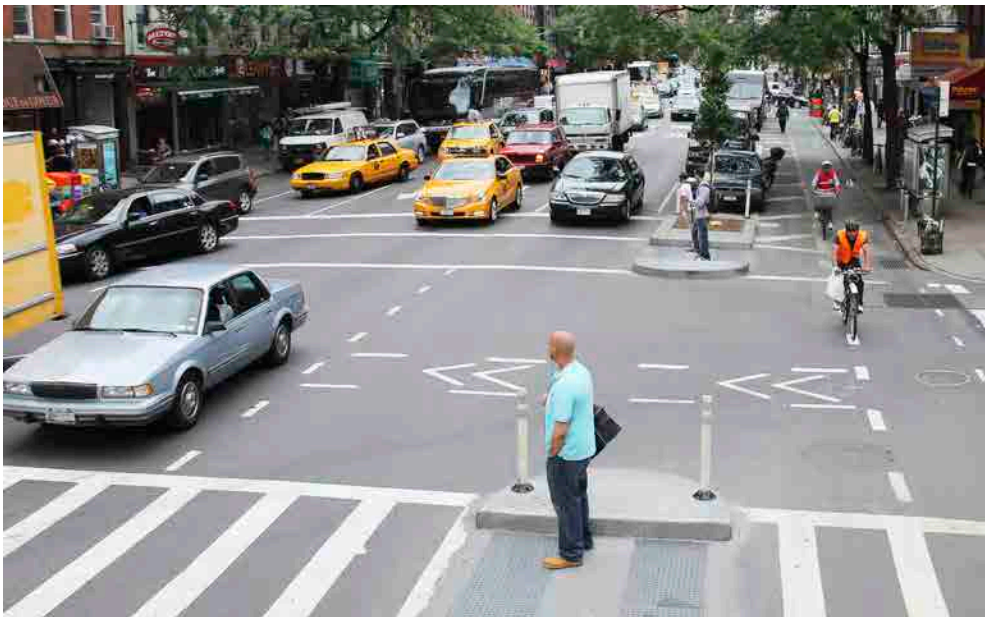
Best Practices on Data Collection

Before planning and designing a separated bike lane, it is critical to formalize data collection procedures in order to provide for effective project evaluation. This is important because only with quality data will a municipality be able to make a quantitative case for the safety, mobility, and economic benefits of separated bike lanes. Use the data collection information checklist (see Appendix E) to collect data before and after separated bike lane installation at key locations. Of particular importance is the need to collect bicycle volume and crash data in a consistent manner during the pre- and post-implementation periods. With advances in automated counting technology and their decreasing costs, municipalities are strongly encouraged to use them to achieve regular and continuous count data. It is also important to maintain a consistent counting methodology in the before and after evaluation periods, preferably using the same technology vendor or contractor. Additional data collection to accompany automated counts, such as maintaining a before and after photo library and conducting qualitative surveys to measure satisfaction on projects, are also advised. Finally, data collection should be viewed as one piece of project evaluation and should be tied into project outreach and the holistic evaluation of a separated bike lane's effect on all street users.

CASE STUDY

Separated Bike Lane Project Evaluation

New York City, NY

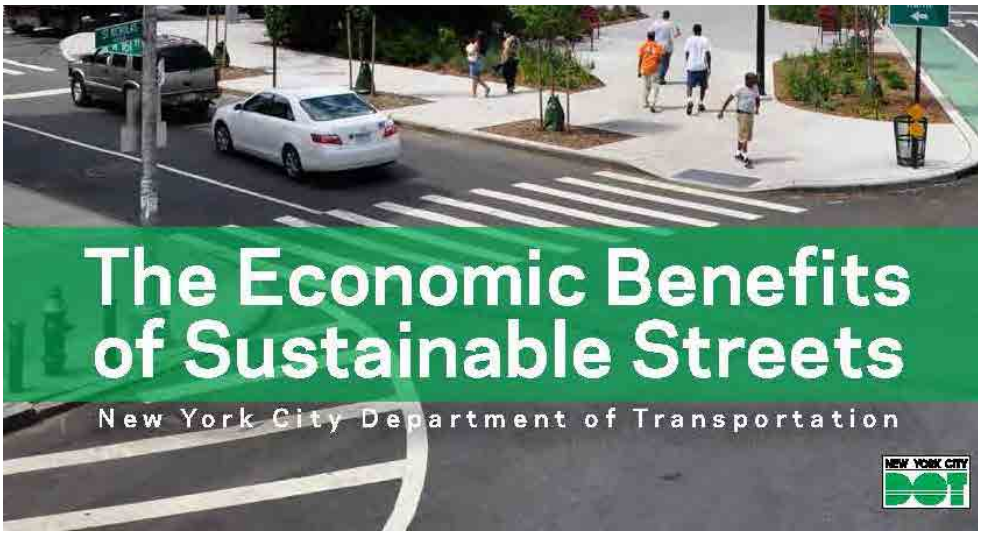


Retail sales grew along New York City's 9th Avenue separated bike lane corridor when compared with comparison corridors without separated bike lanes (Source: NYC DOT)

New York City frames its separated bike lane projects in the context of Complete Streets with improvements that benefit all users. To assess impacts the agency performs a holistic project evaluation that includes data collection on traffic volume and safety in addition to numerous other factors. To evaluate the success of a section of its 1st Avenue separated bike lane between E. 61st Street and E. 72nd Street, the City measured changes in crashes with injuries for all users (cyclists, pedestrians, and motor vehicle occupants) along the corridor before and after implementation, noting a reduction of 10%. (This data is for two years after and will be updated for up to three years after implementation, at which point the City considers the results to be final).

The evaluation measured mobility outcomes and showed a significant 45% weekday increase in bike volumes. The mobility measurement included motor vehicles too, showing that vehicular travel times improved slightly during the PM peak as a result of a more simplified traffic pattern, the addition of left turn bays, and new dedicated loading zones that reduced double-parking. This improvement in travel times also benefits transit users, as 1st Avenue is a one-way street, with a dedicated bus lane on its right side serving the City's M15 Select Bus Service route. Ridership on this bus route has improved 9% since implementation. The City also calculated vehicular Levels of Service at E. 72nd Street and found no change. Within this evaluation framework, New York City also highlights the 14 new landscaped pedestrian islands (which shorten crossing distances) and the new street trees planted within them.

The installation of the separated bike lane also allowed the City to remove PM peak parking restrictions, resulting in the effective creation of 70 new spaces during this time – an accomplishment given the potential losses of on-street parking that can accompany the installation of separated bike lanes with mixing zones. While the City has not yet measured the effect of the subject corridor on local retail, similar studies – such as one on a section of its 9th Avenue separated bike lane – have shown marked increases in revenue for local stores on separated bike lane corridors relative to comparison corridors with no separated facilities. These improvements are cited in the City's 2013 Economic Benefits of Sustainable Streets report for 9th Avenue and Columbus Avenue; similar economic impact studies will expand to other separated bike lane corridors in the future.



New York City has focused on economic factors like retail sales growth along separated bike lane corridors, 2 of which are included in this 2013 report (Source: NYC DOT)

CHAPTER 5

MENU OF DESIGN RECOMMENDATIONS

DESIGN RECOMMENDATIONS

Four Step Design Process

The separated bike lane design process can be categorized into four general categories – Directional and Width Characteristics, Forms of Separation, Midblock Considerations, and Intersection Considerations. These categories form the basis of a four-step design process where the decisions within each step inform future design decisions, resulting in an iterative design process based on available street width, transportation priorities, and other project goals. This chapter groups the design process into these four categories and provides flexible design options to best meet local conditions and the community's goals.

When designing these newer types of facilities, it is important to document the numerous decisions made throughout the design process. Documentation should demonstrate that the final design was developed based on the best available data, good engineering judgment, and sound design principles.

STEP 1: ESTABLISH DIRECTIONAL AND WIDTH CRITERIA

- The decision of one-way and two-way separated bike lanes should be based on traffic lane configurations, turning movement conflicts, parking requirements, and surrounding bicycle route network options and destinations.
- Width considerations include expected bicycle volumes, required buffer width, and maintenance requirements.
- Alignment decisions for running the separated bike lane on the right-side, left-side, or in the center of the road, include transit stop conflicts, intersection and driveway conflicts, locations of destinations, and parking placement.

STEP 2: SELECT FORMS OF SEPARATION

- Separation type decisions should be based on the presence of on-street parking, street width, cost, aesthetics, maintenance, motorized traffic volumes and speeds.

STEP 3: IDENTIFY MIDBLOCK DESIGN CHALLENGES AND SOLUTIONS

- There are several potential conflicts that may occur at midblock locations along a separated bike lane.
- Transit stops occurring on the same side of the street as the separated bike lane present a challenge due to interactions among cyclists, transit vehicles, and those accessing transit stops.
- Locating accessible parking spaces may require additional design adjustments.
- Loading zones should be well-located and designed to minimize conflicts.
- Driveways present concerns due to challenges with sight distance and driver expectations that can be minimized through design treatments and driveway consolidation.

STEP 4: DEVELOP INTERSECTION DESIGN

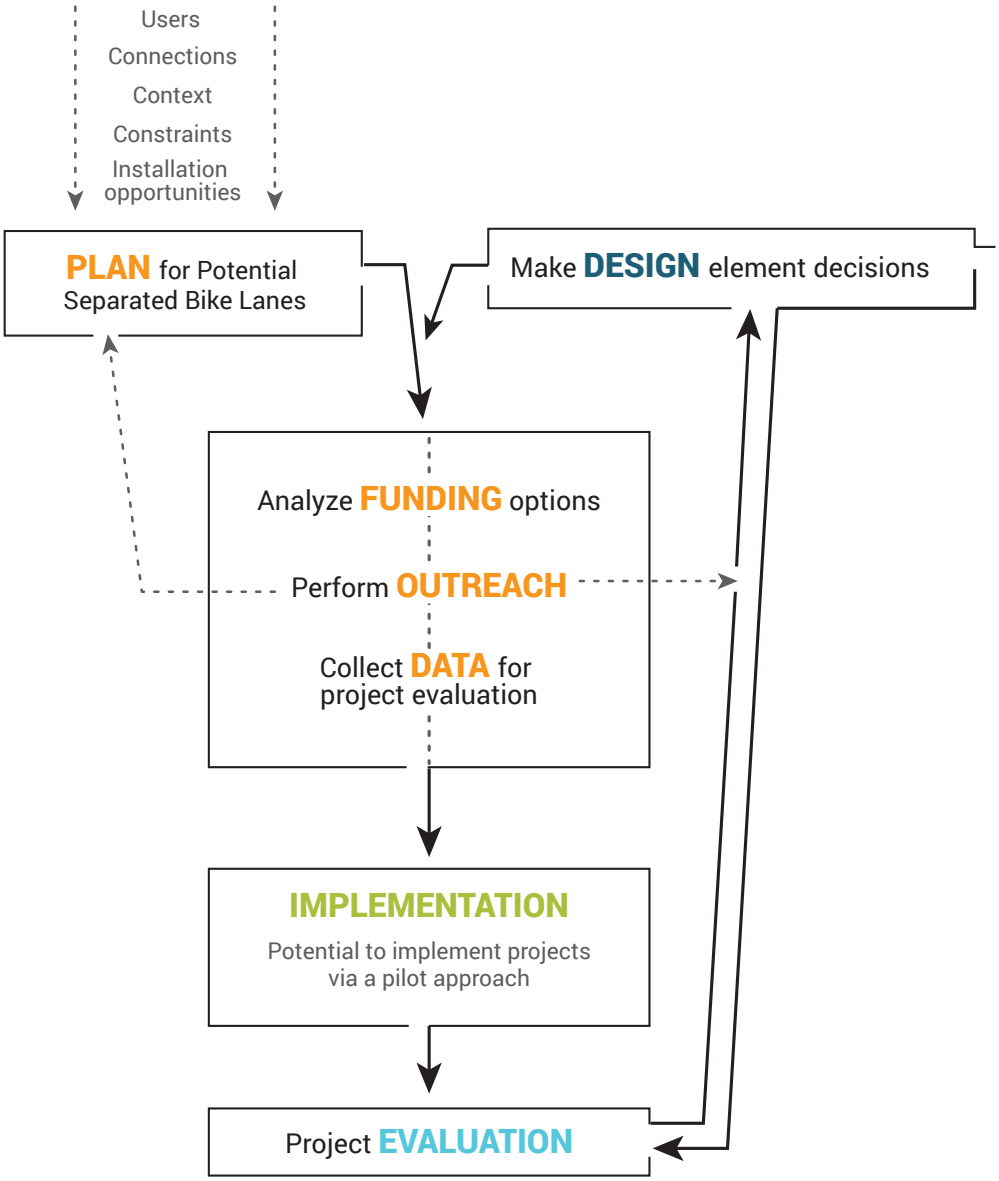
- Intersection design should focus on the safety of all users with additional consideration on delay, queuing, user expectations, motorized traffic volumes and speeds.
- Sufficient sight distance for all street users at intersection approaches should be provided.
- Designs should protect or provide safe interactions between separated bike lane users and conflicting turning movements.
- Signs and markings should be included to appropriately guide and prompt safe behaviors through intersections.

DESIGN RECOMMENDATIONS

Flexibility in the Planning and Design Process

The designs presented in this chapter are based on current design guidance and the state of the practice and are intended to be a starting point for a flexible design process that takes into account site conditions, context, and continually evolving design resources. The graphic below highlights the key elements of a successful design process, but the order and exact execution of the steps are flexible. Evaluation and design are iterative processes, with designs evolving as municipalities evaluate how a facility is functioning.

Figure 7



DIRECTIONAL AND WIDTH CHARACTERISTICS

STEP 1

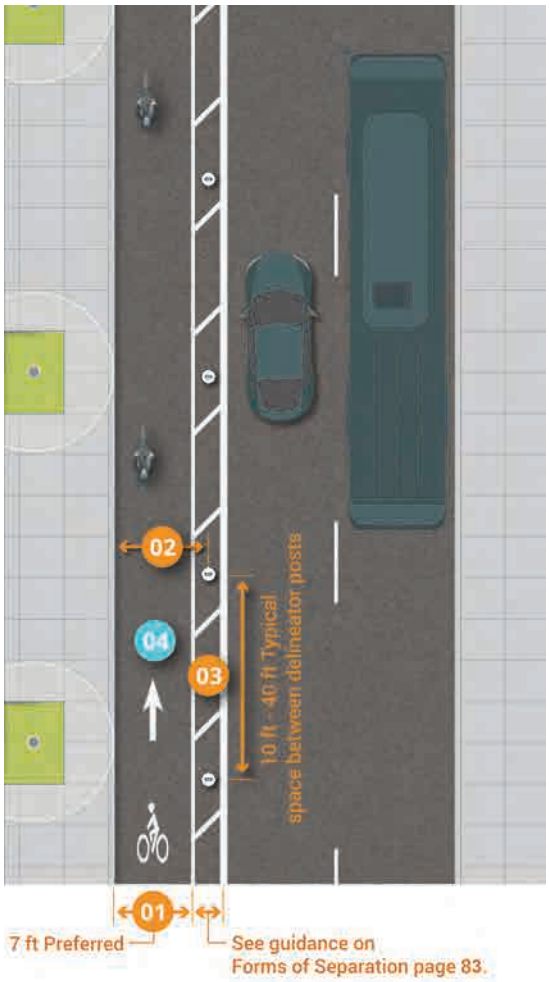
The selection of separated bike lane width and directional characteristics depends on a combination of factors that are most often determined by the existing street and surrounding network characteristics. The most critical considerations are to reduce conflicts with turning vehicles, provide sufficient width for safe operations and ease of maintenance, and ensure predictable behavior by the street users.

DIRECTION AND WIDTH

One-Way Separated Bike Lane on a One-Way Street

A one-way separated bike lane on a one-way street is the least complicated design. This type of design can most easily be implemented on existing streets through the conversion of a motor vehicle lane or removal of on-street parking. Another advantage of this type of facility is the ability to provide a reasonable signal progression for cyclists, improving travel time and signal compliance. One potential complication of this design may be wrong-way riding by bicyclists. This can occur if there are no suitable and attractive bicycle routes (such as a parallel facility) near this separated bike lane.

Figure 8



01 One-way separated bike lanes should have a minimum width of 5 ft. Wider separated bike lanes provide additional comfort and space for bicyclists and should be considered where a high volume of bicyclists is expected. Widths of 7 ft and greater are preferred as they allow for passing or side-by-side riding. Additional care should be taken with wider lanes such that the separated bike lane is not mistaken for an additional motor vehicle lane.

02 Total clear width between the curb face and vertical element should be at least the fleet maintenance (sweeping or snowplow) vehicle width. Widths (inclusive of the gutter pan and to the vertical buffer element) narrower than 7 ft will often require specialized equipment. Consultation with a Public Works department is recommended during the planning process.

03 A minimum 3 ft buffer should be used adjacent to parking. For further guidance on buffer selection and installation, see page 83.

04 For further guidance on typical signs and markings for separated bike lanes, see page 127.

One way Separated Bike Lane on a One-Way Street (Left-Side Running)

Long Beach, CA, has installed left-side, one-way separated bike lanes along a pair of one-way streets downtown. (Source: City of Long Beach)

Consider a left-side running separated bike lane under the following conditions:

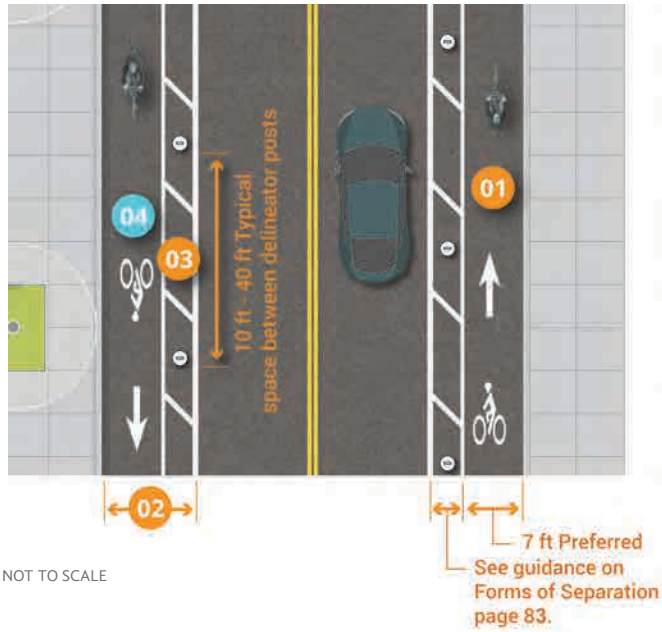
- The corridor includes a high frequency transit route resulting in potential conflicts with transit vehicles, stops, and transit riders.
- There are fewer driveways, intersections, or other conflicts on the left-side of the street.
- The most likely destinations for bicyclists are on the left-side of the street.
- On-street parking is located on the right-side of the street.

DIRECTION AND WIDTH

One-Way Separated Bike Lane on a Two-Way Street

Providing one-way separated bike lanes on each side of a two-way street creates a predictable design for managing user expectations. Typically, each separated bike lane will run to the outside of the travel lanes in a design similar to a one-way separated bike lane on a one-way street. A potential challenge with this design is it takes up more roadway space compared to the alternatives of providing a two-way separated bike lane or developing alternate corridors for directional travel.

Figure 9



01 Bike symbols should be placed periodically in the lane.

02 Drainage grates and gutter seams should generally not be included in the usable width.

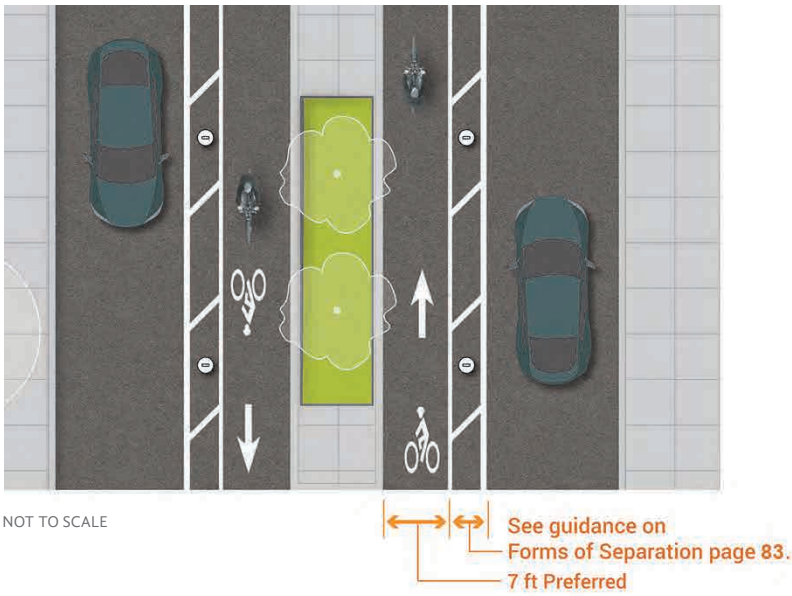
03 For further guidance on buffer selection and installation, see page 83.

04 For further guidance on typical signs and markings for separated bike lanes, see page 127.

Central Median Alternative

An alternative design places separated bike lanes adjacent to a median. This design can be considered when there are significant conflicts due to turning movements, transit activity, or other conflicting curbside uses. Depending on the width of the median, this design may result in intersection design challenges, particularly in how bicyclist right- and left-turns are made.

Figure 10



DIRECTION AND WIDTH

Two-Way Separated Bike Lane on Right-Side of One-Way Street (2 Lanes)

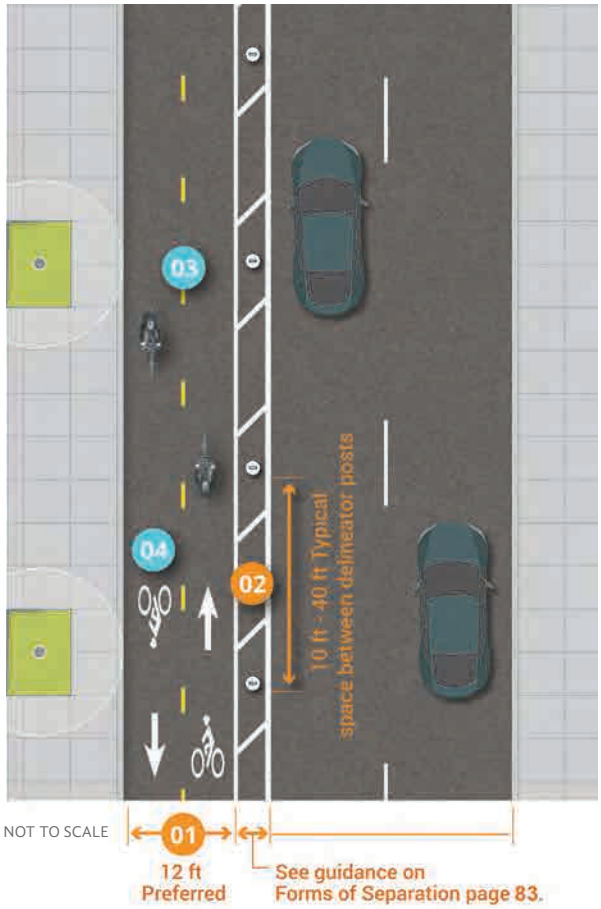
Providing a two-way separated bike lane on a one-way street may be desirable under certain circumstances. This design couples a separated bike lane with a contraflow bike lane in order to route bicyclists in the most direct or desirable way given the street network and destinations. However, this design can create some challenges for roadway user expectancy at intersections and driveways, which could be mitigated by signage suggesting to look both ways for pedestrians. Additionally, certain intersection designs are not possible.

Left-Side Running Alternative

Consider a left-side running separated bike lane under the following conditions:

- The corridor includes a high frequency transit route resulting in potential conflicts with transit vehicles, stops, and transit riders.
- There are fewer driveways, intersections, or other conflicts on the left-side of the street.
- The most likely destinations for bicyclists are on the left side of the street.
- On-street parking is located on the right side of the street.

Figure 11



01 Two-way separated bike lanes should have a preferred combined width of at least 12 ft. Given this total width, clear signs and markings should be provided such that the separated bike lane is not mistaken for an additional motor vehicle travel lane.

02 For further guidance on buffer selection and installation, see page 83.

03 A centerline to separate the two-way bicycle traffic marked in accordance with the MUTCD (2009).

04 For further guidance on typical signs and markings for separated bike lanes, see page 127.

DIRECTION AND WIDTH

Two-Way Separated Bike Lane on Right-Side of Two-Way Street

Providing a two-way separated bike lane on a two-way street may be desirable under certain circumstances such as minimizing conflicts on high frequency transit corridors or along corridors with a higher number of intersections or driveways on one side of the street (such as along a waterfront). This design does, however, create some challenges for roadway user expectancy at intersections and driveways. Additionally, the design limits intersection design options.

Figure 12

NOT TO SCALE

01 Due to operational and user expectations, this design is best used when there is no room for separated bike lanes on both sides of the street.

02 For further guidance on buffer selection and installation, see page 83.

03 A centerline to separate the two-way bicycle traffic marked in accordance with the MUTCD (2009).

04 For further guidance on typical signs and markings for separated bike lanes, see page 127

Center Orientation Alternative

An alternative design places a two-way separated bike lane in the center of the street. This design is uncommon and can be considered when there are significant conflicts due to turning movements, transit activity, or other conflicting curbside uses. Depending on the width of the roadway and the amount of space that can be allocated to the separated bike lane and buffer, this design may result in intersection design challenges, particularly on how bicyclist right- and left-turns are made.

Figure 13

NOT TO SCALE

01 A continuously raised buffer is preferred to reduce the chance of U-turns across the separated bike lane.

For further guidance on buffer selection and installation, see page 83.

02 A centerline to separate the two-way bicycle traffic marked in accordance with the MUTCD (2009).

03 For further guidance on typical signs and markings for separated bike lanes, see page 127.

FORMS OF SEPARATION

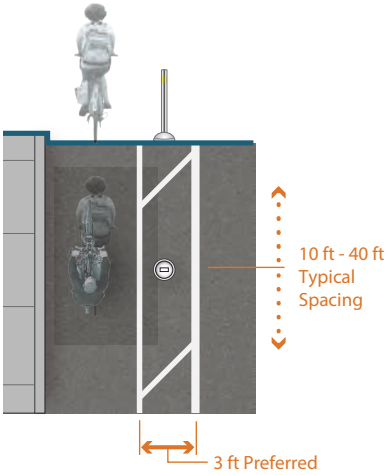
STEP 2

Vertical elements in the buffer area are critical to separated bike lane design. These separation types provide the comfort and safety that make separated bike lanes attractive facilities. The selection of separation type(s) should be based on the presence of on-street parking, overall street and buffer width, cost, durability, aesthetics, traffic speeds, emergency vehicle and service access, and maintenance. In certain circumstances, emergency vehicle access may need to be provided through low or mountable curbs or non-rigid means. The spacing and width dimensions that follow are suggestions; narrower buffer widths may be used so long as the vertical elements can be safely accommodated under the conditions of that roadway. To realize the full benefits of several treatments at a potentially lower overall cost, a combination of separation treatments may be used.

Cyclists enjoy the greatest level of comfort when buffers provide greater levels of physical separation. The National Institute for Transportation and Communities' (NITC) report, "Lessons from the Green Lanes: Evaluating Protected Bike Lanes in the U.S.," found that planters, curbs, and flexible delineator posts provided the greatest sense of comfort, and that any type of buffer shows a considerable increase in self-reported comfort levels over a striped bike lane.

FORMS OF SEPARATION

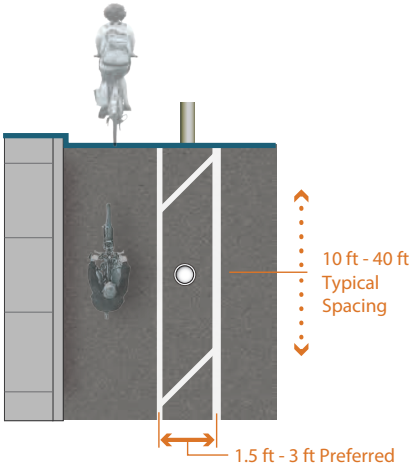
Delineator Posts

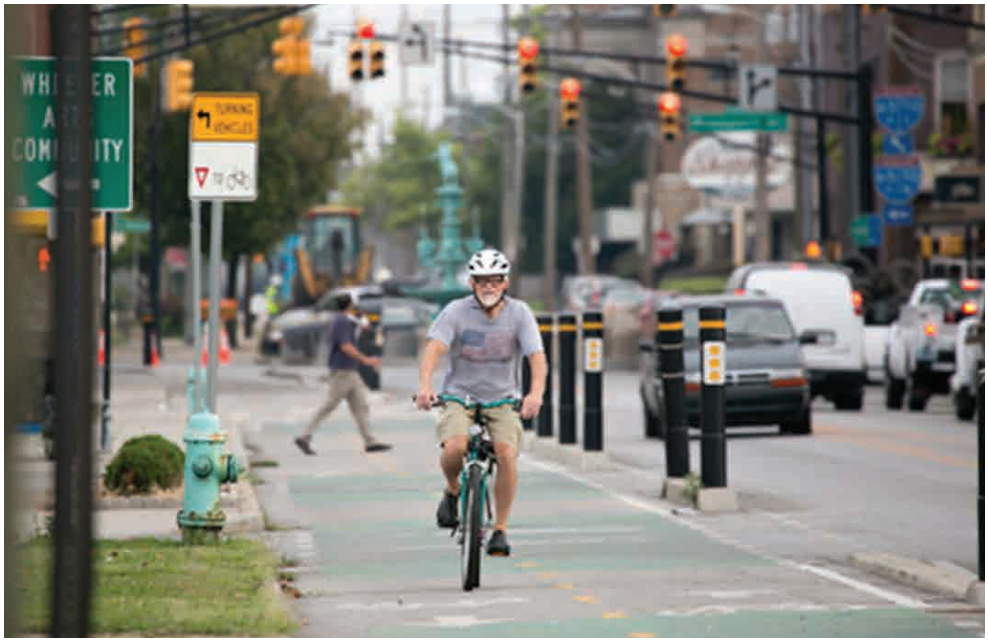


San Francisco, CA. (Source: Dianne Yee)

Flexible delineator posts are one of the most popular types of separation elements due to their low cost, visibility, and ease of installation. However, their durability and aesthetic quality can present challenges and agencies may consider converting these types of buffers to a more permanent style when design and budgets allow. Delineators can be placed in the middle of the buffer area or to one side or the other as site conditions dictate (such as street sweeper width or vehicle door opening).

Bollards



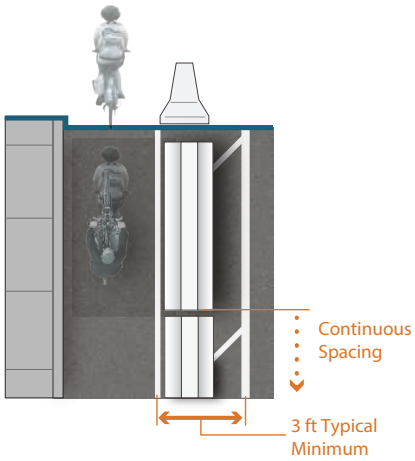


Indianapolis, IN (Source: PeopleForBikes)

Bollards are a rigid barrier solution that provides a strong vertical element to the buffer space. Depending on how frequently the bollards are placed, this form of separation may result in an increased cost compared to others, and may not be as appropriate on higher speed streets.

FORMS OF SEPARATION

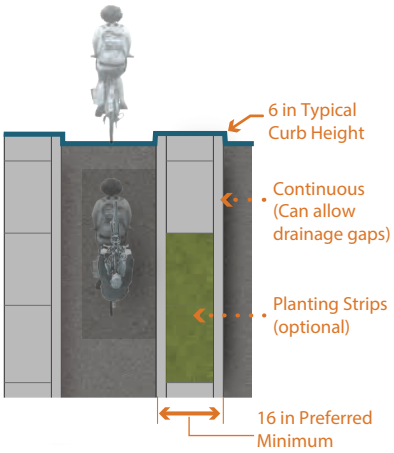
Concrete Barrier



Seattle, WA. (Source: Seattle DOT)

Concrete barriers provide the highest level of crash protection among these separation types. They are less expensive than many of the other treatments and require little maintenance. However, this barrier type may be less attractive and may require additional drainage and service vehicle solutions. A crash cushion should be installed where the barrier end is exposed.

Raised Median

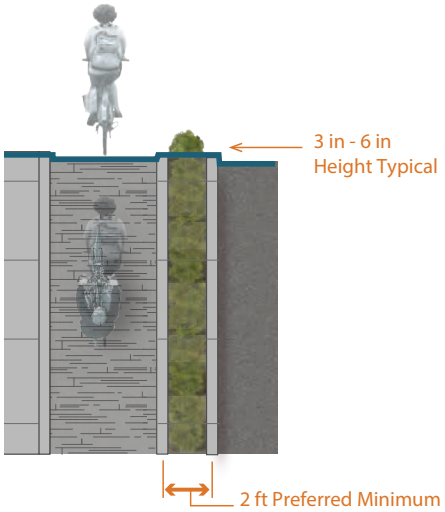


Austin, TX (Source: City of Austin)

Concrete curbs can either be cast in place or precast. This type of buffer element is more expensive to construct and install but provides a continuous raised buffer that is attractive with little long-term maintenance required. Mountable curbs are an option where emergency vehicle access may be required.

FORMS OF SEPARATION

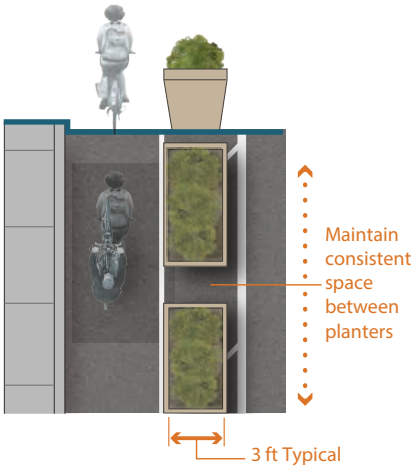
Raised Lane



Cambridge, MA. (Source: City of Cambridge)

Separated bike lanes may also be designed as raised facilities, either at sidewalk grade or at an intermediate grade. If designed at the sidewalk level, the use of different pavement types, markings, or buffers may be necessary to keep bicyclists and pedestrians separated. If placed at an intermediate level, a 3 inch mountable curb may be used to permit access of sweeping equipment.

Planters

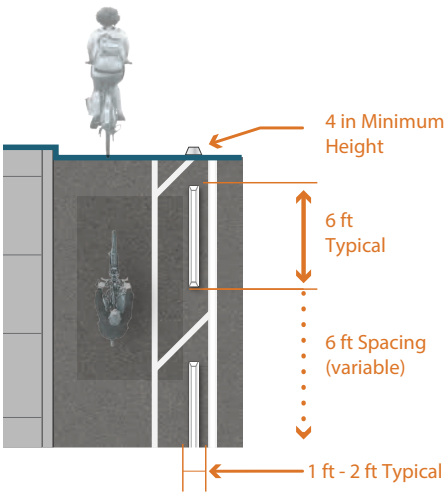


Portland, OR (Source: Oregon Transportation Research and Education Consortium)

This form of separation provides an aesthetic element to the streetscape, a suitable vertical barrier, and is quick to install. However, depending on the placement, this treatment is more expensive than other solutions, requires maintenance of the landscaping, and may not be as appropriate on higher speed streets.

FORMS OF SEPARATION

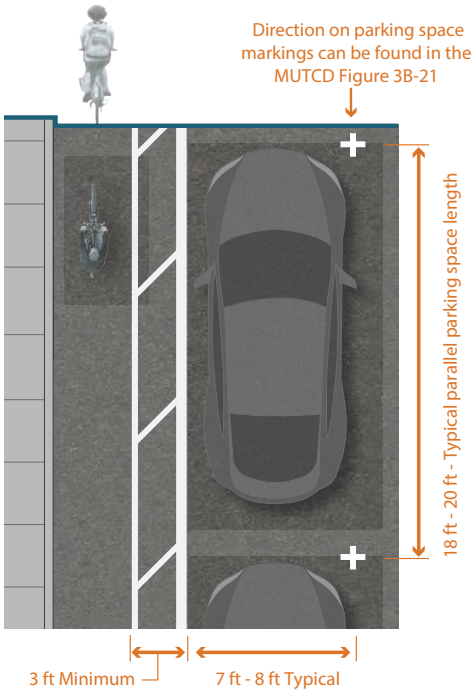
Parking Stops



Baseline Road separated bike lane in Boulder, CO. (Source: City of Boulder)

Parking stops and similar low linear barriers are inexpensive buffer solutions that offer several benefits. These barriers have a high level of durability, can provide near continuous separation, and are a good solution when minimal buffer width is available. However, using the minimum width will not provide the same level of comfort and protection due to their low height and bicyclists' proximity to traffic.

Parked Cars



Parked cars provide separation in Seattle, WA. (Source: Seattle DOT)

While not a barrier type on its own, parked cars can provide an additional level of protection and comfort for bicyclists. A minimum buffer width of 3 feet is required to allow for the opening of doors and other maneuvers. Additional vertical elements such as periodic delineator posts should be paired with this design. Barrier types that obstruct the opening of car doors or create tripping hazards should be avoided.

FORMS OF SEPARATION

Combination of Treatments

Separation types can be used in combination to realize the full benefits of several treatments at a lower overall cost. For example, delineator posts can be alternated with parking stops or other low, linear barriers to provide both horizontal and vertical elements. Planters or rigid barriers and bollards may be used at the start of a block to more clearly identify the separated bike lane and provide an aesthetic treatment, with more inexpensive treatments used midblock.

A raised lane combined with curbside bicycle and car parking provide vertical and horizontal separation from vehicular traffic on Higgins Street in Missoula, MT. (Source: City of Missoula)

Raised curb islands at intersections combined with flexible delineator posts and parked cars midblock on 9th Avenue in New York City, NY (Source: NYC DOT)

MIDBLOCK CONSIDERATIONS

STEP 3

DRIVEWAYS

Driveways that intersect with separated bike lanes create a potential crash risk due to the conflict between turning motor vehicles and through bicyclists. The risk is increased at locations where there is poor sight distance due to parked cars, landscaping, and other obstructions, or where the design may result in unexpected movements such as the contra-flow direction of travel that occurs on two-way separated bike lanes. Many of these conflicts can be mitigated through good design that improves visibility and expected behaviors. An additional measure beyond separated bike lane design is to consolidate or relocate driveways and access to minimize the number of conflict points along the corridor.

DRIVEWAYS

One Way Separated Bike Lanes

01 Parking should be prohibited at least 20 ft from the edge of a driveway, dependent on vehicle speeds and volumes. Paint alone may not be enough to keep vehicles from parking in prohibited spaces without frequent enforcement efforts. Additional elements such as delineator posts, parking stops, or concrete curb extensions can be included to ensure that this area remains clear.

02 Landscaping and other street-side elements that obscure sight distance should not be included within 15 ft of a driveway edge.

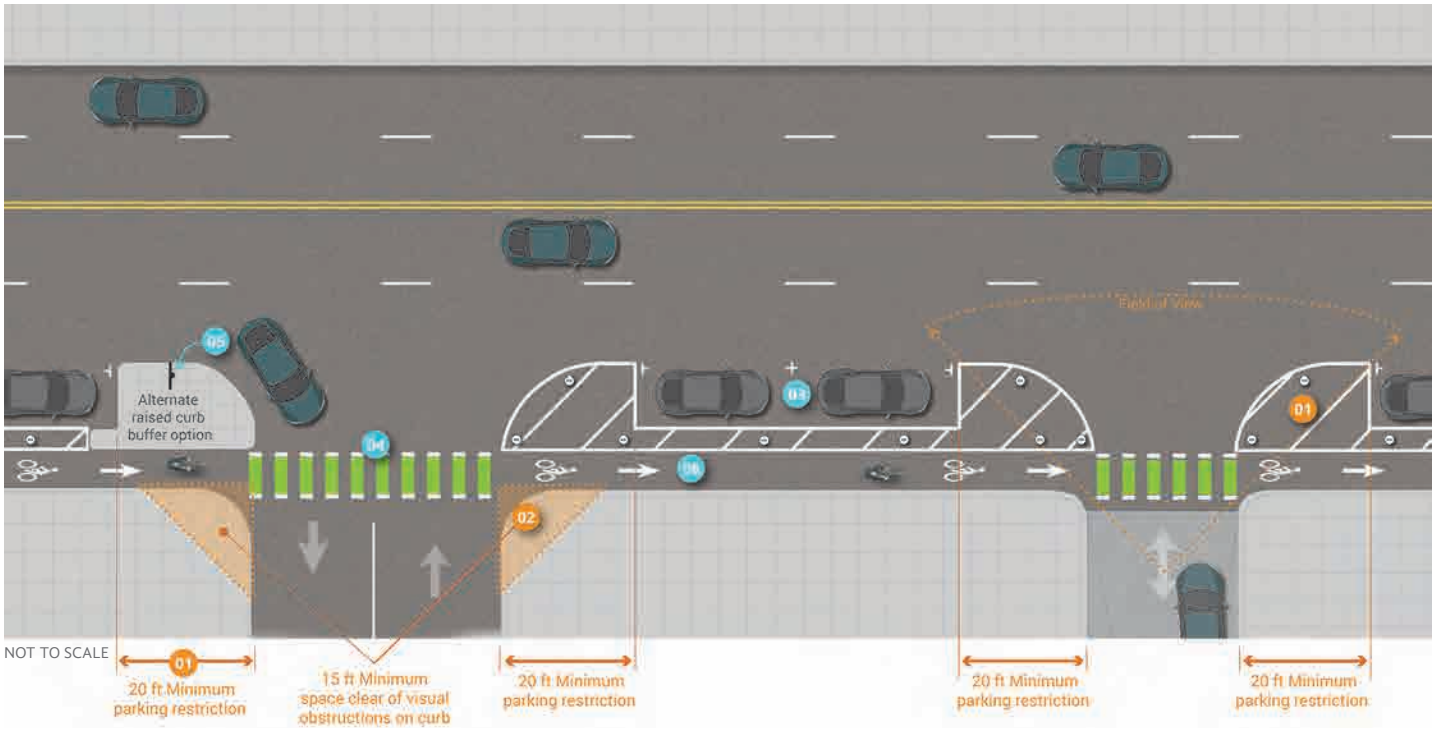
03 Guidance for parking space markings can be found in MUTCD(2009) Section 3B.19. For further guidance on buffer selection and installation, see page 83.

04 A variety of pavement marking treatments can be used to improve visibility of the separated bike lane and reinforce the expected bicyclist behaviors to motorists. For further guidance on paint and striping in conflict areas, see page 114.

05 A "turning vehicles yield to bikes" sign is often used in this scenario to alert turning vehicles to the presence of the separated bike lane; however, it should be noted that while this sign has been proposed it has not yet been specifically approved by FHWA through either the Interim Approval process or adoption into a new edition of the MUTCD.

05 For further guidance on typical signs and markings for separated bike lanes, see page 127.

Figure 14



DRIVEWAYS

Two-Way Separated Bike Lanes

01 Parking should be prohibited at least 20 ft from the edge of a driveway, dependent on vehicle speeds and volumes. Paint alone may not be enough to keep vehicles from parking in prohibited spaces without frequent enforcement efforts. Additional elements such as delineator posts, parking stops, or concrete curb extensions can be included to ensure that this area remains clear.

02 To avoid separated bike lane encroachment of vehicles exiting driveways into the street, landscaping and other street-side elements that obscure sight distance should not be included within 15 ft of a driveway edge.

03 Floating parking design downstream of driveways on one-way streets do not require parking restrictions for visibility since no conflicting traffic is approaching.

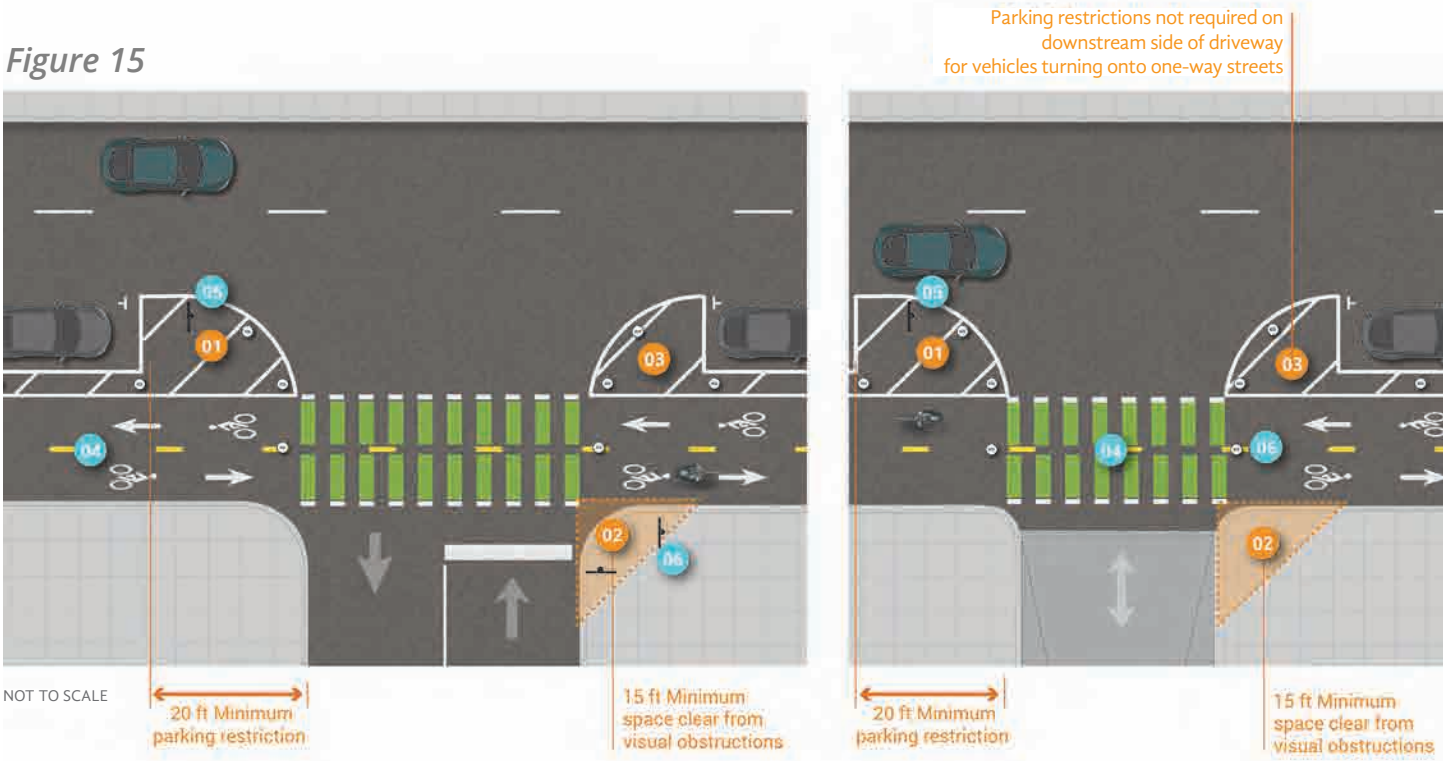
04 A variety of pavement marking treatments can be used to improve the visibility of the separated bike lane and reinforce expected bicyclist behaviors toward motorists. For further guidance on paint and striping in conflict areas, see page 114.

05 Signs on side streets or driveways can alert drivers to expect two-way bicycle traffic, especially on one-way streets.

06 Given the additional width of a two-way separated bike lane, additional measures may be used to reduce the likelihood of accidental entrance by motor vehicles:

- A "Do Not Enter" with a supplementary "Except Bicycles" plaque may be used.
- Or, a BIKE LANE sign (MUTCD R3-17) may be used.
- A delineator post may be placed on the centerline between the two directions of bicycle travel.

Figure 15



TRANSIT STOPS 3

Ideally, separated bike lanes will not operate along the same side of the roadway as high-frequency transit routes, either by using different sides of the street or different streets. However, on many corridors, this division between transit and bicycles is not possible. In these cases transit stops present a challenge among interactions with cyclists, transit vehicles, and those accessing transit stops.

Where possible, separation should continue at transit stops by routing bicyclists behind the bus platform. This type of design avoids conflicts with transit vehicles but does create potential conflicts with pedestrians who must cross the separated bike lane to access the transit stop. This potential pedestrian conflict can be mitigated through design and the provision of discrete crossing locations. Visually impaired pedestrians accessing the bus stop should be directed to the crosswalk using detectable warnings.

TRANSIT STOPS

Island Platform with No Separated Bike Lane Bend

This design may be used at locations where the transit vehicle may stop in a travel lane. In this alignment the separated bike lane does not shift, no sidewalk space is removed, and more on-street parking is allowed. Separating bicycles from bus flow also eliminates "leapfrogging" which improves cyclist comfort and bus operating speeds.

01 The front end of the platform needs 5 ft x 8 ft minimum clear space to accommodate deployment of an accessible ramp from equipped buses.

02 In circumstances without on-street parking, a narrower transit platform may be used so long as a 5 ft x 8 ft level space can be maintained.

03 With a minimum crosswalk width of 6 ft, consider a wider crosswalk dependent on transit boardings. Ideally, the crosswalk is placed at the transit vehicle exit point. If this transit stop is at a street crossing, the bike lane crosswalk should be placed at the start (upstream) end of the platform and included with the full street crossing. If a raised crosswalk is not selected, curb ramps with a marked crosswalk should be used.

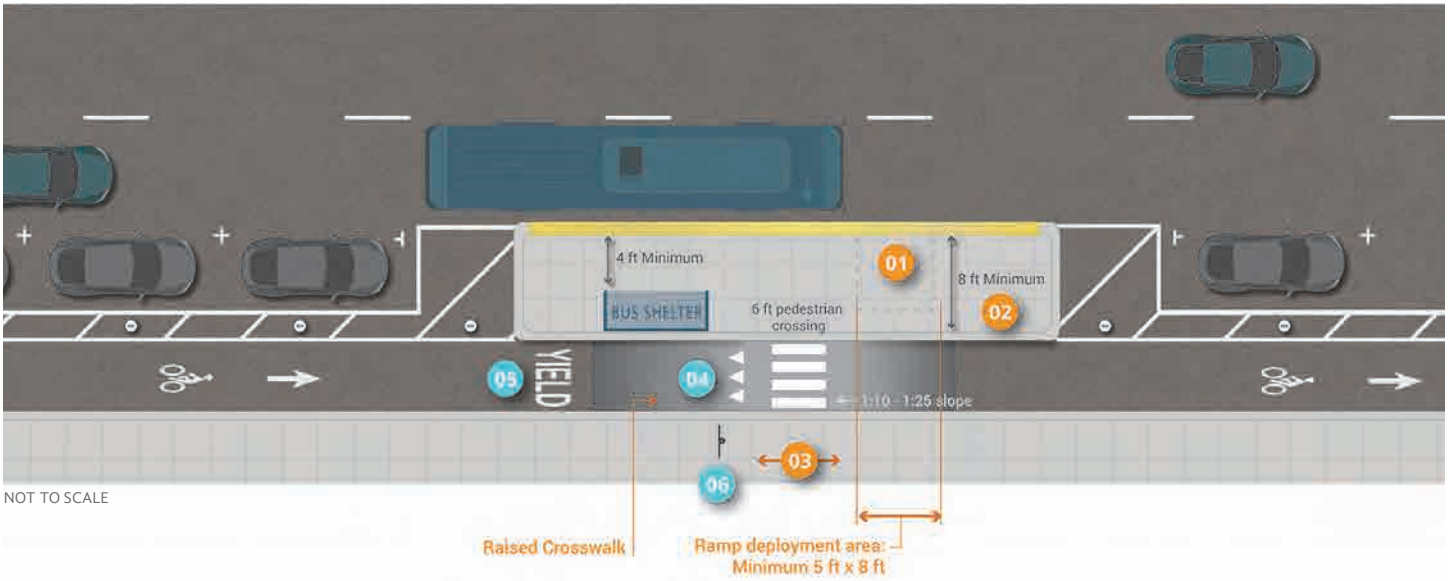
Each curb ramp should have a detectable warning surface in accordance with DOT's regulations implementing Section 504 of the Rehabilitation Act of 1973 at 49 CFR 27.3(b).

04 Place yield line pavement marking just prior to the crosswalk.

05 Optional "YIELD" markings may be placed in the bike lane.

06 Place a YIELD HERE TO PEDESTRIANS (MUTCD R1-5) sign at crosswalk.

Figure 16



NOT TO SCALE

TRANSIT STOPS

Island Platform with Separated Bike Lane Bend

At locations where it is desired to have the transit vehicle move out of the flow of traffic, a separated bike lane may need to bend around the transit platform.

01 This lateral shift of the separated bike lane must be designed based on the offset distance and bicycle design speed.

02 Front end of platform needs 5 ft x 8 ft minimum clear space to accommodate deployment of accessible ramp from equipped vehicles.

03 In circumstances without on-street parking or limited sidewalk space, a narrower transit platform may used so long as a 5 ft x 8 ft level space can be maintained.

04 Minimum crosswalk width is 6 ft. Consider a wider crosswalk dependent on transit boardings. Ideally, the crosswalk is placed at the transit vehicle exit point. If this transit stop is at a street crossing, the bike lane crosswalk should be placed at the start (upstream) end of the platform and included with the full street crossing.

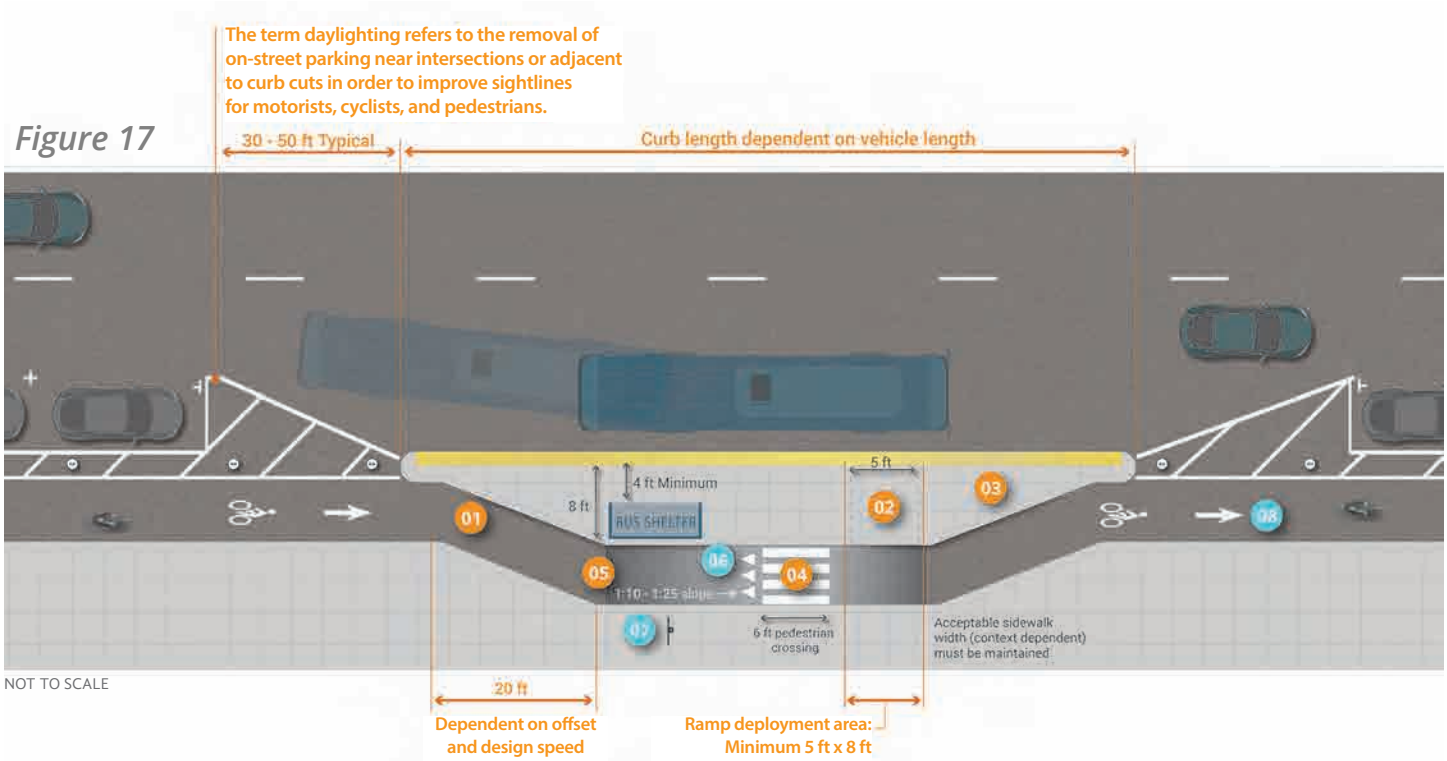
05 To increase awareness between bicyclists and transit users and to emphasize a preferred crossing location, an optional raised crosswalk may be used. Ramp up to raised crosswalk should be 1:10 – 1:25 slope.

06 Yield triangle pavement markings can be placed prior to the crosswalk in accordance with the MUTCD (2009).

07 Place a YIELD HERE TO PEDESTRIANS (MUTCD R1-5) sign at crosswalk

08 For further guidance on typical signs and markings for separated bike lanes, see page 127.

Figure 17



NOT TO SCALE

TRANSIT STOPS

Transit Stop Mixing with Separated Bike Lane

Where bus service is sufficiently infrequent (about four buses per hour or fewer), transit stops can be designed in the separated bike lane. When buses are present, cyclists merge left and pass buses boarding and alighting passengers. At all other times, at least 55 minutes of every hour, bikes continue through the bus stop uninterrupted.

01 Transit vehicles pull up to stops along the curb, across the separated bike lane. Vehicles yield to through bicyclists.

02 Front end of platform needs 5 ft x 8 ft minimum clear space to accommodate deployment of accessible ramp from equipped vehicles.

03 Optional "YIELD" markings in bike lane.

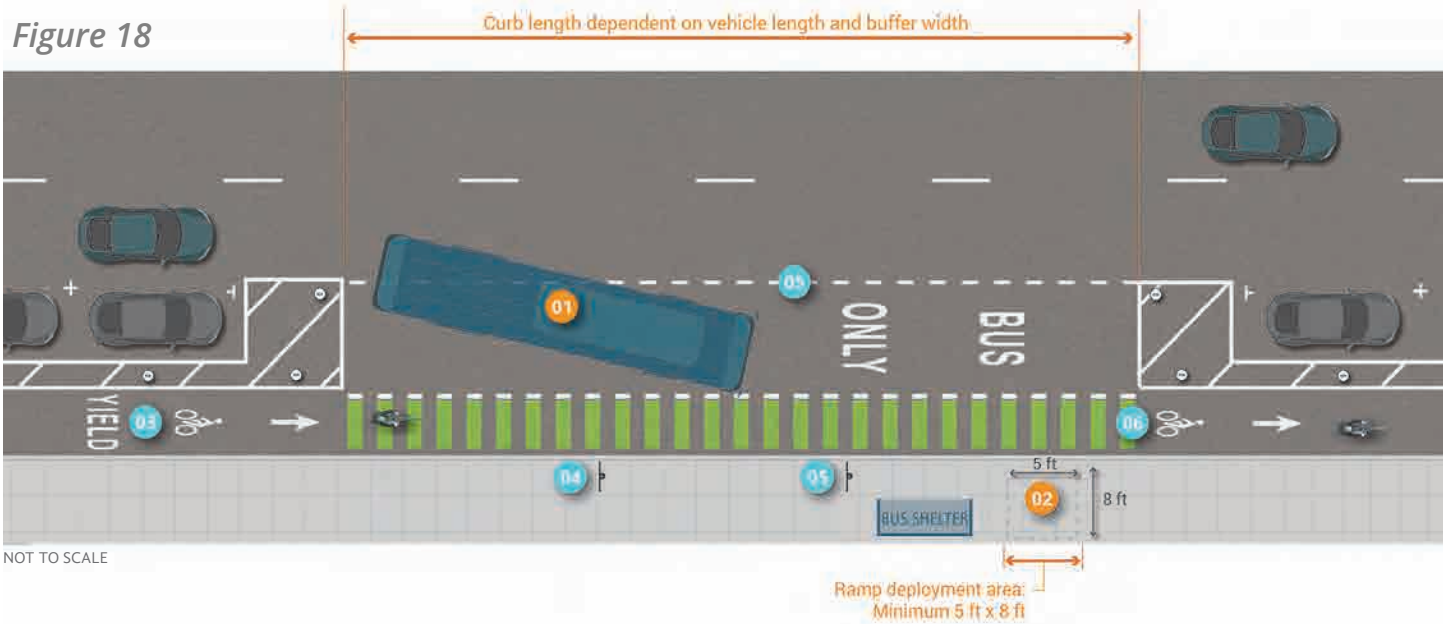
04 NO PARKING BUS STOP sign (MUTCD R7-7).

05 Optional BUS ONLY pavement markings (MUTCD Figure 3B-23).

06 For further guidance on typical signs and markings for separated bike lanes, see page 127.

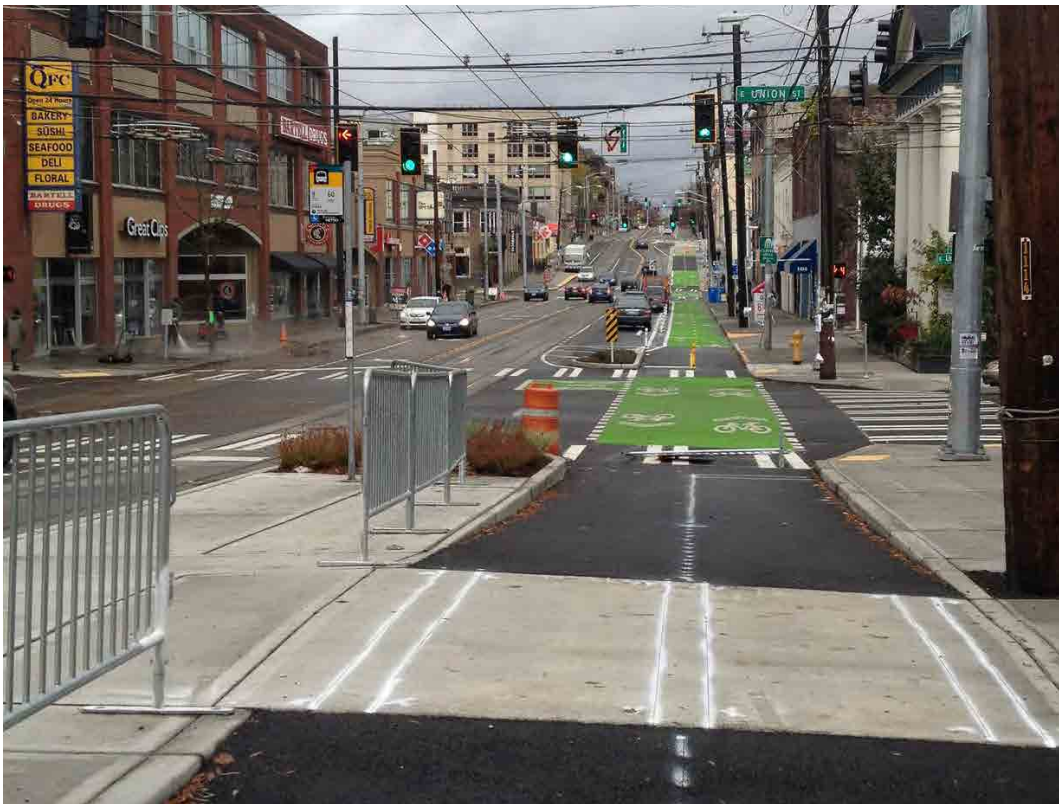
Shared bus stop/bike lane configuration in Boston, MA (Source: Conor Semler)

Figure 18



NOT TO SCALE

Island bus platform adjacent to a separated bike lane in Austin, TX. (Source: Kelly Blume)



Raised crosswalk (under construction) adjacent to a transit stop island platform on Broadway in Seattle, WA. (Source: Seattle DOT)

ACCESSIBLE PARKING 3

Where designated on-street parking is provided, accessible parking must be provided. Refer to the 2010 ADA Standards and the current Public Rights of Way Accessibility Guidelines (PROWAG) published by the U.S. Access Board for more information. These spaces must be provided on the block perimeter where on-street parking is marked or metered. In many cases, the accessible parking may be provided on block faces that do not conflict with separated bike lane alignment. However, a priority for accessibility is locating the parking spaces where the street is most level and, ideally, closest to obvious destinations such as building entrances. Under these circumstances it may be necessary to include accessible parking on the same block face as a separated bike lane.

Providing accessible parking spaces at the start of a block often affords the most flexibility in designing around the separated bike lane. A painted access aisle without any vertical elements provides space to deploy a lift and allows a vehicle to park in the buffer to deploy a left-side lift, if necessary.

A dedicated accessible parking space with access aisle in Austin, TX. (Source: Kelly Blume)

ACCESSIBLE PARKING

Located Midblock Within Parking Lane

01 The design and layout of accessible parking spaces for persons with disabilities is required, and PROWAG provides the best available information on the details.

02 An access aisle shall be provided the full length of the parking space and shall connect to a pedestrian access route. The access aisle shall shall not encroach on the vehicular travel lane. Refer to PROWAG for details.

03 A 5 ft wide minimum access aisle shall be provided at street level. For ease of parking, a best practice is to provide 3 foot front and/or rear aisles.

04 A crosswalk and curb ramp shall connect the access aisle to the sidewalk.

05 No posts or other obstructions shall be placed in accessible parking space buffer. For further guidance on buffer selection and installation, see page 83.

06 Place a YIELD HERE TO PEDESTRIANS (MUTCD R1-5) sign at crosswalk.

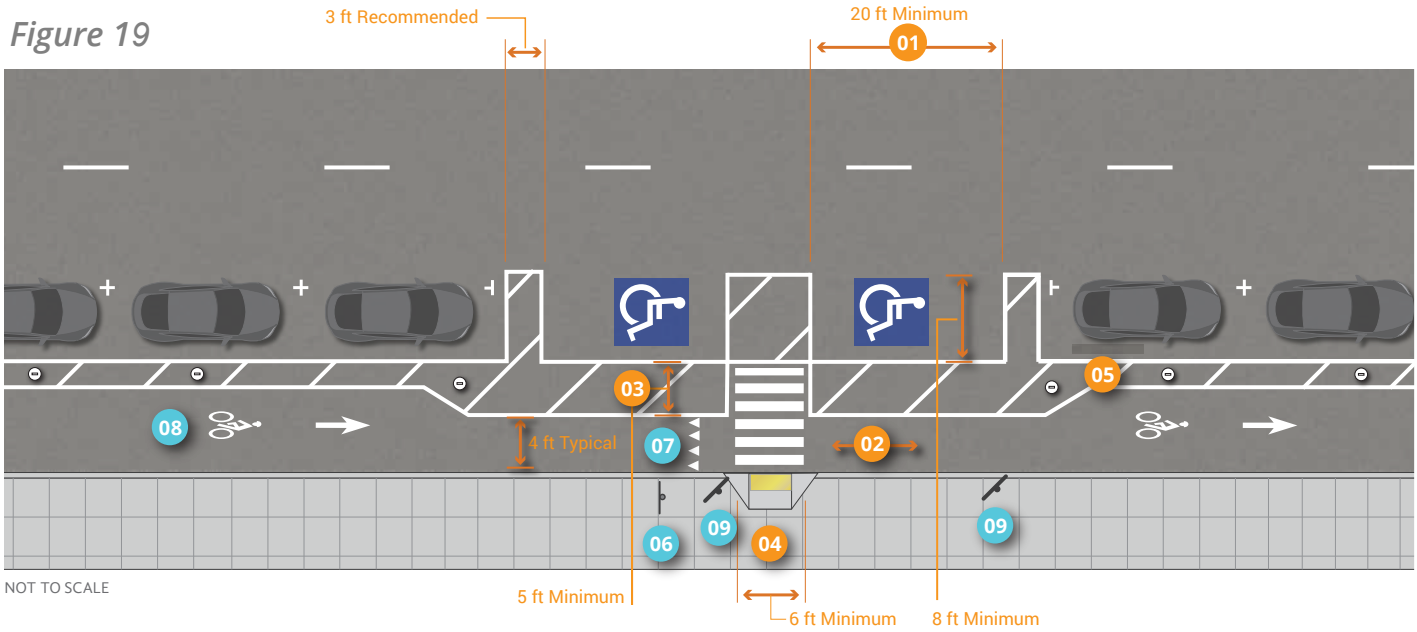
07 Yield line pavement marking may be placed prior to the crosswalk. Refer to MUTCD(2009) Section 3B.20 for pavement symbols and arrow markings.

08 For further guidance on typical signs and markings for separated bike lanes, see page 127.

09 Place an accessible parking sign (MUTCD R7-8) on the sidewalk facing each parking space.

A reserved parking sign is placed alongside a floating parking lane in Austin, Texas (Source: Kelly Blume)

Figure 19



NOT TO SCALE

LOADING ZONES 3

There are a number of circumstances that require access to the curb along separated bike lane corridors including loading and deliveries, temporary bus parking, and hotel drop-off zones. In some cases, these uses can simply be relocated to an adjacent block face or alley. If not, ideally these zones can be well placed and consolidated to reduce the impacts of pedestrian and vehicle intrusion into the bicycle space.

If on-street parking is used in the buffer space, the loading zone design is simpler where parking can be restricted and the pedestrian conflict crossing the bike lane can be managed. When there is not space that can be made available from on-street parking and a loading zone is still required, additional space must be acquired either from the sidewalk, through a roadway widening, through a reduction in vehicle travel lanes, or by creating a vehicle mixing zone with the separated bike lane.

Occupying Parking Lane Only

01 Parking is restricted in loading zone.

02 A 5 ft wide minimum access aisle shall be provided the full length of the accessible loading zone and shall connect to a pedestrian access route. Refer to PROWAG for details. For further guidance on buffer selection and installation, see page 83.

No posts or other obstructions in loading zone buffer.

03 Optional "LOADING ZONE" pavement markings (MUTCD Figure 3B-23). Loading zones need to be accessible – refer to PROWAG R310 for guidance.

04 Green pavement optional. For guidance on green pavement markings, see page 114.

05 NO PARKING LOADING ZONE sign placed on the sidewalk near each end of buffer (MUTCD R7-6).

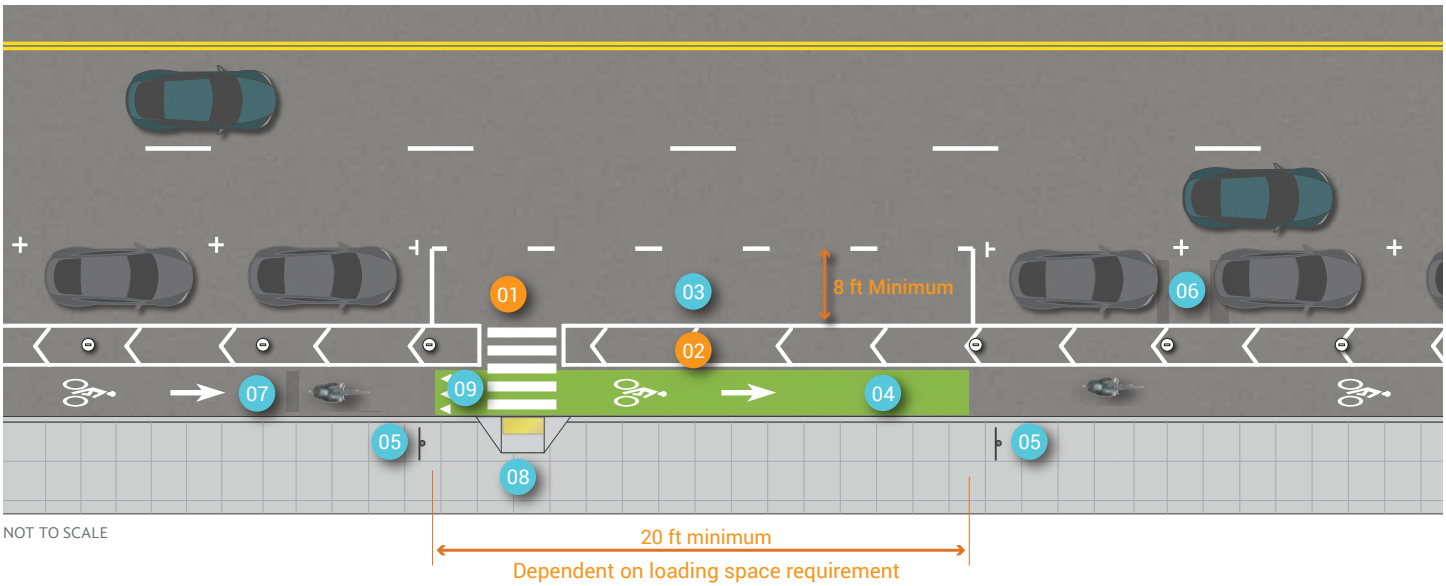
06 Guidance for parking space markings can be found in MUTCD(2009) Section 3B.19.

07 For further guidance on typical signs and markings for separated bike lanes, see page 127.

08 A crosswalk and curb ramp must connect the loading zone to the sidewalk.

09 Optional: Yield bar pavement marking may be placed prior to the crosswalk. Refer to MUTCD(2009) Section 3B.20 for pavement symbols and arrow markings.

Figure 20



NOT TO SCALE

LOADING ZONES

Bending Separated Bike Lane into Sidewalk

01 A lateral shift of the separated bike lane into the sidewalk may be necessary to accommodate a required loading or drop-off zone where there is no on-street parking. The shift must be designed based on the offset distance and bicycle design speed.

If a lateral shift cannot be accommodated and a loading zone is required, loading and drop-off activities may have to mix with bicycle traffic creating a conflict in high-use areas.

02 Parking is restricted in loading zone.

03 A 5 ft wide minimum access aisle shall be provided the full length of the accessible loading zone and shall connect to a pedestrian access route. Refer to PROWAG for details. For further guidance on buffer selection and installation, see page 83.

04 Optional LOADING ZONE pavement markings (MUTCD Figure 3B-23). No posts or other obstructions in loading zone buffer.

05 Green pavement is optional. For guidance on green pavement markings, see page 114.

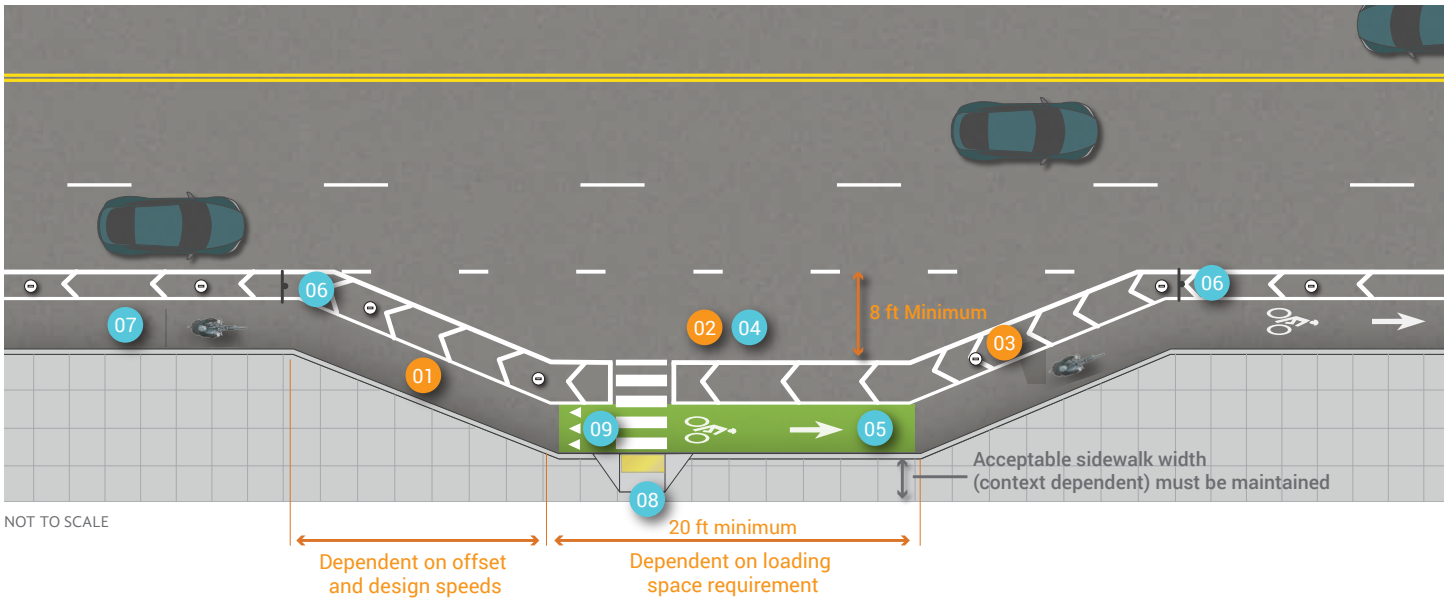
06 NO PARKING LOADING ZONE sign placed at each end in buffer (MUTCD R7-6). The NO PARKING LOADING ZONE sign can also be placed on the sidewalk, where it may be less likely to be hit by motorists and also may have less of an impact on maintenance operations.

07 For further guidance on typical signs and markings for separated bike lanes, see page 127.

08 A crosswalk and curb ramp must connect the loading zone to the sidewalk.

09 Optional: Yield bar pavement marking may be placed prior to the crosswalk. Refer to MUTCD(2009) Section 3B.20 for pavement symbols and arrow markings.

Figure 21



A dedicated loading zone along Polk Street in San Francisco, CA. (Source: Alek Pochowski)

INTERSECTION DESIGN

STEP 4

It is not possible to maintain permanent physical separation of bicycles and automobiles through intersections, where cross street and turning movements must cross the path of bicyclists. Intersections are where most bicycle-vehicle collisions occur, and where riders feel the most stress. Designers have implemented a variety of strategies, including both time- and space-separation, for maintaining the benefits of separated bike lanes through intersections. The configurations and geometries for each specific location will dictate which options are most advantageous.

Intersection design is often the most challenging separated bike lane design element. Above, an intersection along New York City's 9th Avenue facility. (Source: NYC DOT)

TURNING MOVEMENTS 4

The movements of automobiles and bicycles at intersections may conflict with each other. Therefore, design elements are needed to increase visibility of bicyclists for motorists.

Signalized and Unsignalized Treatments

Table 3

		Pros	*Cons*
Maintain Separation	**Signals:** separate through and turning movements in time	Potential elimination of turn conflict	Increased signal cycle length, possibly with increased wait times
	Bend In: position cyclists closer to turning vehicles to increase visibility **Bend Out:** provide space for right-turning vehicles to turn before encountering bicycle conflicts; provide space for queueing	Greater sense of comfort/ less traffic stress	Turning vehicle conflicts at intersections
Shift Bicycles Across Turning Vehicles	**Lateral Shift:** vehicles cross high-visibility bike lane; clear responsibility for yielding **Mixing Zone:** shared lane, requires less space	Organize conflicts; reduce right-hook risk	Greater traffic stress

Signalization

Using signalization to separate the movements of automobiles and bicyclists through an intersection removes potential conflict points which are present with other treatments. A separate signal phase allows bicyclists to proceed without right-turning vehicle conflicts and stops bicyclists at times when right-turning automobiles can proceed. This approach may be selected at intersections with high volumes of right-turning automobiles, or on one-way streets with left-turning automobiles and a left-side running separated bike lane, and where the signal phasing and cycle length can accommodate a bicycle signal phase. Signal phasing, cycle lengths, and traffic progression should all be carefully considered for bicyclists where significant delay frequently results in poor signal compliance.

TURNING MOVEMENTS

Signalization

01 A near-side bicycle signal can supplement far-side signals to improve visibility (refer to MUTCD Interim Approval IA-16).

Near-side signals are required when the far-side signal is 120 ft or greater from the stop bar, and recommended over 80 ft.

Near-side signals can be placed on the pedestrian pushbutton pole, or the bicycle pushbutton pole, if used.

02 Minimum 1 ft buffer at intersection. For further guidance on buffer selection and installation, see page 83.

03 If no dedicated right turn lane is present, bicyclists may use pedestrian walk signal. A 'Turning vehicles yield to bikes' sign may be placed on the mast arm.

04 NO TURN ON RED (MUTCD R10-11) on mast arm near signal head.

05 Guidance for parking space markings can be found in MUTCD(2009) Section 3B.19.

06 For further guidance on signal phasing, see page 119.

07 Signal detection for bicyclists is needed if the signal [or signal operation] is actuated.

An optional signal detection loop may be placed 60 - 120 ft in advance of the intersection.

08 A bicycle detector symbol marking (MUTCD Fig. 9C-7) should be placed over the loop to alert passing cyclists to the in-ground sensor.

For further guidance on typical signs and markings for separated bike lanes, see page 127.

NOT TO SCALE

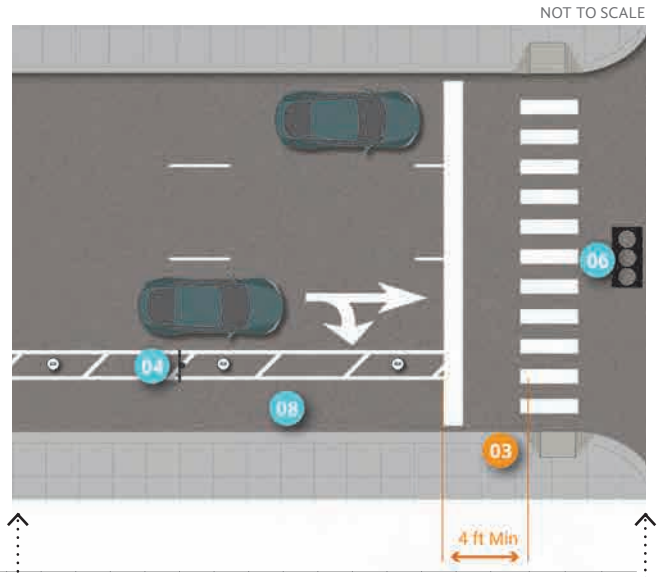
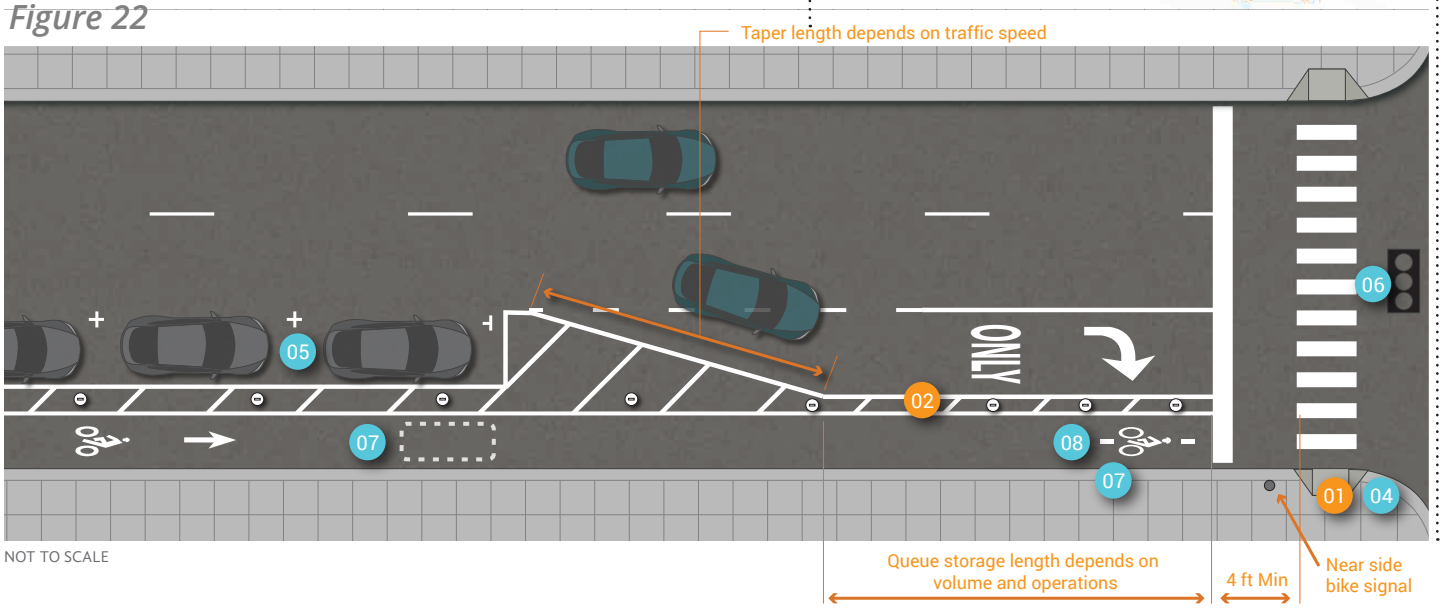


Figure 22



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TURNING MOVEMENTS

Lateral Shift

A lateral shift moves cyclists to the left of the motor vehicle right turn lane before vehicles can move right. This places the responsibility for yielding clearly on drivers turning right, and brings bicyclists into a highly visible position. In the lateral shift configuration, like the mixing zone (see page 107), potential conflicts between right-turning vehicles and through bicyclists occur *before* the intersection. A lateral shift treatment is effective for intersections where a separate bicycle signal and signal phasing is not feasible, because bicyclists can proceed in the same signal phase as through and right-turning vehicles.

01 Provide minimum queue storage length for automobiles needed for operations, depending on right-turn volumes and signal cycle length.

02 For further guidance on bike boxes, see page 122.

03 Shift bike lane closer to motorized traffic prior to weave area so motorists and bicyclists can see each other better.

04 For further guidance on buffer selection and installation, see page 83.

05 Shorter queue storage lengths are preferred because it allows for a longer distance of midblock separation relative to the intersection and slows motor vehicle speeds.

06 Include BEGIN RIGHT TURN LANE YIELD TO BIKES (MUTCD R4-4) at end of parking restrictions.

07 The weave area should be short to force vehicles to make slow and deliberate turning movements into the right turn lane.

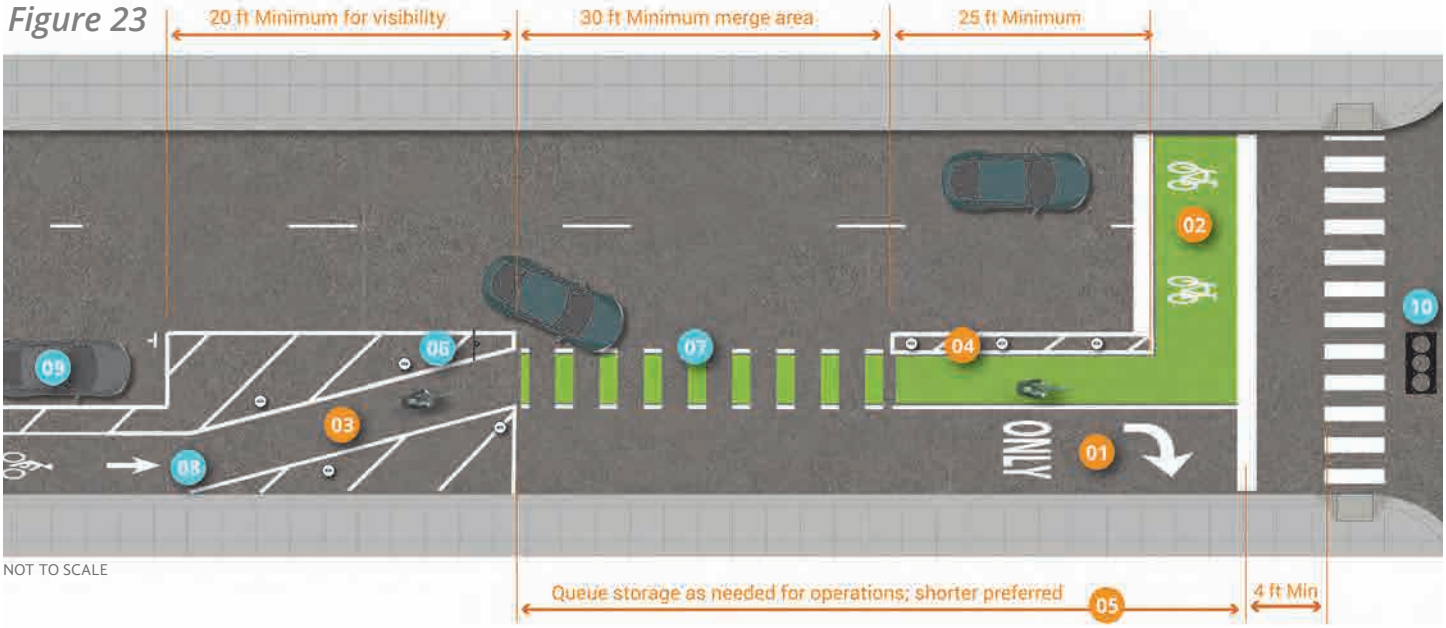
A variety of pavement marking treatments can be used to improve visibility of the separated bike lane and reinforce the expected bicyclist behaviors. For further guidance on paint and striping in conflict areas, see page 114.

08 For further guidance on typical signs and markings for separated bike lanes, see page 127.

09 Guidance for parking space markings can be found in MUTCD(2009) Section 3B.19.

10 For further signal guidance, see page 115.

Figure 23



NOT TO SCALE

CASE STUDY

Salt Lake City's Experimental Lateral Shift

Salt Lake City, Utah

300 East Corridor separated bike lane. (Source: City of Salt Lake City)

Salt Lake City used a pilot project approach to install a temporary separated bike lane along 300 East Corridor. A lane of parked cars provides additional separation between moving vehicles and cyclists; however, the City drops the parking lane in advance of intersections to improve visibility. To manage through-bicycle and right-turning vehicle conflicts at intersections, the City chose to apply an experimental lateral shift approach. Cyclists move to the left of the motor vehicle right-turn lane in advance of any opportunity for vehicles to move right. This approach places the onus of yielding to cyclists squarely on motor vehicles that need to make a right turn. The City has received positive feedback from planners and designers who have observed the facility, and plans to use design for its future separated bike lane intersection approaches where roadway width can accommodate a dedicated right turn lane.

TURNING MOVEMENTS

Mixing Zone

A mixing zone is an area where bicyclists and right-turning automobiles merge into one travel lane approaching an intersection. Mixing zones provide a design option in which the potential conflict between right-turning vehicles and through bicyclists occurs before the intersection, similar to the lateral shift. Mixing zones may provide the best option in locations without on-street parking and/or with a constrained right-of-way where the roadway width will not accommodate both a bicycle lane and a right-turn lane at the intersection.

01 Mixing zones are often used at intersections with turning vehicle volumes high enough to cause frequent conflicts, but not high enough to require signalization.

Mixing zones may be most effective at intersections with 50-150 turning vehicles in the peak hour.

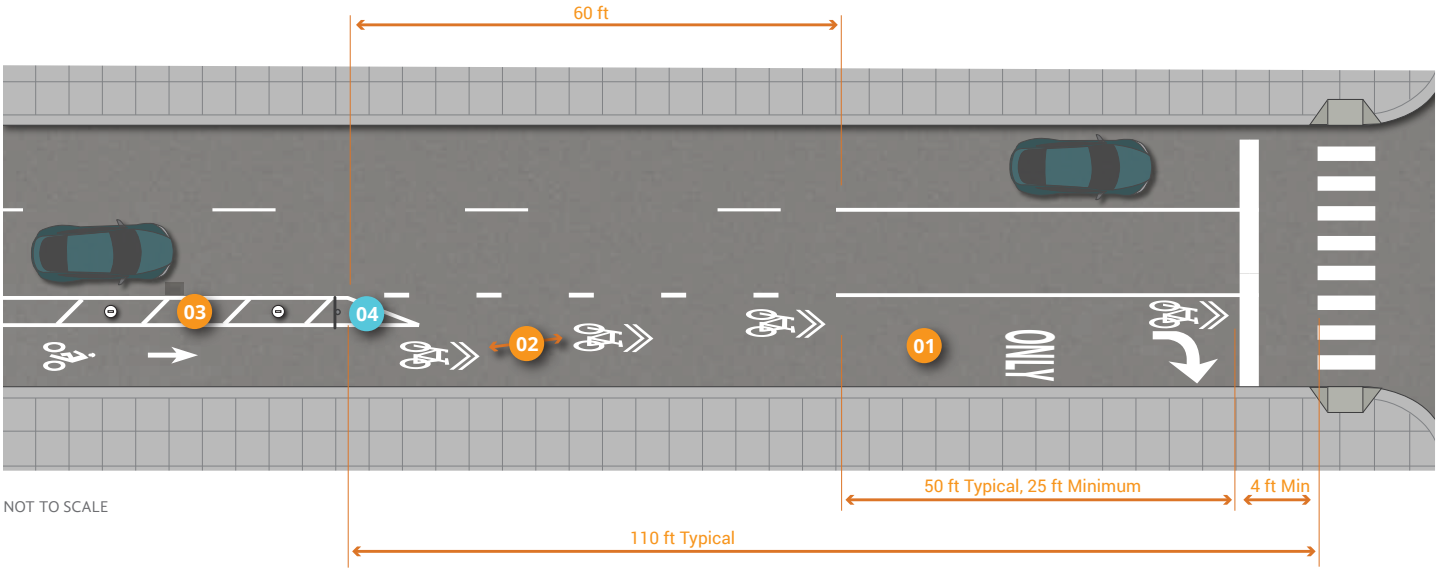
02 Shared lane markings help guide bicyclists to the left side of turning vehicles.

03 For further guidance on buffer selection and installation, see page 83.

04 Include BEGIN RIGHT TURN LANE YIELD TO BIKES (MUTCD R4-4) at end of parking restrictions.

Figure 24

Additional mixing zone designs are highlighted in the pictures on pages 50, 102, and 108.



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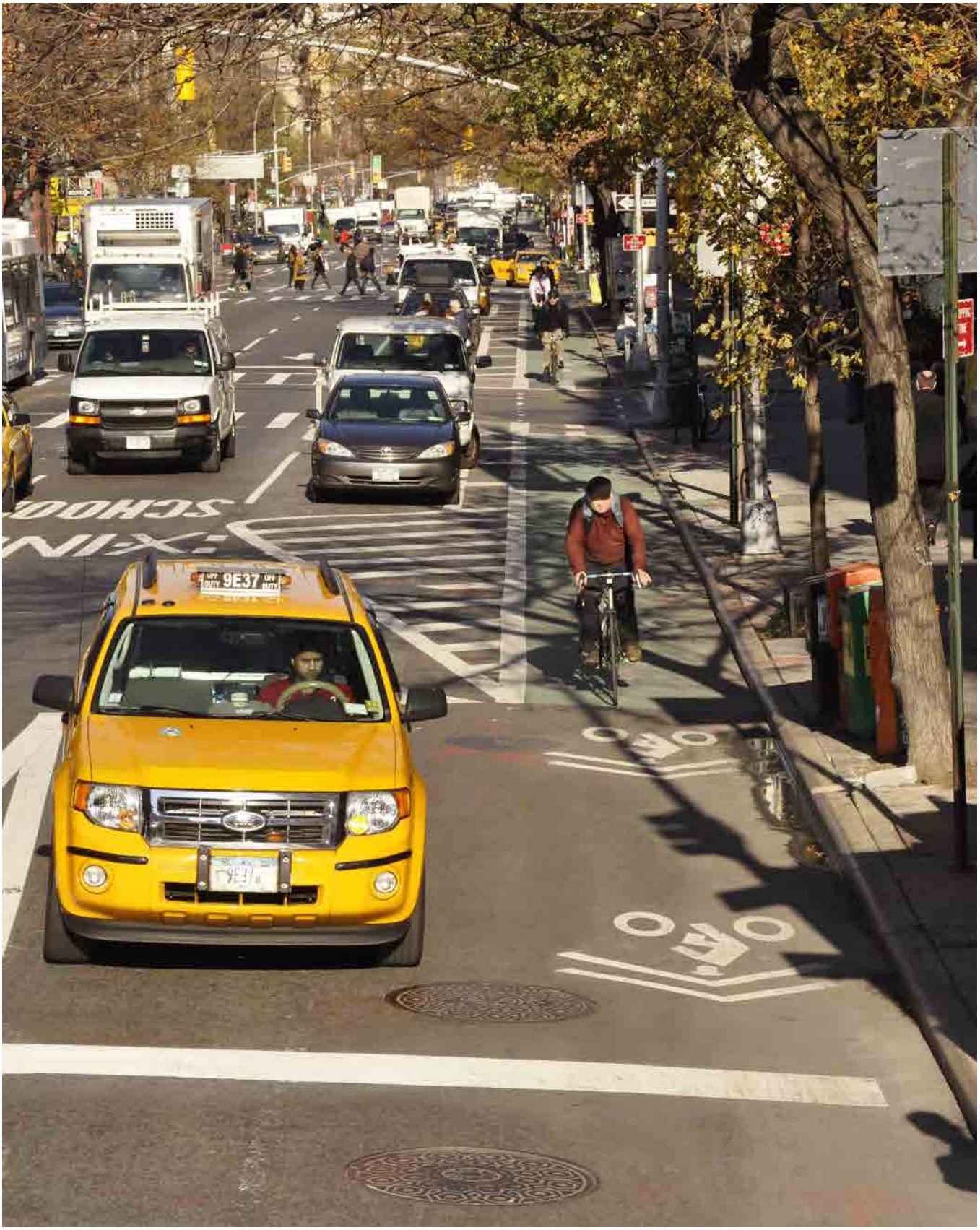


A mixing zone along New York City's 2nd Avenue separated bike lane. (Source: NYC DOT)

TURNING MOVEMENTS

Bend-In and Bend-Out

When the separated bike lane approaches an intersection with right-turning vehicles still positioned to the left of the separated bike lane, the designer may choose to either "bend-in" or "bend-out" the separated bike lane at the intersection to reduce the likelihood of conflicts with right-turning vehicles. The decision to bend-in or bend-out depends on a number of factors, including buffer type and width, available right-of-way, sight distance, side-street characteristics, and other contextual factors. Considerations for selecting bend-in or bend-out are highlighted in Table 5 on the following page.

A bend-in design approaching an intersection in St. Petersburg, FL. (Source: Rory Rowan)

Table 4

	Advantages	*Disadvantages*
Bend - In	• Motorists on a side street can see bicycles and vehicles in a similar field of vision. • Requires less space than bending out	• Parking spaces close to the intersection may be lost • Bicyclists may perceive less separation due to proximity of through vehicles
Bend - Out	• Allows vehicle traffic turning across separated bike lane to queue out of the way of through traffic and before the separated bike lane. • Allows a queuing location for cyclists wanting to turn left. • Raised crossing provides traffic calming for automobiles and can also slow bicyclists.	• Requires more space • Less familiar design • Adequate sight distance may be difficult for vehicles approaching on the side street.

TURNING MOVEMENTS

Bend-In

To increase the visibility of bicyclists for turning vehicles, the bend-in design positions bicyclists adjacent to the vehicle turn lane.

01 Shift bicycle lane closer to motorized traffic so motorists and bicyclists can see each other better.

02 Bend-in design creates opportunity to build a curb extension to reduce pedestrian crossing distance.

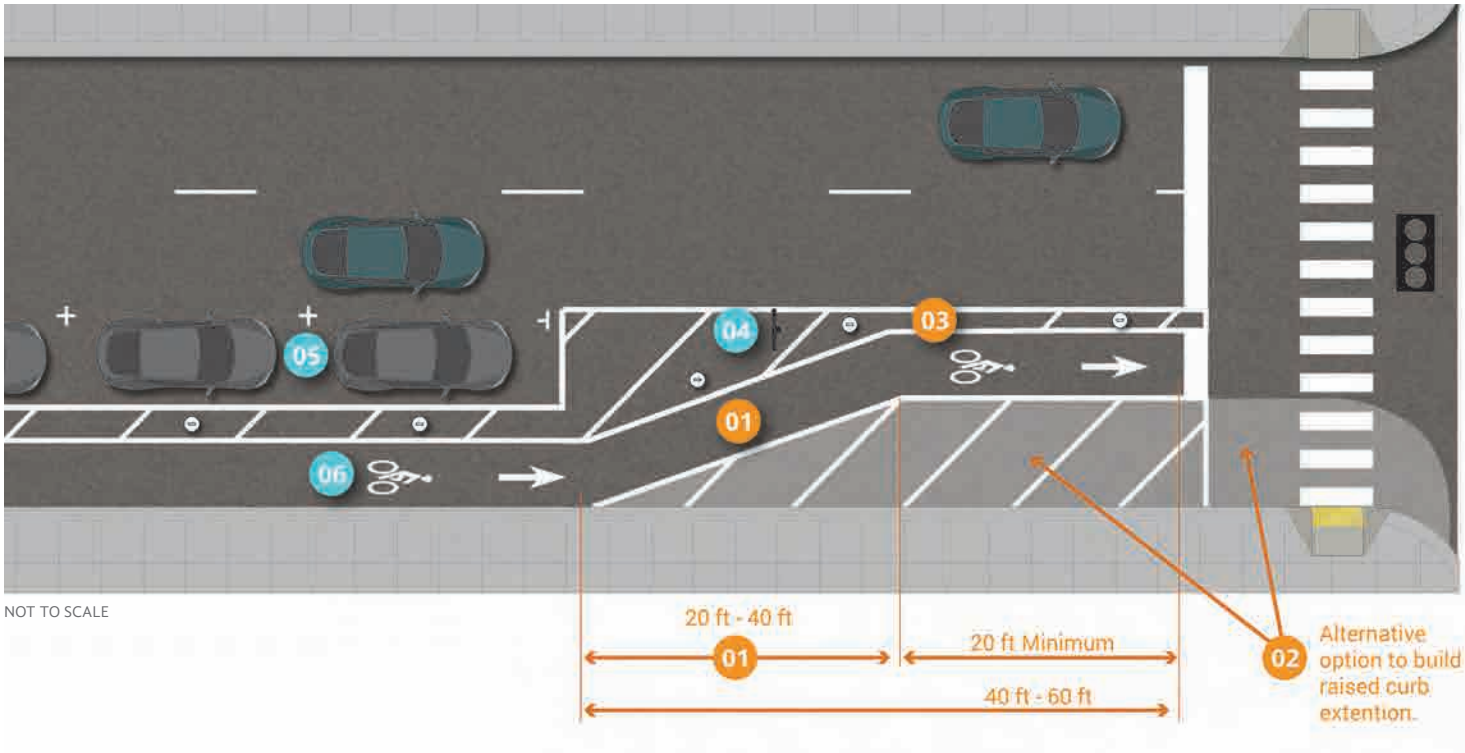
03 For further guidance on buffer selection and installation, see page 83.

04 A 'Turning vehicles yield to bikes' sign may be placed on the mast arm.

05 Guidance for parking space markings can be found in MUTCD(2009) Section 3B.19.

06 For further guidance on typical signs and markings for separated bike lanes, see page 127.

Figure 25



TURNING MOVEMENTS

Bend-Out

The bend-out design positions bicyclists downstream on the side street away from the intersection, allowing vehicles to complete turning movements before interacting with bicyclists. This design, which could be used on lower-volume side streets or driveways, provides space for a vehicle to yield to crossing bicycles without blocking through traffic on the main street. A Bicycle/Pedestrian Warning (W11-15) sign may be used as driveways approach separated bike lanes to alert drivers to be aware for bikes and pedestrians.

01 Bend-out design provides opportunity for an ample pedestrian refuge between the separated bike lane crossing and the roadway crossing.

02 Separated bike lane and crosswalk may be raised to sidewalk level through the intersection, providing a traffic calming effect.

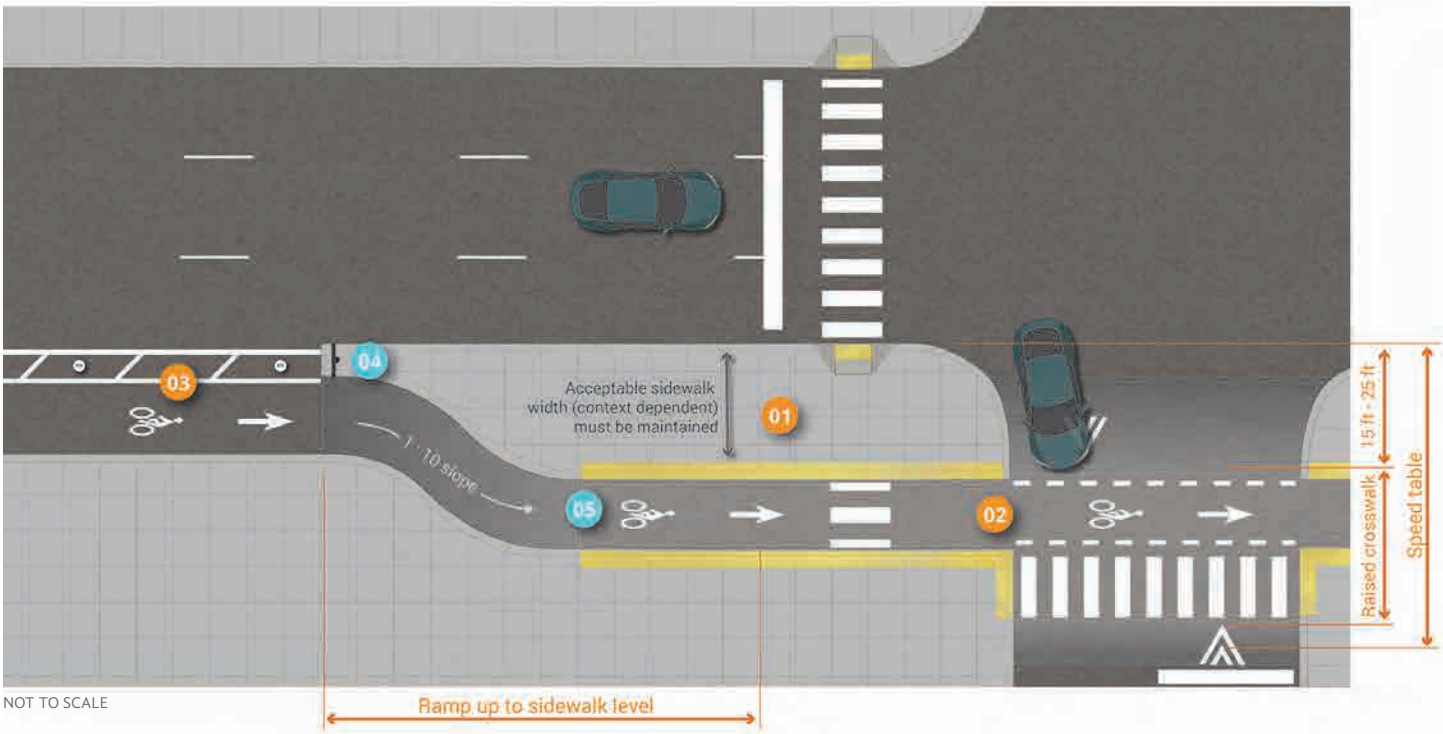
03 For further guidance on buffer selection and installation, see page 83.

04 A 'Turning vehicles yield to bikes' sign may be placed on the mast arm.

05 For further guidance on typical signs and markings for separated bike lanes, see page 127.

06 For further guidance on signal phasing, see page 119.

Figure 26



NOT TO SCALE

TURNING MOVEMENTS

Opportunities for Space Created by Bend-In

A bend-in design creates the opportunity to construct a curb extension to reduce pedestrian crossing distances. The design can create public space which could be used for:

- Bike parking corrals
- Bikeshare stations
- Parklets
- Public art exhibits
- Bioswales/rain gardens

Boulder, CO uses some of the sidewalk space created by the bend-in intersection design for bike parking. (Source: Kevin Zolkiewicz)

INTERSECTION MARKINGS 4

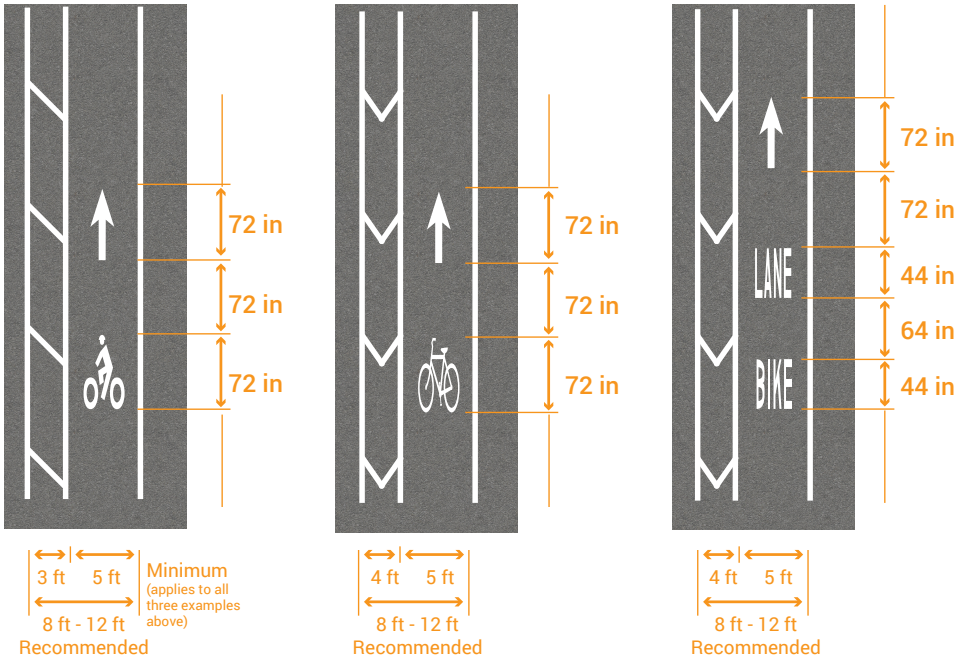
White Chevrons and White Lines

White dashed lines may be used to mark extensions of the separated bike lane through intersections or other traffic conflict areas. These dotted lines are intended to increase awareness of where bicyclists may be positioned. White chevrons should be used in wider painted buffers with a width of 4 feet and above.

Bike lane symbols should be placed periodically to reduce the intrusion of pedestrians and motorists into the separated bike lanes. The words BIKE LANE may be used as an alternative to the bike symbol. Periodic maintenance will be required to ensure markings remain visible.

Seattle's first downtown separated bike lane on Second Avenue between Pike Street and Yesler Way. (Source: SDOT)

Figure 27

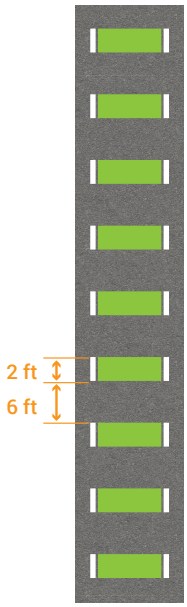


Diagonal crosshatch markings are often used in narrower buffers (i.e. 3-4 feet wide) and given their typical dimensions white chevrons are generally used in buffers with a width of 4 feet and above.

INTERSECTION MARKINGS

Use of Green Colored Pavement

Green pavement increases awareness of bicycles and can be used to indicate an area of potential conflict with motor vehicles. The green colored pavement is an additional treatment and shall *not* be used instead of dotted lines to extend a bicycle lane across an intersection, driveway, ramp, or at the beginning of a turn bay.

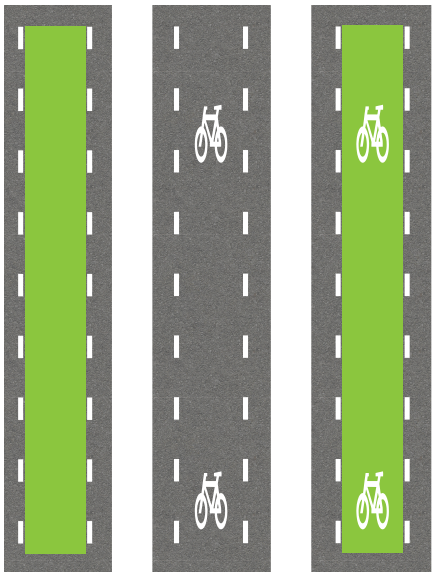


Green paint across a mixing zone opening on M Street NW in Washington, DC (Source: Jason Broehm)

The pattern of the green colored pavement may be in a manner matching the pattern of the dotted lines; filling in only the areas directly between a pair of dotted line segments (MUTCD Interim Approval IA-14) as shown in the diagram above.

The green pavement and other conflict zone markings in the designs below are non-standard but currently in use by many U.S. municipalities.

Figure 28



SIGNALIZATION STRATEGIES 4

Bike Signals

Bicycle signals may be used to separate bicycle through movements from vehicle right turning movements for increased safety.

They can also be used to facilitate complex bicycle movements or help people on bicycles navigate complex intersections safely.

A leading bicycle interval, which uses a bicycle signal lens to provide three to five seconds of green time before the corresponding vehicle green indication, can be used to increase the visibility of bicyclists to motorists.

The yellow change interval and all-red clearance interval may need to be adjusted to provide for passage of bicyclists through an intersection. The yellow change interval is when the steady yellow signal indication is displayed preceding the red signal interval.

The Urban Bikeway Design Guide (NACTO) uses the following equation to calculate the total clearance interval (i.e. the time that all signals are red that follows a yellow change interval and precedes the next green interval):

$$C(i) = 3 + W / V$$

- C (i) = Total Clearance Interval
- W = Intersection Width
- V = Cyclist Speed (9.5 mph can be used as a default if no speed is known)

Dedicated bicycle signalization along New York City's 9th Avenue separated bike lane. (Source: NYC DOT)

SIGNALIZATION

Signal Phasing and Coordination

Bicyclists exert the most energy when starting from a stopped position. Decreasing the number of stops at traffic signals in a corridor will increase the comfort for people on bikes and improve bicyclist compliance with the signals.

Bicycle Progression Speed

- The bicycle progression speed should be set to minimize the chance of stopping at each intersection based on the average bicycling speed.
- The average bicycle speed on a corridor may vary depending on roadway grades and typical speeds of bicyclists. A bicycle speed study may be conducted to find the actual progression speed.
- 10 mph is a comfortable speed for the general population; more confident cyclists may travel around 15 mph.
- Bicycle progression speed is largely dependent on street grade.
- Two-way separated bike lanes on a one-way street can cause significant challenges with signal progression for bicyclists in the contra-flow direction and may lead to poor compliance with the traffic signals.

Average Bicycle Delay at Intersections

- Related to the progression speed, bicyclists are less willing to wait at red traffic signals than motorists. Cycle lengths should be short to minimize the average bicyclist delay. A maximum 90 second cycle length is recommended.

Signal Detection

- Automatic detection by loops and/or video are important devices to give bicyclists green lights.
- Other detector feedback devices should be considered to provide information for bicyclists to receive a green light. Examples include the TO REQUEST GREEN WAIT ON SYMBOL sign (MUTCD R10-22), blue light detector device, and others. For sign and markings guidance, see page 127.
- Detection across the entire separated bike lane is preferred to call a green light for the user. Bicycle detection 60 or 120 feet in advance of the intersection could be used to call a green light for the bicyclist to minimize the chance of stopping and thereby increasing cycling comfort.

A bicycle detector pavement marking (MUTCD Figure 9C-7) communicates to bicyclists where to position themselves for signal detection in Portland, Oregon (Source: Jesse Boudart)

A blue light detector feedback device along NE Multnomah Street in Portland, OR. (Source: Jesse Boudart)

SIGNALIZATION

Additional Guidance on Bicycle Signals

The California MUTCD contains thresholds for when to use a bicycle signal. The thresholds below, in particular, relate to separated bike lanes:

Volume:

- W = B x V and W > 50,000 and B > 50.
- W is volume warrant, B is the number of bicycles at the peak hour entering the intersection. V is the number of vehicles at the peak hour entering the intersection. B & V shall use the same peak hour.

Collision:

- When 2 or more bicycle/vehicle collisions of the types susceptible to correction by a bicycle signal have occurred over a 12-month period and the responsible public works official determines that a bicycle signal will reduce the number of collisions.

Geometric:

- Where a separated bike lane or multi-use path intersects a roadway.
- At other locations to facilitate a bicycle movement that is not permitted for a motor vehicle.

SIGNALIZATION

Bike Signal Alternatives

When bicycle signals cannot be used, active detection, such as a blue indicator light, inform cyclists that they have been detected by the signal and will be receiving a green signal during the cycle. Active detection may decrease frustration and improve red light compliance among cyclists.

SIGNAL PHASING 4

Considerations:

- A bicycle green signal shall not be used with coinciding vehicle green signal faces which allow permitted turning movements across bicycle movements.
- Bicycle signal faces should be placed such that visibility is maximized for bicyclists and minimized for adjacent or conflicting motor vehicle movements. If drivers could be confused by viewing bicycle signal indications, such as when the start or end of a bicycle green indication occurs at different times than concurrent motor vehicle movements, consideration should be given to using visibility-limited bicycle signal faces.
- If bicycle signals are used, NO RIGHT ON RED (or left for one way roads) signs (MUTCD R10-11) should be used.

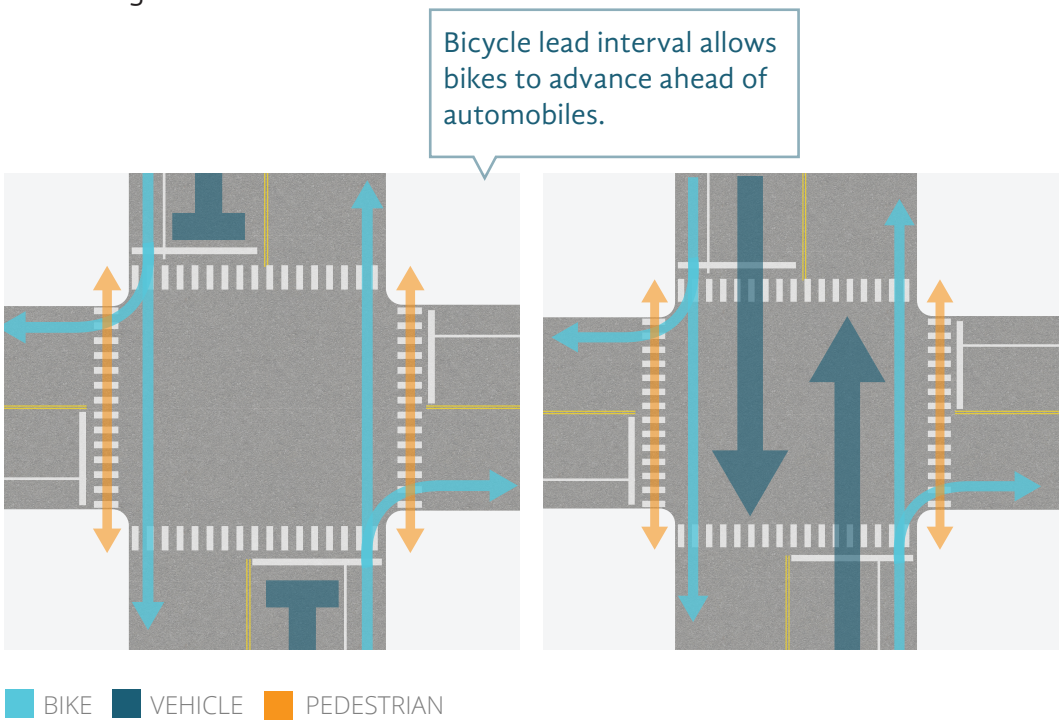
Optional:

- The interim approval (MUTCD Interim Approval IA-16) specifies the permitted use of bicycle signal phases with arrows in the signal assembly as well as the bicycle icon. The use of arrows in a bicycle signal assembly have not been implemented in the United States.

Figure 29

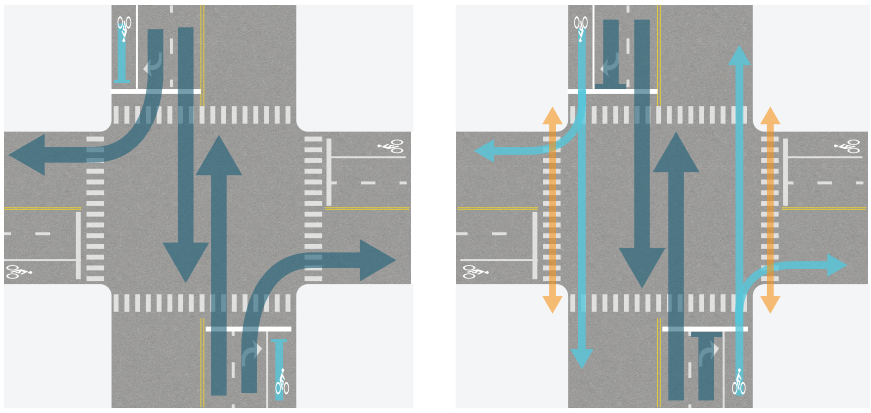
Signal Phase Example 1

A leading bicycle interval can be used to increase the visibility of a bicyclist through the intersection.



Signal Phase Example 2

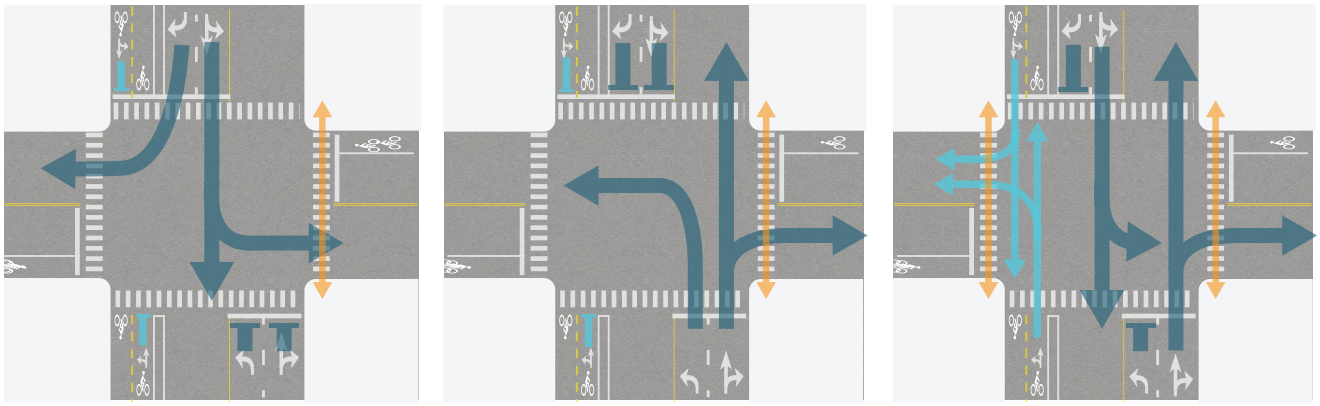
Bicycle movements can be separated from conflicting vehicle movements with automobile right-turn restrictions during the bicycle through movement, and bicycle signals stopping bikes while automobiles turn right.



BIKE VEHICLE PEDESTRIAN

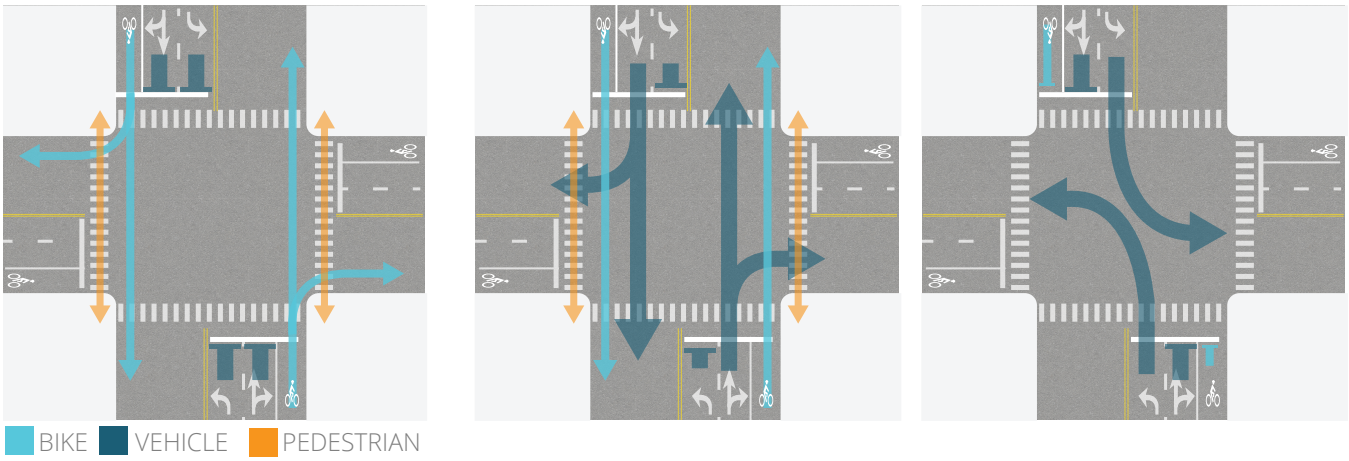
Signal Phase Example 3

A two-way separated bike lane adds complexity to signal phasing at two-way intersections. Importantly, the separated bike lane movement should be separated from conflicting vehicle turning movements.



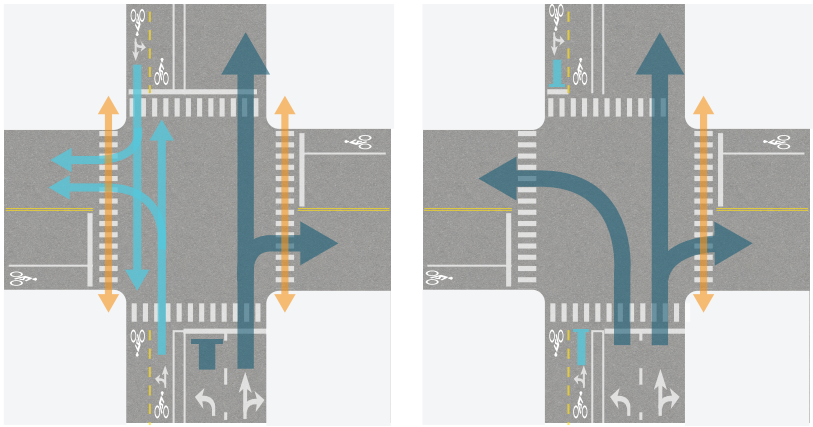
Signal Phase Example 4

In low vehicle traffic situations with separated bike lanes, a dedicated bicycle movement should be considered. The interim approval for bicycle signals (IA-16) does not permit a "bicycle scramble" (where bicycle movements are permitted from all four directions simultaneously).



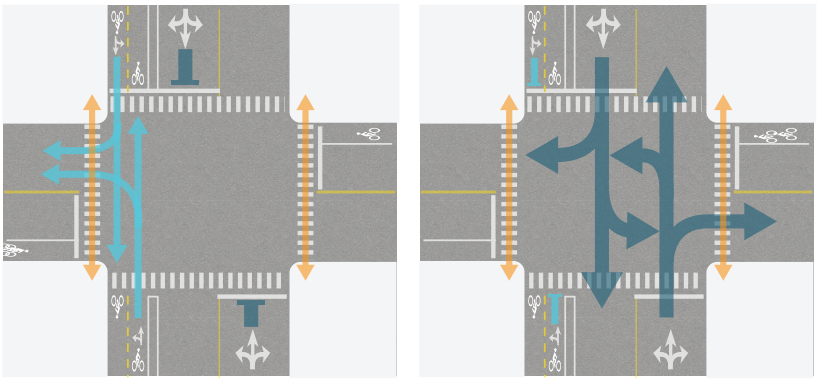
Signal Phase Example 5

One way streets with two-way separated bike lanes have fewer conflicting vehicle turning movements but should nevertheless be separated in time.



Signal Phase Example 6

When all vehicle turning movements must be accommodated, bicycle movements should be completely separated from vehicle movements.



BICYCLE TURNING MOVEMENTS

4

To allow bicyclists to comfortably navigate intersections, intersection design must account for right-turning, through, and left-turning movements where these movements are allowed. Left-turn movements (from right-side or center-running separated bike lanes) create the most potential for conflict with motor vehicles, but specific treatments such as bike boxes or two-stage turn queue boxes can facilitate safe and comfortable turning movements for bicyclists.

Bike Boxes and Early Exit

Bike boxes are designated spaces at signalized intersections that allow bicyclists to queue in front of motor vehicles at red lights. Placed between the stop line and the pedestrian crosswalk, bike boxes increase the visibility of queued bicyclists and provide them with the ability to start up and enter the intersection in front of motor vehicles when the signal turns green. Bike boxes, which have experimental status in accordance with the MUTCD, also provide bicyclists with the opportunity to position for a left turn. For more information on the MUTCD experimentation process, see http://mutcd.fhwa.dot.gov/condexper.htm. On multilane streets, the bike box may extend across all lanes up to the left turn lane to allow for left-turning bicyclists.

In locations with few travel lanes or low volumes, an early exit can allow more confident cyclists to weave from the separated bike lane into the travel lane and position themselves to turn with mixed traffic.

A cyclist approaches a bike box on M Street, Washington DC. Source: DDOT

BIKE TURNING MOVEMENTS

Bike Boxes and Early Exit

01 The bike box should include a minimum depth of 10 ft and minimum combined width of the bike lane, buffer space, and adjacent travel lane.

02 At signalized intersections, passive bicycle detection (inductive loops) may be used to give bicyclists a green light. For additional information on signal detection, see Page 116.

03 On multilane streets where left turns are allowed, bike boxes may be extended across the left turning lane.

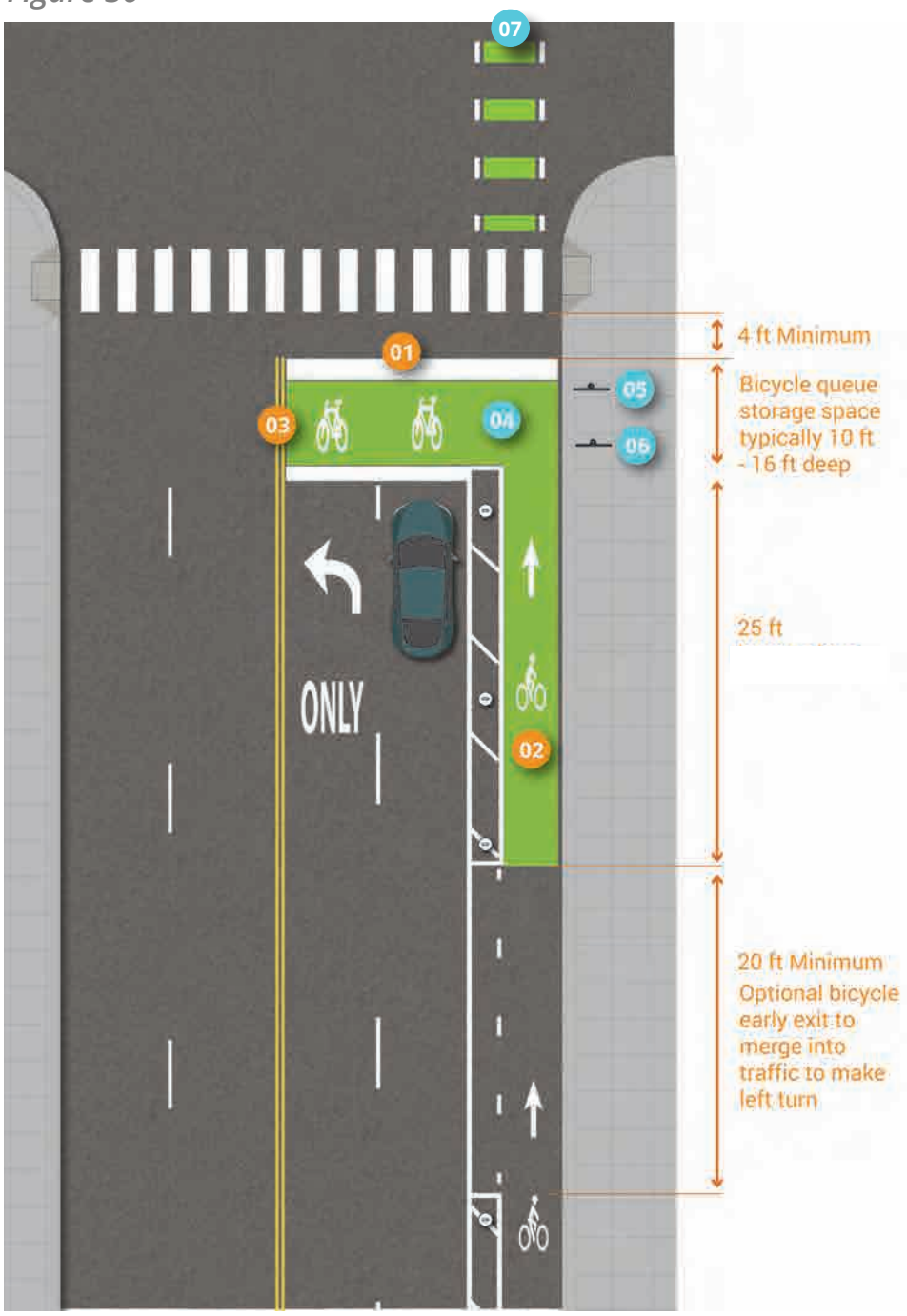
04 A variety of pavement marking treatments can be used to improve the visibility of the separated bike lane and reinforce expected bicyclist behaviors. For further guidance on paint and striping in conflict areas, see page 114.

05 A 'Turning vehicles yield to bikes' sign may be used. For further guidance on typical signs and markings for separated bike lanes, see page 127.

06 Install STOP HERE ON RED sign (MUTCD R10-6A).

07 Install NO TURN ON RED sign (MUTCD R10-11) if turns on red would otherwise be permitted.

Figure 30



NOT TO SCALE

TURNING MOVEMENTS

2- Stage Turn Queue Boxes

Two-stage turn queue boxes allow bicyclists to make left turns at multilane intersections from a right-side separated bike lane, or right turns from a left-side separated bike lane. Cyclists who arrive on a green light travel into the intersection and pull out into the two-stage turn queue box away from through-moving bicycles and in front of cross-street traffic. They may also be used at unsignalized intersections to simplify turning movements. Various positioning options are possible, depending on the corridor and intersection configuration. The two-stage turn queue box is experimental in accordance with the MUTCD.

An example of a left-turn queue box used on a bike lane in San Francisco. (Source: San Francisco Municipal Transportation Agency)

TURNING MOVEMENTS

2- Stage Turn Queue Boxes

01 The two-stage turn queue box should be designed in accordance with the MUTCD experimental approval. It should be located out of the way of through bicyclists, usually between the bike lane and crosswalk.

The two-stage left-turn box dimensions are about the same size or larger than the dimensions of four (4) cyclists standing side by side (10 ft wide X 6.5 ft deep).

02 Where on-street parking is located upstream of the intersection, the two-stage turn queue box can be located between the bike lane and vehicle travel lane.

03 Include a bicycle symbol and arrow indicating direction of turn in the two-stage queue box.

04 At signalized intersections, passive bicycle detection (inductive loops) may be used to give bicyclists a green light.

05 Install a NO TURN ON RED (MUTCD R10-11) sign where the two-stage left-turn box is installed in the path of a right turning vehicle.

06 A variety of pavement marking treatments can be used to improve the visibility of the separated bike lane and reinforce expected bicyclist behaviors. For further guidance on paint and striping in conflict areas, see page 114.

07 Guidance for parking space markings can be found in MUTCD (2009) Section 3B.19.

08 For further guidance on typical signs and markings for separated bike lanes, see page 127.

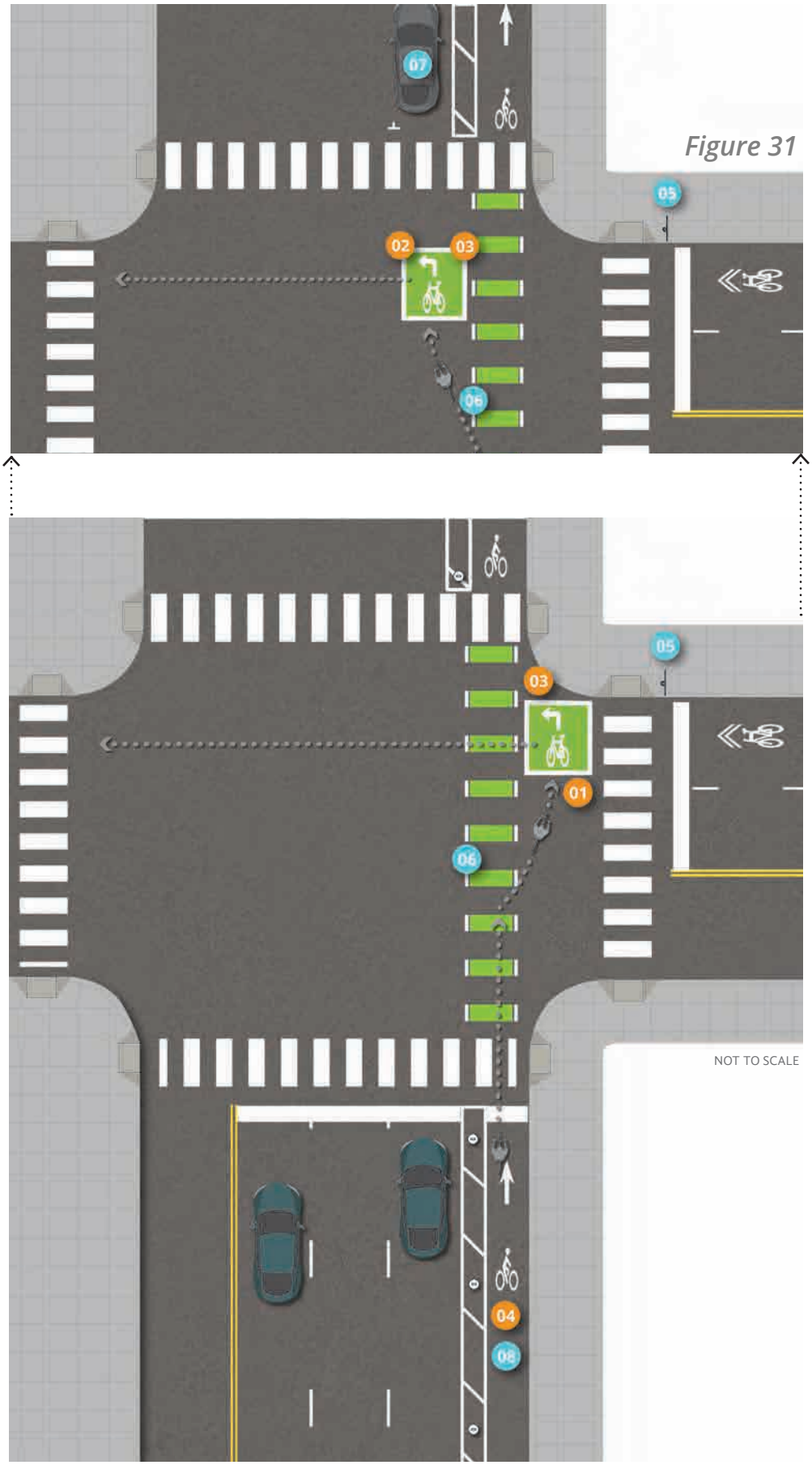


Figure 31

NOT TO SCALE

NOT TO SCALE

TURNING MOVEMENTS

No Bicycle Turning Treatments

Geometric constraints may not allow for two-stage left-turn queue boxes, or bike boxes to be located on separated bike lane routes. The provision of BICYCLISTS MAY USE FULL LANE sign (MUTCD R4-11) prior to intersections may help bicyclists cross the roadway to perform left-turns. Excluding areas to comfortably perform left-turns at intersections may discourage bicycling.

OTHER DESIGN ELEMENTS

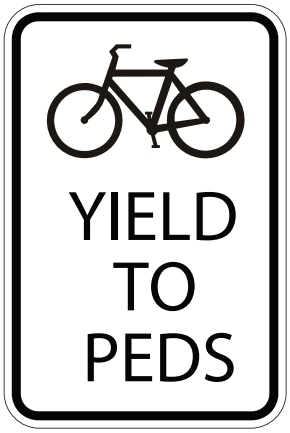
Signs and pavement markings supplement good design and reinforce appropriate behavior for all roadway users. This section provides a summary of the most commonly used signs and pavement markings related to separated bike lane installation.

SIGN GUIDANCE

Bike lane
MUTCD Sign R3-17

No turn on red
MUTCD Sign R10-11

Turning vehicles yield to bikes
MUTCD Sign R10-15 (Mod.)



Bicyclists yield to pedestrians
MUTCD Sign R9-6

Bicyclists may use full lane
MUTCD Sign R4-11

No Parking Bike Lane
MUTCD Sign R7-9

Bicycle signal actuation sign
MUTCD Sign R10-22

Right lane must turn right
MUTCD Sign R3-7R

Begin right turn lane yield to bikes
MUTCD Sign R4-4

Reserved parking for persons with disabilities
MUTCD Sign R7-8

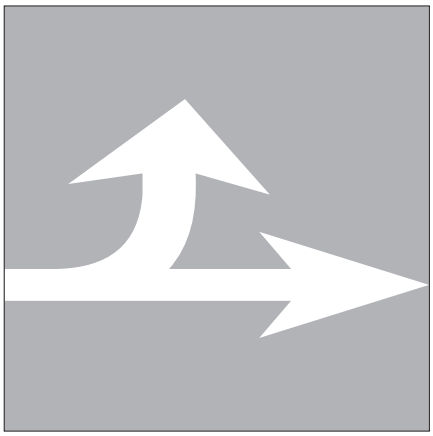
Van accessible
MUTCD Sign R7-8P

No parking loading zone
MUTCD Sign R7-6

No parking bus stop
MUTCD Sign R7-7

Bicycle/Pedestrian Warning
MUTCD Sign W11-15

MARKINGS GUIDANCE



Standard arrows for pavement markings (example shown)
MUTCD Fig. 3B-24

Bicycle pavement marking: bike symbol
MUTCD Fig. 9C-3

Bicycle pavement marking: helmeted bicyclist symbol
MUTCD Fig. 9C-3

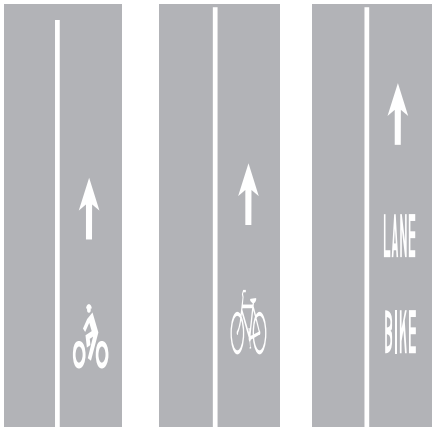
Bicycle pavement marking: word legends
MUTCD Fig. 9C-3

Pavement marking
MUTCD Fig. 9C-5

Shared lane marking
MUTCD Fig. 9C-9

Bike detector pavement marking
MUTCD Fig. 9C-7

Recommended yield line pavement markings layout
MUTCD Fig. 3B-16



Word, symbol & arrow pavement markings for bicycle lanes

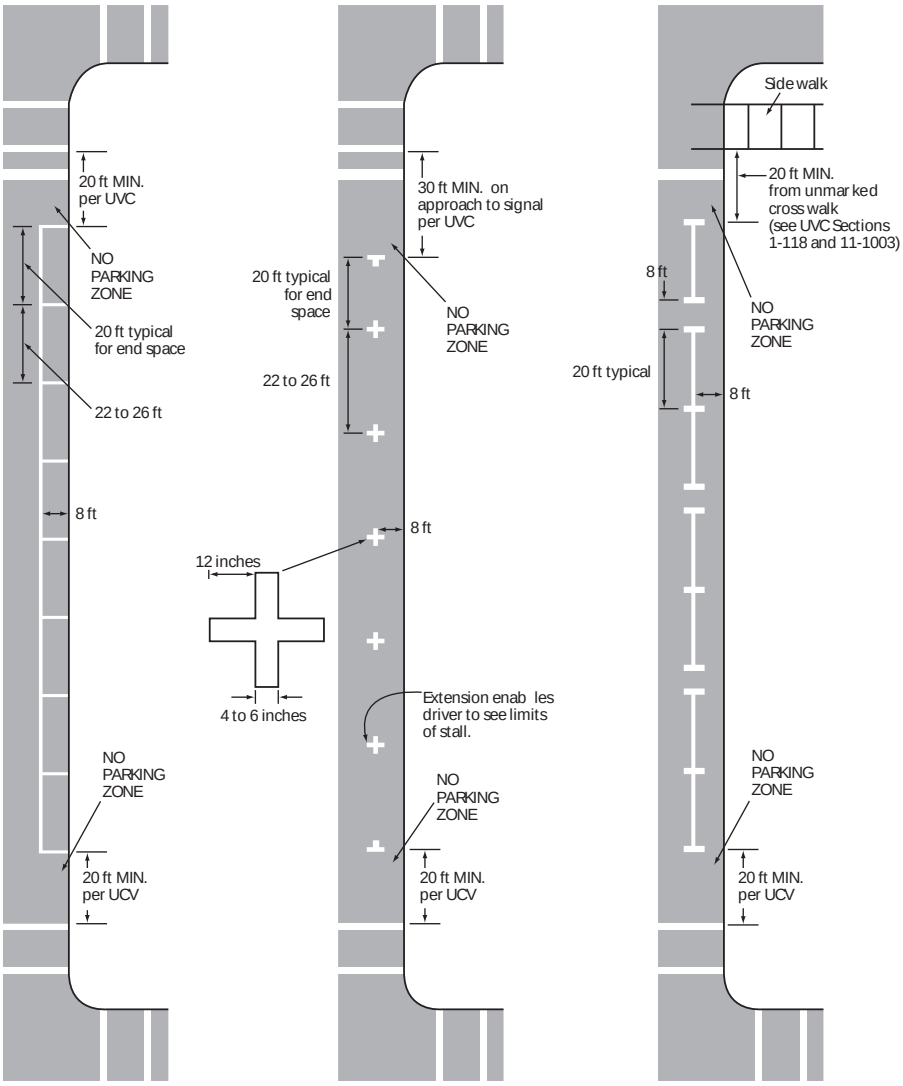
MUTCD Fig. 9C-3

SLOW pavement marking

MUTCD, Similar to Fig. 3B-23

International symbol of accessibility parking space marking

MUTCD Fig. 3B-22



Examples of Parking Space Markings

MUTCD Section 3B.19

SEPARATED BIKE LANE TRANSITIONS

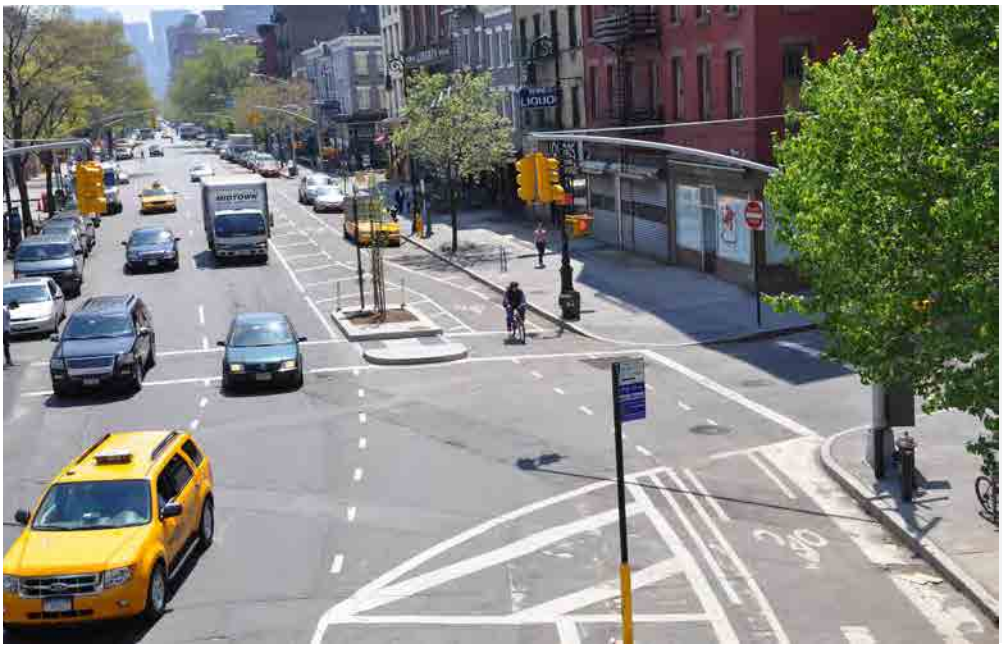
A separated bike lane should be designed so users do not face uncertainty where the facility begins, ends, or intersects with another bicycle facility. Design treatments at a separated bike lane's terminus can vary significantly depending on the context. In all cases, however, planners and engineers should attempt to minimize bicycle conflicts with vehicular traffic and/or pedestrians and create clear pathways to safely enter and exit the separated facility. These transitions can be loosely categorized into five scenarios.

Transitions to Off-Street Trails or Sidepaths

When a separated bike lane terminates at an off-street trail or sidepath, designers should place markings and signage to emphasize the connection and enforce space designations for different user groups (generally differentiating space for cyclists from space for pedestrians or joggers). Green paint can be used at the junction of these facilities in order to alert different path users to the presence of cyclists entering and exiting the trail to and from the separated bike lane. Depending on the nature of the off-street trail, bicycle-specific wayfinding signage should be installed near the end of the separated bike lane to encourage the off-street trail's use.

Transitions to On-Street Bicycle Lanes

A roadway with a separated bike lane may narrow to the point that there is no longer space for separation. In other cases there may not be funding available to construct a separated lane through an entire corridor, or there may be operational or context related constraints. Designers should seek to continue the bicycle facility through on-street painted lanes (or, if necessary, shared lane markings) on the roadway beyond the end of the separated bike lane segment. Green paint prior to, through, and beyond the intersection where the separated facility terminates is advised.



Transition from a buffered bike lane to separated bike lane on 8th Avenue in New York City, NY. (Source: NYC DOT)

Transitions to Roads with No Dedicated Bicycle Facilities

Situations where a separated bike lane ends with no bicycle facility beyond it should be avoided where possible. Care should be taken to alert both cyclists and motorists to the end of the separated bike lane through green markings and signs. For cyclists approaching the end of a facility, alerts should be provided with enough advance notice to allow for a change in route to side streets or adjacent corridors, especially if the separated bike lane terminates in an area with high vehicular traffic volumes (for example, at highway interchanges or high-volume attractions like stadiums). For transitions that occur in high-volume locations, design flexibility is encouraged to create a safe landing point for cyclists, even if it requires a change in local law to allow cyclists to use sidewalks, or involves other unique treatments.

Transitions from Two-Way Separated Bike Lanes

Transitions at the beginning and end of a two-way separated bike lane require special consideration. On two-way streets, bicyclists will have to move across conflicting through vehicle movements to connect between the separated bike lane and the standard bike lane or shared lane. Bicycle signals or two-stage turn queue boxes may be needed to manage conflicts. Two-way separated bike lanes on one-way streets must accommodate contraflow bicycles getting to and exiting from the separated bike lane at either end of the facility. Cross streets or contraflow bike lanes may be used to connect bicyclists to other streets or facilities. Two-way separated bike lanes pose an additional challenge of wrong-way riding after the bike lane terminates.

Intersections with Other Separated Bike Lanes

When one separated bike lane intersects with another, practitioners should design intersections to facilitate turns between them. On high-volume corridors, this may be best accomplished through a “protected intersection” design, which includes corner islands to shield through- and turning bicycle traffic from the adjacent roadways. Cyclists turning left from a right-side running separated bike lane should be encouraged to make two-stage left turns and queue in two-stage turning boxes adjacent to corner islands. Depending on the street’s existing geometry, pedestrian crosswalks may need to be set back from intersections in order to make room for the turning queue boxes. Bicycle specific wayfinding and directional signage should be installed to simplify cyclists’ experience navigating the intersection. The “protected intersection” treatment can be viewed as an expansion of the “bend out” design treatment covered in the turning movements section of this chapter.

DECISION MAKING PROCESS EXAMPLES

The preceding sections highlighted numerous factors that inform the design of separated bike lanes, from the four primary design categories (directional characteristics and width, separation type, midblock considerations and intersection considerations) to secondary areas of focus. Because of space constraints and the complex nature of streets, design is often an iterative process where trade-offs between different design options must be evaluated and a change to one element of the design necessitates changes to other elements. Similarly, trade-offs may continually be made between facility design and planning considerations such as potential ridership, transit access, parking supply and maintenance throughout the design process.

This section illustrates the decision-making process for separated bike lane design through three hypothetical examples, underscoring the integrated nature of their designs.

DECISION MAKING PROCESS EXAMPLES

ONE-WAY STREET WITH LEFT-SIDE CONFLICTS

Design Challenge

While one-way separated bike lanes positioned on the left side of a one-way street offer several potential advantages, this scenario illustrates a case where the benefits of a right-side facility are seen as outweighing the drawbacks. Note: This design could also be mirrored on both sides of a two-way street to create one-way separated bike lanes in each direction.

STEP 1 DIRECTION AND WIDTH

One-way vs Two-way

Because this one-way street is coupled with, and well-connected to, a one-way street in the opposite direction a short block over, significant demand does not exist for a contra-flow bicycle facility. Therefore, a two-way bike lane is not seen as critical on this street. The narrower profile of a one-way lane also ensures that a parking lane can be preserved along with the preferred number of travel lanes. The lane and buffer are sized at 7 ft and 3 ft respectively so as to accommodate the municipality's street sweepers and snow plows until smaller models can be integrated into the fleet.

Lane Alignment

The land use patterns along the street are such that the left side of the street has many more driveways – which increase potential vehicle conflicts, detracting from the safety and comfort of a separated bike lane – than the right side. A right-side facility is seen as the safer choice. Although this option creates additional conflicts at the bus stops along the right side, the parking lane alongside the separated bike lane creates additional space to mitigate this challenge as described under the Midblock section on the following page.

STEP 2 FORMS OF SEPARATION

Buffer Type

Because this type of bicycle facility and street configuration is a new one for this jurisdiction, an interim design using low-cost and easily modified materials is preferred. Separation from traffic for the bicycle lane is provided using flexible delineator posts. Once the project has been evaluated and funding has been identified, the design can be improved if needed and built-out with more permanent materials such as a raised median with landscaping and bioswales.

STEP 3 MIDBLOCK

Transit Stops

Because a bus service runs along this street, with stops along the right side, it is necessary to carefully design the separated bike lane where it interacts with the bus stops. Having buses stop in the travel lane is not desired due to motor vehicle volumes, therefore the width provided by the parking lane along the right side is utilized to create "mixing zones" for bicyclists and stopped buses at bus stops. While not as comfortable for bicyclists as a design that maintains the separated bike lane through the bus stop, in this case it is seen as a reasonable compromise between motor vehicle capacity, bicycle facilities, transit service, and parking needs.

Curbside and Accessibility

To ensure the availability of space for commercial loading and unloading activity, dedicated loading zones are provided at intervals within the parking lane. The removal of parking along the left side of the street creates challenges for some businesses on that side of the street, which are partially mitigated by providing loading zones at the corners of the cross streets.

STEP 4 INTERSECTIONS

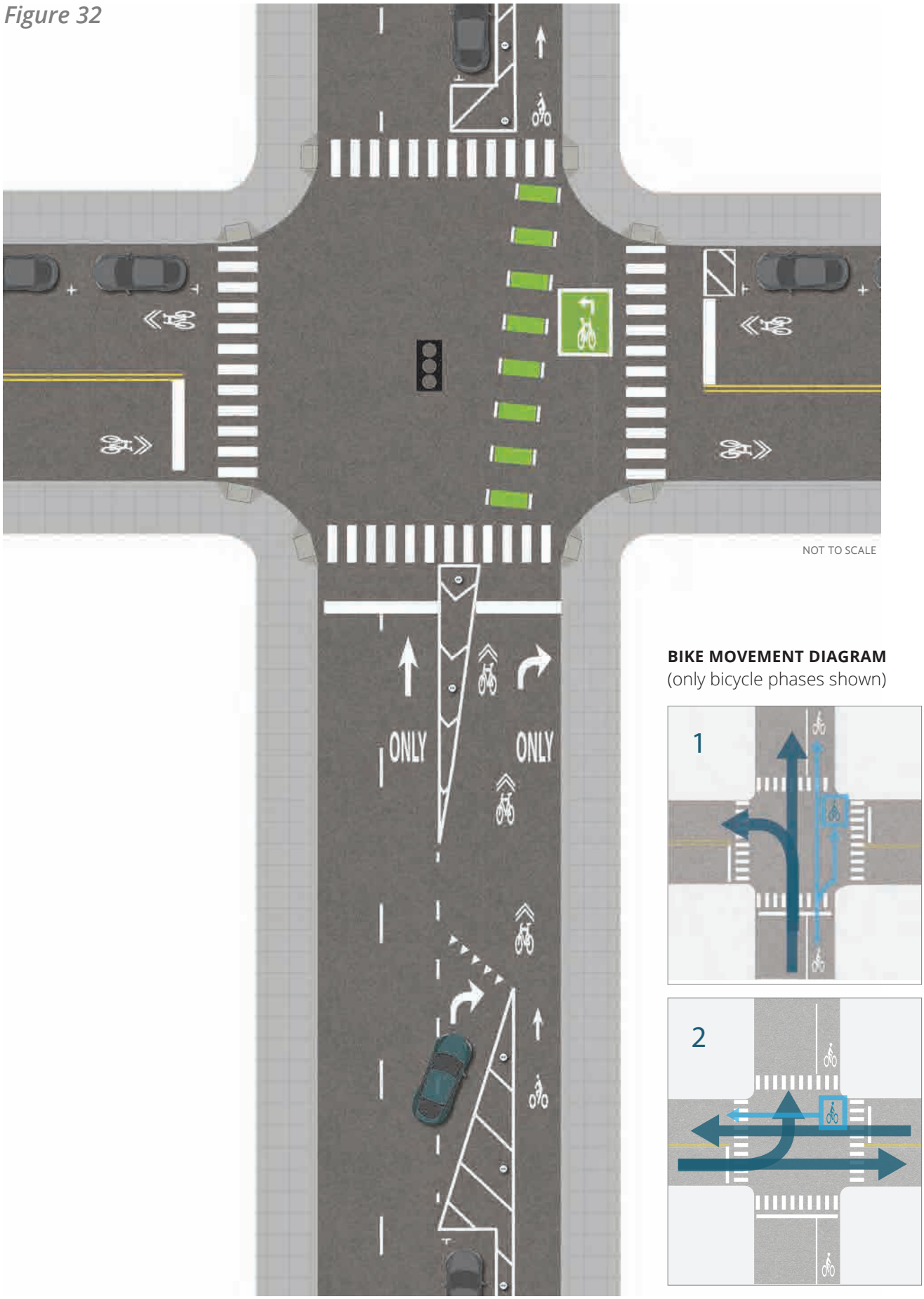
Turning Movements

Right-turning volumes at this intersection are low enough that mixing zones are employed at intersections to manage turning conflicts.

Markings and Signage

Signs and markings require motorists to yield to bicyclists when entering the mixing zones. Shared lane markings within the mixing zones guide bicyclists to the outside of right-turning automobiles, while green paint through the intersection calls attention to the bicycle lane. 2-stage bicycle turn boxes are provided on the far side of the intersections to collect left-turning bicyclists, and NO TURN ON RED signage prevents right-turning motorists from interfering with bicyclists queuing ahead of them to make 2-stage left turns.

Figure 32


ONLY
ONLY
NOT TO SCALE
BIKE MOVEMENT DIAGRAM
(only bicycle phases shown)
1
2

DECISION MAKING PROCESS EXAMPLES

TWO-WAY SEPARATED BIKE LANE ON ONE-WAY STREET

Design Challenge

Two-way separated bike lanes can be desirable on one-way streets when there is a high level of bicyclist demand in both directions due to limited alternatives for the contra-flow direction. However, they create additional turning conflicts that must be mitigated through careful design.

STEP 1 DIRECTION AND WIDTH

One -way vs Two-way

Bicyclists have expressed a preference to be able to utilize this street for two-way travel because of its numerous destinations, it is the most direct route and because comfortable bicycle facilities are not feasible on parallel streets. In addition, new developments along the street and related road work provides an opportunity to create an attractive, permanent bicycle facility. A comprehensive redesign of the streetscape is completed, providing a two-way separated bike lane that responds to user preferences and supports the economic development taking place along the street.

Lane Alignment

In this location, the left side is preferred for the two-way bike lane as it puts bicyclists and turning motorists moving in the same direction next to each other, maximizing visibility. Doing so also minimizes impacts on bus stops along the route.

STEP 2 FORMS OF SEPARATION

Buffer Type

It made economic sense to incorporate a permanent bicycle lane design into the road work that is already planned to address utility infrastructure and roadway condition as it would represent only an incremental cost. The bicycle lane is placed at sidewalk grade since cross streets and driveways are widely spaced and to reinforce the bicycle-oriented nature of the street. The bicycle lane is paved in asphalt rather than concrete to reinforce its purpose. A buffer zone along the curb separates the raised bicycle lane from the parking lane while a landscaped buffer separates it from the pedestrian portion of the sidewalk.

STEP 3 MIDBLOCK

Designing for Driveways

Driveways are designed to prioritize those on foot and bicycle by bringing crossing motor vehicles up to sidewalk grade rather than vice versa. To ensure that bicyclists are visible to drivers entering and exiting the few driveways along the route, ample visibility is provided through the removal of several parking spaces at each driveway to provide clear sight lines. Furthermore, the asphalt bicycle lane pavement is carried through the driveways and enhanced with green paint and warning signage to call both drivers' and bicyclists' attention to the presence of each other.

Curbside and Accessibility

Much of the loading activity for businesses along the left side of the street takes place off-street, but to minimize conflicts between on-street loading and bicyclists, dedicated loading zones are provided towards the middle of each block. Accessible parking spaces are also located mid-block by narrowing the bike lane and shifting it towards the landscaped buffer to create the necessary width.

STEP 4 INTERSECTIONS

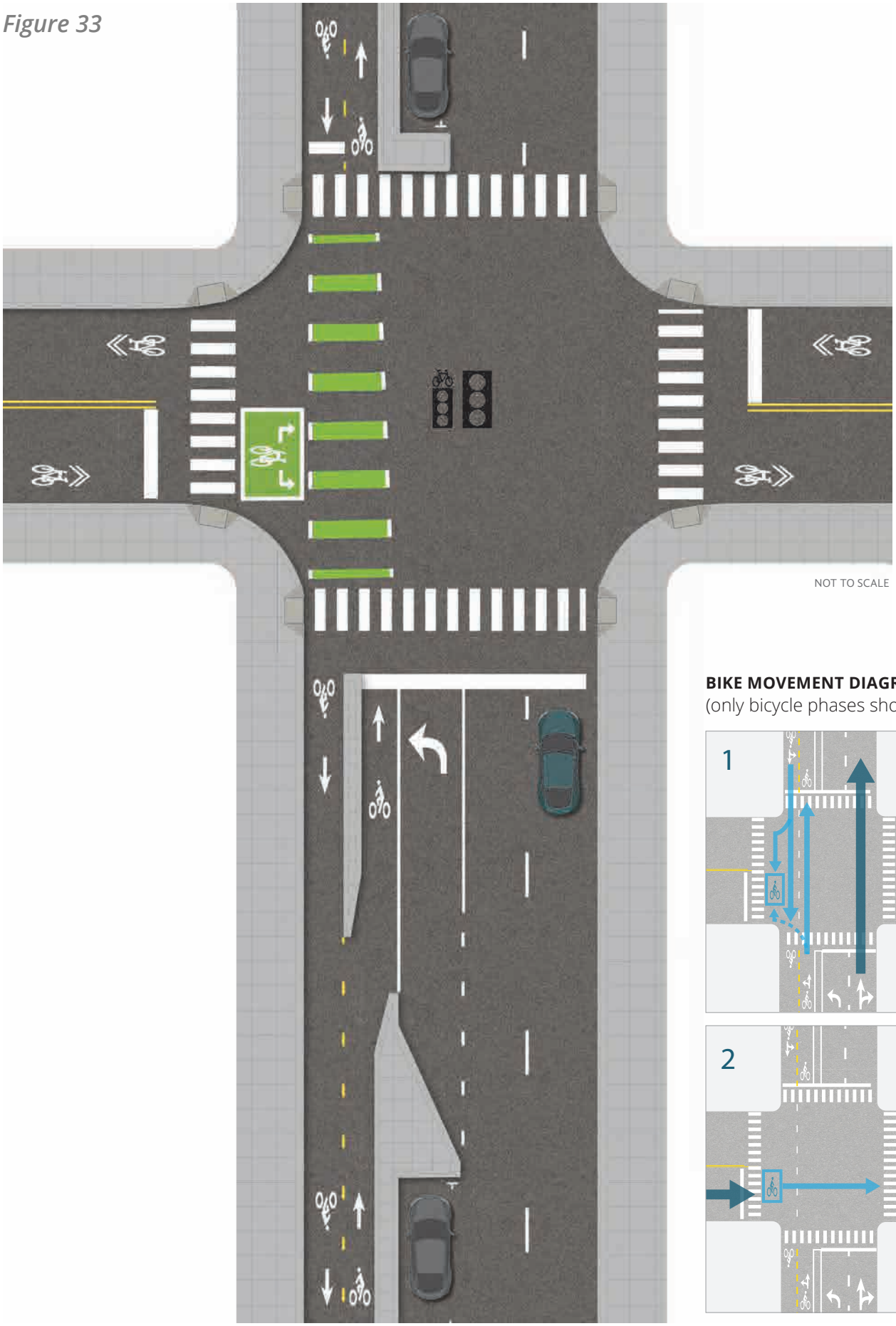
Turning Movements

Two-way separated bike lanes generally require their own protected signal phase at signal-controlled intersections where conflicting turns are allowed. Dedicated left turn bays are included at intersections (in exchange for several parking spaces) with a separate signal phase from that of the bicycle movement, and the northbound bike lane "bends in" at the intersection approach to visibly position bicyclists immediately next to left-turning drivers. In addition, minor cross streets are treated similarly to driveways with a raised pedestrian and bicycle crosswalk that slows motor vehicles while enhancing sidewalk users' visibility.

Markings and Signage

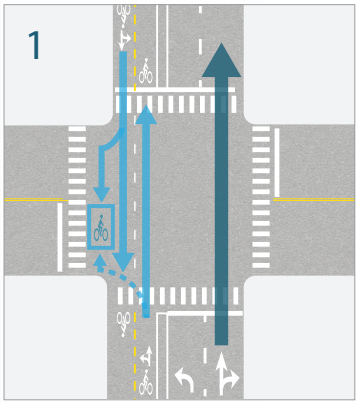
The two-way bicycle lane is painted green through intersections, whether it remains at sidewalk grade or crosses at roadway grade. A bicycle turn queue box facilitates right turns by northbound bicyclists and left turns by southbound bicyclists.

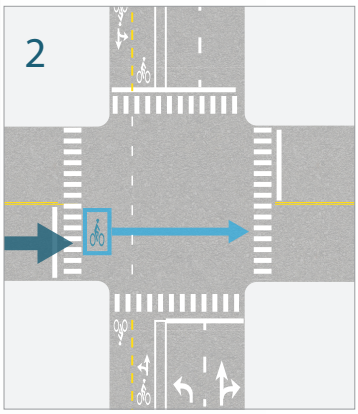
Figure 33



NOT TO SCALE

BIKE MOVEMENT DIAGRAM
(only bicycle phases shown)





DECISION MAKING PROCESS EXAMPLES

MEDIAN-RUNNING TWO-WAY SEPARATED BIKE LANE

Design Challenge

Some two-way streets lend themselves to two-way bike lanes running down the center rather than one-way bike lanes on the outside edges, particularly on a route oriented to bicycle through traffic. Such a design can create a boulevard-like experience but management of bicycle, motor vehicle and pedestrian interactions at intersections is key.

STEP 1 DIRECTION AND WIDTH

Lane Alignment

A two-way separated bicycle lane down the median of the street may be appropriate when many bicyclists use the street as a commuting "through" route; the outer edges experience a heavy combination of parking, bus stop and commercial loading activity; left turn volumes for motorists are modest; and the neighborhood plan envisioned the street serving as a grand "boulevard" with a tree-lined median. The two-way bike lane is a comfortable 12 ft wide, which also easily accommodates maintenance vehicles.

STEP 2 FORM OF SEPARATION

Buffer Type

To implement the new design in a short-term, low-cost way, the separated bike lane is primarily separated using interim materials such as markings, flexible delineator posts and landscaped planters (which are maintained by the local merchants association). However, an available grant is sufficient to build out raised islands at intersection approaches to better protect pedestrians at the crossings and move closer to the long-term boulevard vision by including large-canopy trees.

STEP 3 MIDBLOCK

Midblock Considerations

Locating the two-way separated bicycle lane within the median of the street generally eliminates midblock design issues such as transit stops, accessibility, parking, loading and driveway conflicts. This configuration concentrates design challenges at the intersections.

STEP 4
INTERSECTION

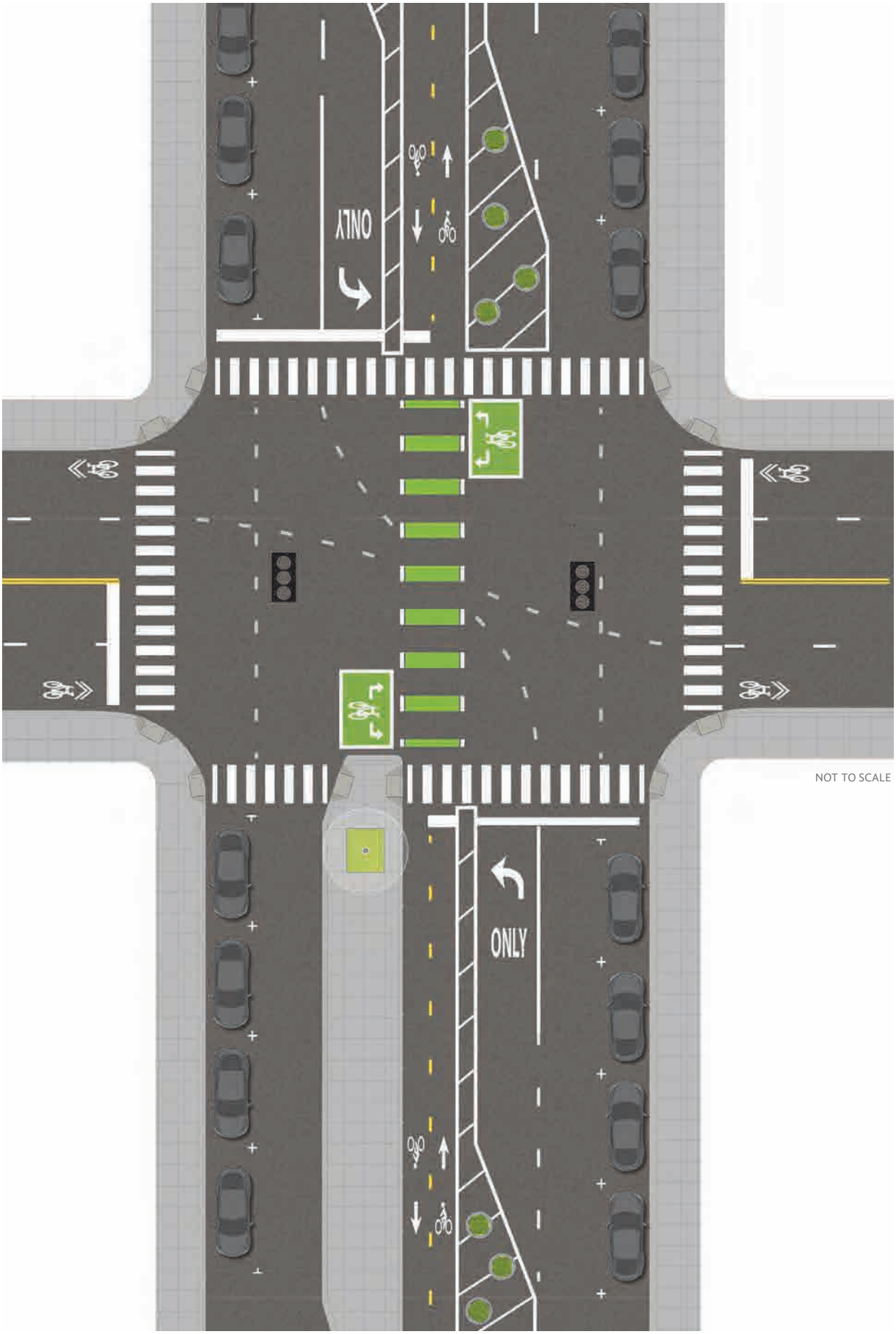
Turning Movements

"Carving out" the left turn bays from the median brings bicyclists and turning motorists directly alongside each other, improving visibility at the intersection approaches. Separate signal phases are necessary for the bike lane and left turning motor vehicles given the multiple conflicts present in this design. A stop bar is provided for bicyclists in advance of the crosswalk so that pedestrians can cross unimpeded during their "walk" phase.

Markings and Signage

The two-way bicycle lane is painted green through the intersections. Bicycle turn queue boxes are provided on the near side of the intersection (in the "shadow" of the median) to facilitate right turns by northbound bicyclists and left turns by southbound bicyclists and on the far side of the intersection for northbound left turns and southbound right turns. Dotted lane line extensions within the intersection help organize drivers' through and turning movements, particularly around the bicycle turn queue boxes. Signs reinforce the designated lanes and stopping locations and alert both motorists and bicyclists to the conflicting movements.

Figure 34



CHAPTER 6

MOVING FORWARD

MOVING FORWARD

This *Separated Bike Lane Planning and Design Guide* builds on existing research and design guidance through an in-depth review of relevant literature, interviews with practitioners throughout the U.S., and analysis of available crash and volume data. The guide provides practical information and promotes design flexibility to facilitate the planning, design, and implementation of separated bike lanes.

Separated bike lanes are one of many "tools in the toolbox" that communities will use to create connected bicycle networks. They can boost bicycle ridership and draw a broader spectrum of users, and they may provide safety and economic benefits to non-users as well. Separated bike lanes can have a wide range of safety impacts for bicyclists and other street users depending on site-specific conditions and context.

FHWA supports a flexible approach to the planning and design of separated bike lanes, in part because the state of the practice is evolving as more separated bike lanes are implemented throughout the U.S. In order to advance the state of the practice there must be an ongoing conversation among those that are planning, designing, implementing, using, and evaluating separated bike lanes. This conversation should incorporate lessons from separated bike lanes built as part of new projects, and also those implemented within constrained urban, suburban, and rural environments. Data, research, capacity building, and evaluation will be cornerstones of this effort and are described briefly below. *Safety and Equity* will be integral components of all four areas.

Key Considerations

1. Data: Because they are relatively new in the U.S., data specific to separated bike lanes on safety, ridership, user comfort, maintenance, economic impacts, and cost are limited. Data on these attributes will improve over time. Moving forward planners and designers should collect before- and after-volume and crash data for all planned separated bike lanes. States, MPOs, and local governments implementing separated bike lanes should consider incorporating robust data collection and project evaluation methodologies into their standard project implementation process. A data collection information checklist and project evaluation worksheet are included as appendices to this guide (refer to Appendices E and D, respectively). Pre- and post-implementation data on bicyclist crashes and volumes is necessary at a minimum to provide meaningful results and to continue to improve the state of the practice.

2. Research: The crash analysis conducted as part of the development of this guide is a first step towards understanding the safety trends related to separated bike lanes. However, to truly understand the safety effects of separated bike lanes, it will be necessary to collect more robust crash data (e.g., crash severity) and bicyclist volume data. Future research should be conducted to develop crash modification factors for different SBL configurations. To facilitate this process, a mechanism to receive and compile new and updated data on separated bike lanes will be needed and, to the extent possible, this effort should be coordinated with ongoing efforts to modify FHWA's Traffic Monitoring Analysis System (TMAS) based on the Traffic Monitoring Guide format so that exposure rates for SBLs can be properly assessed. Future research identified in Appendix F, and also by other stakeholders such as the Transportation Research Board's Bicycle Transportation Committee, should also be undertaken and should involve stakeholders and partners at all levels, including cities, MPOs, States, advocacy organizations, University Transportation Centers, private nonprofit institutions, foundations, and the Federal government.

3. Capacity Building: Ongoing peer exchange and capacity building efforts are needed, especially given that the state of the practice for planning and designing separated bike lanes is still evolving. A venue to compile and make available to practitioners the best separated bike lane designs should be created and maintained. In the interim, stakeholders are encouraged to continue ongoing peer exchanges focused on innovative bicycle facility design and to look for opportunities to "broaden the base" of practitioners and communities that are participating. Additional venues for providing training and peer exchange to practitioners planning and designing separated bike lanes should be identified and could potentially include universities, advocacy organizations, MPOs, States, and national training providers.

4. Evaluation: Project evaluation should extend beyond safety and ridership to consider the sustainability and performance of projects in relation to all relevant policy goals. These might include accessibility, job access, economic development, tourism, public health, and environmental quality. A holistic performance evaluation framework is needed to enable communities to evaluate separated bike lanes in a way that is comprehensive and that responds to policy goals and community needs. To the extent possible, this evaluation framework should be coordinated with other established ways to evaluate performance. This framework should cover the broad range of transportation goals and objectives, while at the same time incorporating social, environmental, and economic considerations.

For More Information

Visit http://www.fhwa.dot.gov/environment/bicycle_pedestrian

FHWA-HEP-15-025