Federal Highway Administration

SEPARATED BIKE LANES

ON HIGHER SPEED ROADWAYS: A TOOLKIT AND GUIDE

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Federal Highway Administration

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CONTENTS

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Source: Kittelson & Associates, Inc.

1. INTRODUCTION

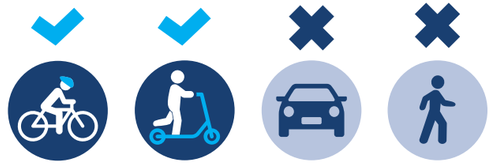
Source: Illinois Department of Transportation

This toolkit includes information references, agency policies, processes, and other resources and procedures that can help agencies overcome the obstacles limiting them from implementing separated bicycle lanes where users most require separation from motor vehicles: on higher speed roads. Despite their importance in higher speed contexts, installations of separated bicycle lanes in the U.S. have so far occurred largely in lower speed environments.

This toolkit defines separated bicycle lanes as (1) intended exclusively for bicyclists; (2) having a horizontal buffer that separates bicyclists from motor vehicle traffic; and (3) using some type of vertical element within that buffer space. Higher speed roadways were defined for the purpose of this guide as roadways with a posted speed limit of 35 mph or greater. This toolkit does not define an upper speed limit where shared-use paths separated from the roadways would be the preferred treatment. Speeds 50 mph or greater are most likely on limited-access roadways, which are not the focus of this guide. However, in general, the importance of horizontal and vertical separation of cyclists increases along with speed.

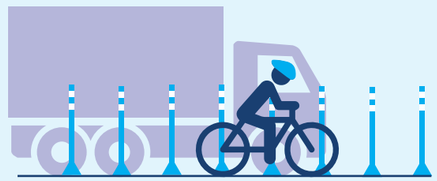
WHAT IS A SEPARATED BIKE LANE?

1 INTENDED EXCLUSIVELY FOR BICYCLISTS AND SCOOTERS



2 HORIZONTAL BUFFER SEPARATES BICYCLISTS FROM MOTOR TRAFFIC

3 HAS SOME TYPE OF VERTICAL ELEMENT WITHIN THE BUFFER SPACE



Source: Mapillary, user: carlheinz

Guide Overview

The toolkit is organized into the following sections:

Section 1: Introduction presents the toolkit guide's purpose.

Section 2: Background describes the toolkit guide's scope and background.

Section 3: Overview of State of Practice and Current Challenges summarizes existing research and challenges of implementing separated bike lanes on higher speed roads.

Section 4: Planning Separated Bike Lanes outlines key considerations for practitioners in the planning phase.

Section 5: Designing Separated Bike Lanes provides best practices on the form of separation, directional and width characteristics, and driveway and intersection designs.

Section 6: Maintaining Separated Bike Lanes identifies maintenance considerations including managing stormwater and assets, street-sweeping requirements, and seasonal maintenance procedures.

Section 7: Moving Forward summarizes key takeaways from the toolkit guide.

2. BACKGROUND

In 2021, the U.S. Department of Transportation (USDOT) released the National Roadway Safety Strategy (NRSS), outlining a comprehensive approach to reducing serious injuries and deaths on the country's highways, roads, and streets. The first NRSS was released in January 2022 following an increase of 6.8 percent in motor vehicle and road traffic fatalities in 2020 compared to 2019. An estimated 42,915 lives were lost on U.S. roads in 2021, an increase of over 10 percent compared to 2020. Early estimates for the first nine months of 2022 indicate deaths will remain near those levels in 2022, while getting worse for incidents involving trucks as well as for people walking, biking, or rolling.

As part of this effort to improve safety, a growing body of evidence in the United States and internationally demonstrates that separated bike lanes can reduce crashes involving people bicycling. In response to these studies, the National Transportation Safety Board (NTSB) concluded in 2019 that separated bike lanes could reduce bicyclist fatalities and injuries, recommending that the Federal Highway Administration (FHWA) include this lane type in its list of Proven Safety Countermeasures and in its Every Day Counts program. FHWA has developed bicycle lane Proven Safety Countermeasures to make bicycling safer. The Proven Safety Countermeasures include guidance on the application of different facilities in various contexts and considerations for adding a bicycle lane by reducing lane or shoulder widths.

Separated bike lanes also have the potential to increase comfort and ridership. FHWA's Bikeway Selection Guide generally recommends separated bike lanes or shared-use paths on roads with speeds greater than 30 mph to provide a low-stress bicycling experience. Surveys of road users have found a preference for separated bike lanes compared to other types of bicycle facilities, a view shared by both bicyclists and drivers.

Scope of the Guide

This guide synthesizes existing research on separated bicycle lanes, including research on potential benefits and obstacles, as well as on existing design and planning guidance. Using information from the limited case studies available and from stakeholders, this research aims to identify key obstacles, considerations, and experiences of those who have designed, implemented, and maintained separated bike lanes on higher speed roadways.

The findings of this guide can inform local jurisdictions that have higher speed arterials with bicycle lanes how to plan, design, and maintain buffers and vertical separations for those lanes. This guide is not intended to be a detailed design guide covering all aspects of roadway design in all contexts. NCHRP Report 1036: Roadway Cross Section Reallocation provides guidance on reconfiguring streets that may be applicable to higher speed road contexts.

Additionally, following the measures described in this guide alone cannot promise to deliver a more comfortable experience in higher speed arterial contexts sufficient to induce greater rates of participation in bicycling. The decision to ride a bicycle is a complex one, involving safety, perception of safety, land uses, connectivity of the network, and many other determinants of ridership.

Source: Steven Vance (CC BY-NC-SA 2.0)

SECTION 3: OVERVIEW OF STATE OF PRACTICE AND CURRENT CHALLENGES

This section summarizes the research regarding the benefits and challenges of implementing separated bike lanes on higher speed roads, as well as the current challenges for State and local agencies looking to implement these lanes on higher speed roads.

Summary of Research

Separated bike lanes have the potential to reduce fatal and severe injuries and to increase bicycle ridership; it is no surprise that the planning, design, and construction of them has rapidly increased over the last decade.[1] There is, however, a lack of research on the safety performance of separated bicycle lanes specifically on higher speed roadways. The existing research draws several conclusions:

- higher speeds are a risk factor associated with bicyclist crashes and injuries;
- separated bicycle lanes have an overall improved safety performance;
- separated bike lanes influence driver behavior, decreasing speed and instances of motor vehicle encroachment; and
- both people bicycling and people driving feel more comfortable with separated bicycle lanes.

These conclusions, taken together, suggest that separated bicycle lanes may have a positive safety effect on higher speed roads.

RISK FACTORS FOR BICYCLISTS ON HIGHER SPEED ROADS

Researchers have explored a wide range of temporal, environmental, and behavioral risk factors that increase the likelihood and severity of crashes involving bicyclists. Speed is a well-documented risk factor in severe injury crashes involving bicyclists, with that risk increasing substantially when vehicles travel faster than 20 mph.[2] The NTSB report (2019) explored bicyclist deaths, injuries, and crashes by location and found that nearly two-thirds (65 percent) of all bicyclist crashes occurred at intersections. However, 56 percent of bicyclist fatalities occurred at midblock locations, suggesting that although there are more bicycle crashes occurring at intersections, crash severity is higher when a crash occurs at a midblock location.[3]

Using the Pedestrian and Bicycle Crash Analysis Tool, researchers from the University of North Carolina Highway Safety Research Center used standardized data from bicyclist crashes to determine whether different types of driver

1. Hold for NCHRP 17-84

2. Cushing, M., Hooshmand, J., Pomares, B., & Hotz, G. (2016). Vision Zero in the United States versus Sweden: Infrastructure improvement for cycling safety. American Journal of Public Health, 106(12), 2178–2180. https://doi.org/10.2105/AJPH.2016.303466

3. National Transportation Safety Board. (2019). Bicyclist Safety on US Roadways: Crash Risks and Countermeasures. Safety Research Report NTSB/SS-19/01. Washington, DC: NTSB

and bicyclist maneuvers carried different levels of risk for crashes.[4] For example, a crash that occurs when a driver overtakes a bicyclist was found to be the most common type of crash resulting in bicyclist fatalities, accounting for 38 percent of fatal and serious injury bicyclist crashes in North Carolina. It is also a type of crash that could be directly mitigated by separating bicyclists and drivers using separated bike lanes.

Similarly, the NTSB (2019) paper linked crash type with crash location to find that, between 2014 and 2016, 45 percent of all bicyclist deaths shown in the NHTSA Fatal Analysis Reporting System were "driver overtaking bicyclist" crash types occurring at midblock locations. NTSB states that "separated bike lanes could prevent bicycle crashes involving motor vehicles at midblock locations and, thereby, also reduce the number of fatalities and serious injuries associated with such crashes."

SAFETY PERFORMANCE OF SEPARATED BIKE LANES

The improved safety performance of separated bike lanes compared to either no bike facility or some other type of facility is well documented. Along routes with separated bike lanes, researchers have observed a lower risk of bicyclist injuries, crashes, and falls compared to routes with no bicycle facilities.[5, 6, 7, 8, 9] Research for the National Institute for Transportation and Communities examined bicyclist-motor vehicle interactions at separated bicycle lanes in five cities: Austin, TX; Chicago, IL; Portland, OR; San Francisco, CA; and Washington, D.C., and deemed nearly all observed interactions (conflicts) precautionary after the separated bike lane installations.[10] While some studies have documented increases in bicyclist crashes, these were accompanied by greater increases in bicycle volumes, resulting in lower rates of injuries and crashes.[11, 12]

4. Thomas, L., Nordback, K., & Sanders, R. (2019). Bicyclist Crash Types on National, State, and Local Levels: A New Look. Transportation Research Record, 2673(6), 664–676. https://doi.org/10.1177/0361198119849056

5. Lusk, A.C., Furth, P.G., Morency, P., Miranda-Moreno, L.F., Willet, W.C., and Dennerlein, J.T. (2011). Risk of injury for bicycling on cycle tracks versus in the street. Injury Prevention, 2011;17:131-135.

6. Teschke, K., Harris, M. A., Reynolds, C. C., Winters, M., Babul, S., Chipman, M., Cusimano, M. D., Brubacher, J. R., Hunte, G., Friedman, S. M., Monro, M., Shen, H., Vernich, L., & Cripton, P. A. (2012). Route infrastructure and the risk of injuries to bicyclists: a case-crossover study. American journal of public health, 102(12), 2336–2343. https://doi.org/10.2105/AJPH.2012.300762

7. Lusk, A. C., Morency, P., Miranda-Moreno, L. F., Willett, W. C., and Dennerlein, J. T. (2013). Bicycle Guidelines and Crash Rates on Separated bike lanes in the United States. American Journal of Public Health, 103(7), 1240-1248.

8. Rothenberg, H., Goodman, D., & Sundstrom, C. (2016). Separated Bike Lane Crash Analysis. Transportation Research Board, Washington, D.C.

9. Sundstrom, C. A., Quinn, S. M., & Weld, R. (2019). Bicyclist Crash Comparison of Mixing Zone and Fully Split Phase Signal Treatments at Intersections with Protected Bicycle Lanes in New York City. Transportation Research Record, 2673(12), 115–124. https://doi.org/10.1177/0361198119859301

10. Monsere, C., Dill, J., McNeil, N., Clifton, K., Foster, N., Goddard, T., Berkow, M., Gilpin, J., Voros, K., van Hengel, D., & Parks, J. (2014). Lessons from the Green Lanes: Evaluating Protected Bike Lanes in the U.S. National Institute for Transportation and Communities, Portland, OR.

11. Goodno, M., McNeil, N., Parks, J., & Dock, S. (2013). Evaluation of Innovative Bicycle Facilities in Washington, DC: Pennsylvania Avenue Median Lanes and 15th Street Separated bike lane. Transportation Research Record 2387, pp. 139-148

12. Jensen, S.U. (2008). Bicycle Tracks and Lanes: A Before-and-After Study. Transportation Research Board 87th Annual Meeting Compendium of Papers DVD. Retrieved from https://trid.trb.org/view/848364

Source: Seattle Department of Transportation

Numerous studies also documented mixed results when it came to assessing separated bike lanes and safety performance, particularly at intersection locations and along routes with two-way (compared to one-way) separated bike lanes on one side of the road. An analysis performed alongside the development of FHWA's Separated Bike Lane Planning and Design Guide (2015) documented positive safety outcomes overall, but it also identified locations where crash risk increased at intersections following the installation of two-way separated bicycle lanes.[13]

A recent FHWA study (2023) evaluated the safety effect for various on-street bicycle facilities. The research developed a crash modification factor (CMF) for the placement of separated bike lanes at roadway segment locations. The CMFs for separated bike lanes show a clear trend that, with the implementation of separated bike lanes, a transportation agency can expect to see a reduction in bicycle crashes.

EFFECTS OF SEPARATED BIKE LANE DESIGN ELEMENTS ON DRIVER BEHAVIORS

Researchers have also examined how separated bike lane designs influence driver behaviors. Drivers along corridors with separated bike lanes provided more space when passing bicyclists and were less likely to encroach into bicycle lanes when compared to other bicycle facility types.[14] A study using instrumented bicycles in Minnesota found that

13. Rothenberg, H., Goodman, D., & Sundstrom, C. (2016). Separated Bike Lane Crash Analysis. Transportation Research Board, Washington, D.C.

14. Burbridge, S.K. & Shea, M. S. (2018). Measuring Systemic Impacts of bike Infrastructure Projects. Utah Department of Transportation Research Division. Retrieved from https://www.udot.utah.gov/main/uconowner.gf?n=2404180664921364

drivers allowed more distance when passing bicyclists on roads with buffered and separated bike lanes than with other types of facilities.[15] Several studies also found that driver speeds decreased in the presence of separated bike lanes and that the presence of pavement markings and curb extensions typically used in protected intersection designs significantly reduced the approach and turning speeds of motor vehicles.[16, 17]

Other studies revealed impacts on driver behavior that were not beneficial for bicyclist safety, and which may warrant further investigation. A study of driver-permissive left turns along corridors with two-way separated bike lanes revealed that the left-turning driver only safely yielded in 9 percent of cases, and that more than half of the observed bicyclists arriving during the green signal had to make some sort of avoidance maneuver to keep from being hit by a turning vehicle.[18] A team exploring driver behaviors at protected intersections and along separated bike lane corridors in a simulator setting found that drivers traveling alongside a separated bike lane performed fewer glances toward the bike lane to identify, detect, or perceive bicyclists traveling there.[16]

USER PERCEPTIONS OF SAFETY AND COMFORT

The consensus from the existing research is that separated bike lanes are preferred by both bicyclists and drivers to most other bicycle facilities along higher traffic streets.[19, 20, 21, 22, 23, 24] A recent study measuring bicyclist stress levels found that bicyclists traveling in separated bike lanes experienced the lowest stress levels, traveled at lower speeds, and reported higher levels of comfort than those traveling along other facility types.[25]

Speed was mentioned throughout the papers that focused on bicyclist safety and comfort. In a paper defining the “four types of cyclists”, survey results suggested that decreases in motor vehicle traffic speeds and increased separation between road users would increase the perceived safety and comfort of cyclists, as well as cycling levels overall. A survey found that 89 percent of respondents identified the safety concern of “fast or busy traffic” as impacting their ability to bicycle to work or school.[26, 27]

Though much of the existing research supports the idea that more separated facilities will improve bicyclist comfort and lead to increased levels of bicycling, other studies sought to understand less frequently documented perspectives of potential bicyclists. Even the “best-designed” facilities may not be enough to get prospective bicyclists to ride beyond shared-use paths; other factors, like overall network connectivity and traffic speeds and volumes, may play a bigger role in this decision.[28]

Source: SupapleX, Wikimedia Commons

15. Evans, I., Pansch, J., Singer-Berk, L., & Lindsey, G. (2018). Factors Affecting Vehicle’ ‘ Passing Distance and Encroachments While Overtaking Cyclists. ITE Journal.

16. Deliali, A., Campbell, N., Knodler, M., & Christofa, E. (2020). Understanding the Safety Impact of Protected Intersection Design Elements: A Driving Simulation Approach. Transportation Research Record, 2674(3), 179–188. https://doi.org/10.1177/0361198120909382

17. Deliali, K., Christofa, E., & Knodler Jr., M. (2021). The role of protected intersections in improving bicycle safety and driver right-turning behavior. Accident Analysis & Prevention, Volume 159, 106295, ISSN 0001-4575.

18. Saeidi Razavi, R., & Furth, P. G. (2021). Risk to Bicyclists in a Separated Path from Left Turns across Multiple Lanes: A Case for Protected-Only Left Turns. Transportation Research Record, 2675(10), 174–183. https://doi.org/10.1177/03611981211010789

19. Winters, M., & Teschke, K. (2010). Route Preferences among Adults in the near Market for Bicycling: Findings of the Cycling in Cities Study. American Journal of Health Promotion, 25(1), 40–47. https://doi.org/10.4278/ajhp.081006-QUAN-236

20. Monsere, C.M., McNeil, N., & Dill, J. (2012). Multiuser Perspectives on Separated, On-Street Bicycle Infrastructure. Transportation Research Record: Journal of the Transportation Research Board, No. 2314, Transportation Research Board of the National Academies, Washington, D.C., 2012, pp. 22–30. DOI: 10.3141/2314-04

21. McNeil, N., Monsere, C. M., & Dill, J. (2015). Influence of Bike Lane Buffer Types on Perceived Comfort and Safety of Bicyclists and Potential Bicyclists. Transportation Research Record 2520, pp. 132-142.

22. Sanders, R. L. (2016). We can all get along: The alignment of driver and bicyclist roadway design preferences in the San Francisco Bay area. Transportation Research Part A, 91, 120-133. doi:10.1016/j.tra.2016.06.002

23. Monsere, C., Dill, J., McNeil, N., Clifton, K., Foster, N., Goddard, T., Berkow, M., Gilpin, J., Voros, K., van Hengel, D., & Parks, J. (2014). Lessons from the Green Lanes: Evaluating Protected Bike Lanes in the U.S. National Institute for Transportation and Communities, Portland, OR.

24. Watkins, K.E., Clark, C., Mokhtarian, P., Circella, G., Handy, S., and Kendall, A. (2020). Bicyclist Facility Preferences and Effects on Increasing Bicycle Trips. Washington, DC: The National Academies Press. https://doi.org/10.17226/25792.

25. Guo, X., Tavakoli, A., Robartes, E., Angulo, A., Chen, T.D., and Heydarian, A. (2022). Roadway Design Matters: Variation in Bicyclists’ Psycho-Physiological Responses in Different Urban Roadway Designs. arXiv. https://arxiv.org/abs/2202.13468

26. Dill, J., & McNeil, N. (2013). Four Types of Cyclists?: Examination of Typology for Better Understanding of Bicycling Behavior and Potential. Transportation Research Record, 2387(1), 129–138. https://doi.org/10.3141/2387-15

27. Sanders, R. L., & Judelman, B. (2018). Perceived Safety and Separated Bike Lanes in the Midwest: Results from a Roadway Design Survey in Michigan. Transportation Research Record, 2672(36), 1–11. https://doi.org/10.1177/0361198118758395

28. Fitch, D.T., Carlen, J., Handy, S.L. (2022). What makes bicyclists comfortable? Insights from a visual preference survey of casual and prospective bicyclists. Transportation Research Part A: Policy and Practice. Volume 155, January 2022, Pages 434-449.

Source: Kittelson & Associates, Inc.

Existing Design Guidance and Policies

There are several existing design guidelines and planning tools that specifically address the development of bicycle facilities on higher speed roadways. Applicable national guidance includes:

AASHTO Guide for the Development of Bicycle Facilities (AASHTO, 2012): The 2012 edition of this guide only provides general guidance on the design of bicycle lanes adjacent to or within freeway rights-of-way, as well as basic design principles for freeway interchanges.

Separated Bike Lane Planning and Design Guide (FHWA, 2015): Though this report does not specifically address higher speed roads, it notes that "Separation type decisions should be based on the presence of on-street parking, street width, cost, aesthetics, maintenance, motorized traffic volumes and speeds."

Bikeway Selection Guide (FHWA, 2019): This resource provides flexible guidance for developing bicycle facilities on higher speed roadways, generally recommending separated bike lanes or shared-use paths where speeds exceed 30–35 mph and/or where volumes exceed approximately 7,000 vehicles per day.

Traffic Analysis and Intersection Considerations to Inform Bikeway Selection (FHWA, 2021): This resource supplements the Federal Highway Administration's (FHWA) Bikeway Selection Guide and is intended to inform tradeoff decisions associated with bikeway selection at intersections. It discusses common performance metrics, spatial needs of bikeways at intersections, safety- and equity-focused design principles, and operational traffic analysis tradeoffs and assumptions.

On-Street Motor Vehicle Parking and the Bikeway Selection Process (FHWA, 2021): This resource is intended to inform discussions about on-street parking and bikeway selection. It is a supplementary resource to the FHWA Bikeway Selection Guide. It begins with a discussion of on-street parking and bikeway types, with associated dimensional requirements and tradeoff considerations.

Urban Bikeway Design Guide (NACTO, 2010): This NACTO design guide recommends protected or separated bicycle lanes where speed limits exceed 35 mph.

Designing for All Ages and Abilities (NACTO, 2017): This contextual guidance follows recommendations from the Urban Bikeway Design Guide and includes a selection matrix specifying that roads with speed limits greater than 25 mph should have some type of protected/separated bike lane. It also recommends these types of facilities on roads with speed limits between 20 and 25 mph if traffic volumes exceed 3,000 vehicles per day or if there are multiple lanes in each direction.

Recommended Design Guidelines to Accommodate Pedestrians and Bicycles at Interchanges: A Recommended Practice (ITE, 2016): This guide recommends a series of treatments and possible alternatives for safely accommodating bicyclist travel at higher speed interchange locations. While there are recommendations for slowing vehicle speeds on the approach to mixing zones and potential conflict areas, there are not specific recommendations for handling separated facilities for bicyclists in these areas.

Small Town and Rural Multimodal Networks (FHWA, 2016): This guide from FHWA identifies appropriate conditions for physically separated facilities, with ranges of speeds and volumes provided for these separated facilities.

Several States and local municipalities also have guidance for designing bicycle facilities on higher speed roads. State-level examples include:

- Massachusetts Department of Transportation Separated Bike Lane Planning and Design Guide (2015)
- Minnesota Department of Transportation Bicycle Facility Design Manual (2020)
- Ohio Multimodal Design Guide (2023)
- Virginia Department of Transportation Road Design Manual (2005)

Local examples include:

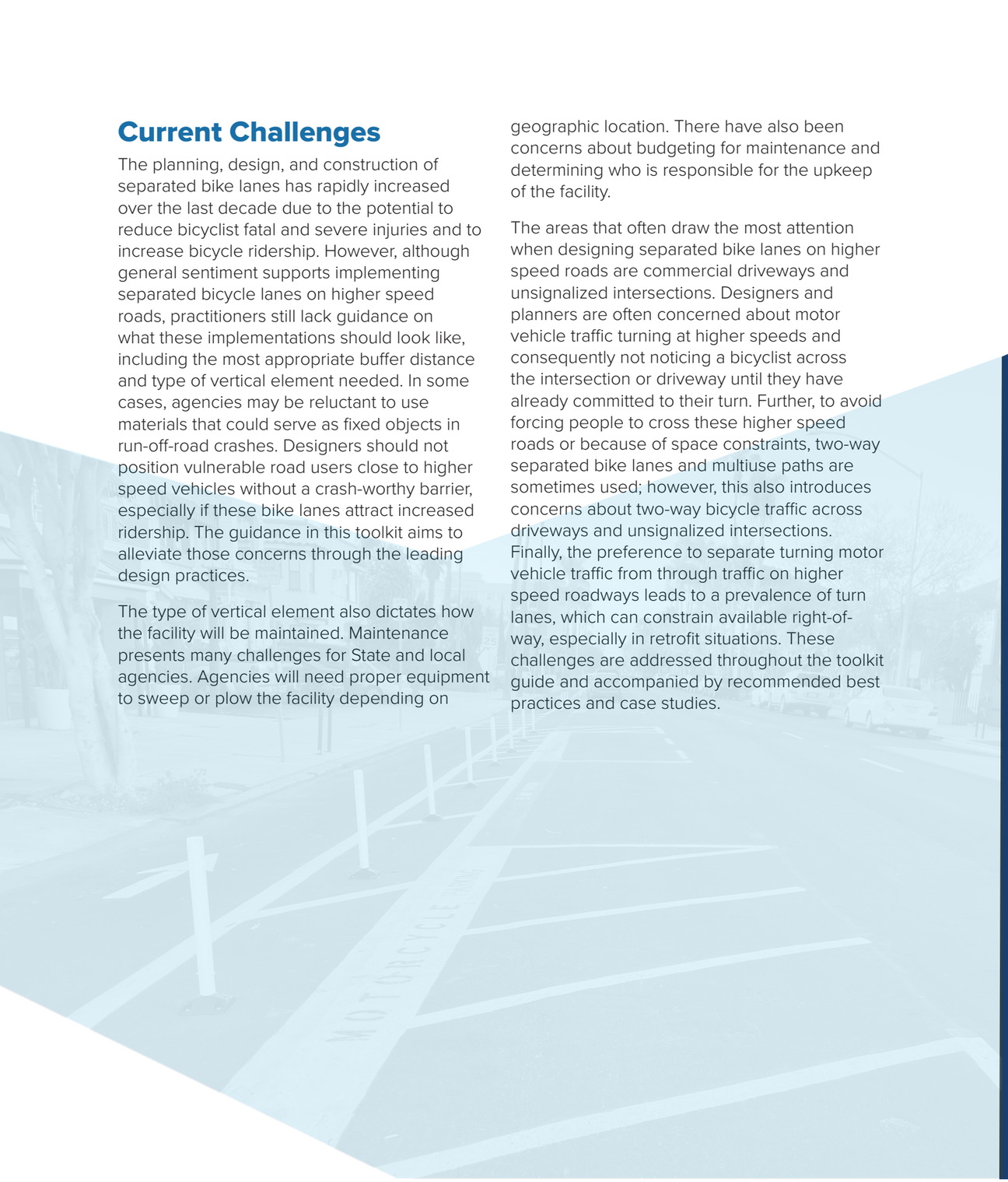
- District Department of Transportation Bicycle Facility Design Guide (2020)
- Portland Protected Bicycle Lane Planning and Design Guide (2021)
- Austin 2014 Bicycle Plan (2014)
- Valley Transportation Authority Bicycle Technical Guidelines (2022)
- Fresno-Clovis Class IV Bikeway Design Guide (2017)
- Austin Transportation Criteria Manual (2022)

Current Challenges

The planning, design, and construction of separated bike lanes has rapidly increased over the last decade due to the potential to reduce bicyclist fatal and severe injuries and to increase bicycle ridership. However, although general sentiment supports implementing separated bicycle lanes on higher speed roads, practitioners still lack guidance on what these implementations should look like, including the most appropriate buffer distance and type of vertical element needed. In some cases, agencies may be reluctant to use materials that could serve as fixed objects in run-off-road crashes. Designers should not position vulnerable road users close to higher speed vehicles without a crash-worthy barrier, especially if these bike lanes attract increased ridership. The guidance in this toolkit aims to alleviate those concerns through the leading design practices.

The type of vertical element also dictates how the facility will be maintained. Maintenance presents many challenges for State and local agencies. Agencies will need proper equipment to sweep or plow the facility depending on geographic location. There have also been concerns about budgeting for maintenance and determining who is responsible for the upkeep of the facility.

The areas that often draw the most attention when designing separated bike lanes on higher speed roads are commercial driveways and unsignalized intersections. Designers and planners are often concerned about motor vehicle traffic turning at higher speeds and consequently not noticing a bicyclist across the intersection or driveway until they have already committed to their turn. Further, to avoid forcing people to cross these higher speed roads or because of space constraints, two-way separated bike lanes and multiuse paths are sometimes used; however, this also introduces concerns about two-way bicycle traffic across driveways and unsignalized intersections. Finally, the preference to separate turning motor vehicle traffic from through traffic on higher speed roadways leads to a prevalence of turn lanes, which can constrain available right-of-way, especially in retrofit situations. These challenges are addressed throughout the toolkit guide and accompanied by recommended best practices and case studies.



Source: Kittelson & Associates, Inc.

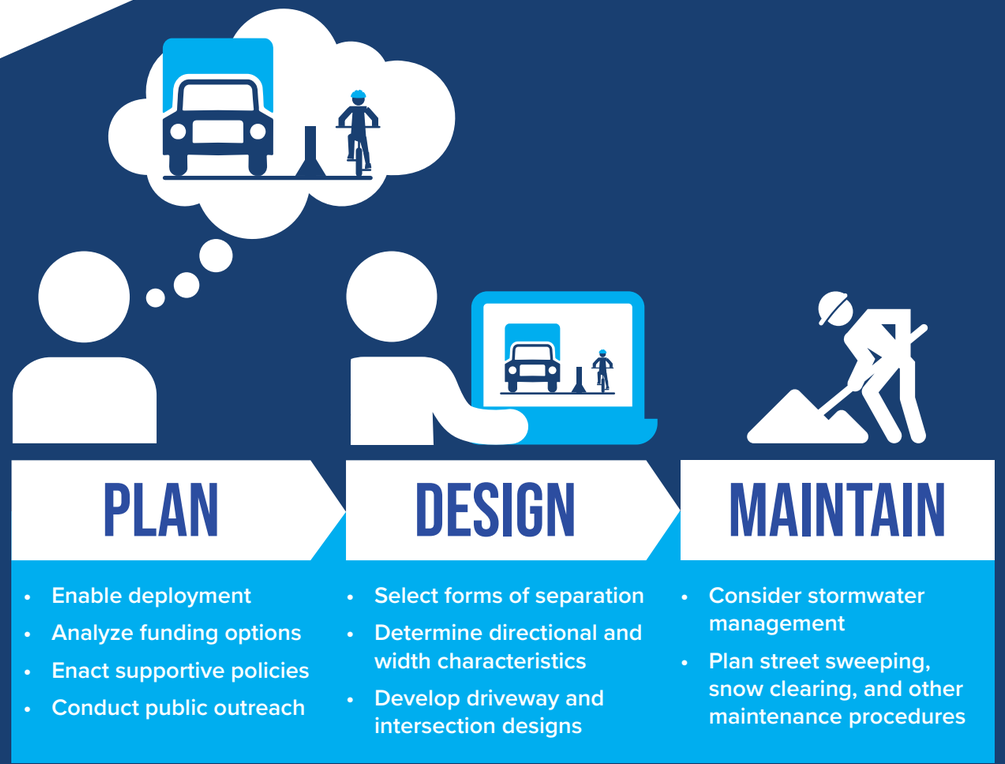


FIGURE 1. DECISION-MAKING PROCESS FOR SEPARATED BIKE LANES ON HIGH-SPEED ROADS

STRUCTURE OF THE GUIDE

The flowchart above walks users through the design decision-making process. The flowchart below points users to the appropriate section for each step of the process along with key questions for the user to consider. Please note this guide focuses on the planning process—planning, designing, and maintaining separated bike lanes on higher speed roads. Other steps, including construction and evaluation of treatments to review impacts and adjust facilities and policies, are outside the scope of this guide.

Source: Mapillary, user: carlheinz

Key Questions

- What are the existing conditions?
  - What is the roadway type and context?
  - Which types of users are currently using the roadway?
  - Who are the potential users (e.g., connections to key destinations or completing missing network links)?
  - What crash patterns or crash risk factors are present?
  - Is there a safety problem?
  - Are there connections to nearby bicycle networks?
- What are the funding options?
- Do local policies address treatments on higher speed roadways?
- Is there local support?

Source: Seattle Department of Transportation

4. PLANNING SEPARATED BIKE LANES ON HIGHER SPEED ROADS

Project Justification

Before deploying a bicycle facility on a higher speed road, practitioners must first make several considerations in the planning phase. The FHWA Bikeway Selection Guide advises planners to propose separated bike lanes on all higher speed roads in order to meet an all-ages-and-abilities goal; shared lanes or other bike facilities without separation are not appropriate. Exceptions to this approach are possible, such as when an alternate facility for bicyclists, such as a shared-use path, is present or planned to run parallel to the road.

Other considerations that will influence project viability include network effects, compatibility with other planned projects, supportive land-use context, and existing public support.

IDENTIFY SAFETY OR NETWORK NEED

The public may deem a separated bike lane as successful if it is heavily used by bicyclists. Bicyclists will be more likely to use a bicycle facility if: (1) it improves service by addressing high-stress areas within the existing (or planned) low-stress bicycling network; (2) it directly serves important destinations or will in the future; and/or (3) it provides a first- or last-mile connection to transit.

It may take time for ridership to acclimate to the new facility as well as the developing land use around it. Even with a separated bicycle lane, ridership on higher speed roads may remain lower than on similar roads with lower speeds depending on the separation type; in many cases, the noise and intersection interactions may still intimidate potential riders.

LEVERAGE PLANNED PROJECTS

In urban areas, planned road diets and other retrofits of higher speed roads are opportunities to add separated bike lanes. In contrast, the opportunity to add separated bike lanes may come from roadway reconstruction projects or frontage improvements that occur with development in exurban (edge of metropolitan area) or suburban areas. It is important that engineers and planners proactively review existing resurfacing and maintenance plans to see if locations identified through bicycle safety and network analyses align with planned maintenance projects. Additionally, reviewing planned developments or future land-use plans can aid successful implementation of a separated bike lane.

IDENTIFY SUPPORT

Planners should engage in comprehensive outreach to all possible stakeholders early in the project. Engaging with local stakeholders is critical to bring diverse viewpoints and inputs to the project and build trust between the public and local agencies to support the effort. Stakeholders may include, but are not limited to:

- Bicyclists
- Pedestrians, including people with disabilities
- Drivers
- Local property owners
- Advocacy groups and community organizations
- Policymakers
- Local, regional, and State government
- Operations and maintenance staff

Source: Kittelson & Associates, Inc.

Engagement is particularly important for underserved communities who may not have an established champion to advocate for improvements. Outreach should also include various venues available for engagement (online, in person), different days and times, and different communication mediums to reach the widest possible audience.

Specifically for higher speed locations, choosing a location that provides a key community connection or mitigates a known safety challenge is essential to gaining public support.

A lack of advocacy for bicycling may not mean there is no need for separated bike lanes. Low-income communities may not have the means or access to decision-makers needed to advocate for biking safety, and existing ridership in these communities may be systematically undercounted or disregarded. With generally lower access to vehicles, these very communities may represent the greatest need for bicycle accommodation. An equitable and inclusive approach to bikeway planning draws from data on travel behavior and land-use density to identify those areas with the greatest opportunity for bicycle trips and the greatest risk to people on bicycles.

Analyze Funding Options

Funding for separated bike lanes on higher speed roads can be acquired through Federal, State, and/or local contributions, as well as through private or nonprofit entities.

FEDERAL FUNDING

Municipalities have pursued funding through Federal programs such as the Congestion Mitigation and Air Quality Improvement Program, Surface Transportation Block Grant Program, and Rebuilding American Infrastructure with Sustainability and Equity (RAISE) grants. Other examples of Federal funding opportunities include:

- Highway Safety Improvement Program
- Railroad Highway Crossing Program
- National Highway Performance Program
- Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation Formula Program
- Transportation Alternatives Set-Aside
- Safe Routes to School activities eligible under the Surface Transportation Block Grant Program and Transportation Alternatives Set-Aside
- National Scenic Byways Program
- RAISE Discretionary Grants
- INFRA Grants Program
- Reconnecting Communities Pilot Program—Planning Grants and Capital Construction Grants
- Safe Streets and Roads for All Grant Program
- FTA Urbanized Formula Grants

FHWA maintains a comprehensive list of potential Federal funding sources for Pedestrian and Bicycle Funding Opportunities: see https://www.fhwa.dot.gov/environment/bicycle_pedestrian/funding/funding_opportunities.cfm.

LOCAL OR PRIVATE SECTOR FUNDING

Local funding options such as development impact fees or local sales tax ordinances can be used for separated bike lane development. Some cities, like Louisville, KY, leverage a 0.2 percent tax on local residents to help fund the Transit Authority of River City. Similar taxes could be established for bicycle and pedestrian infrastructure or expanded to allow funding to provide better connections to transit via improved bicycle infrastructure. Local businesses often have reason to advocate and even pay for separated bike lane investment; some municipalities are considering or have already received funding for separated bike lanes from local businesses, taxes from business improvement districts, or other private entities that consider investments in bicycle infrastructure to be economically beneficial.

Tax increment financing mechanisms or infrastructure impact fees may represent future collaborations between the public and private sectors that treat separated bicycle lanes like other investments in local transportation infrastructure. Health organizations and other nonprofits can also help fund separated bicycle lanes.

FHWA's Active Transportation Funding and Finance Toolkit highlights notable, innovative practices for expanding pedestrian and bicycle infrastructure. The toolkit can help local agencies understand the full range of funding and financing options available and build support for active transportation projects.

Enact Supportive Policies

Local policies can support separated bicycle lanes on higher speed roads by requiring separation where bicycle lanes are present. Separation between vehicular traffic and bicyclists is essential on higher speed roads for the safety of bicyclists. Policies that can support separated bicycle lanes on higher speed roads include:

VISION ZERO

Vision Zero is a widely adopted strategy to eliminate all traffic fatalities and severe injuries while increasing safe, healthy, and equitable mobility for all. Separated bicycle lanes support Vision Zero objectives by preventing and decreasing bicyclist fatal and serious injuries.

SAFE SYSTEMS APPROACH

The Safe Systems Approach aims to eliminate fatal and serious injuries for all road users. It does so through a holistic view of the road system that first anticipates human mistakes and second keeps impact energy on the human body at tolerable levels.

More information on Zero Deaths and Safe System Approach is available from USDOT here: https://highways.dot.gov/safety/zero-deaths

DESIGN GUIDELINES

The FHWA Bikeway Selection Guide is a resource to help transportation planners and engineers make informed decisions about the types of bikeways they select. Though the guide is a reference document and not a policy, it has informed many States' policies and guidance, including the Ohio DOT Multimodal Design Guide, the Oregon DOT Blueprint for Urban Design, and the MassDOT Separated Bike Lane Planning and Design Guide.

Some State DOTs have also implemented Complete Streets policies requiring separated bike lanes in higher speed or volume contexts.

- Washington State DOT passed Senate Bill 5974, the Move Ahead Washington package. It included a Complete Streets requirement, which requires State transportation projects starting design on or after July 1, 2022, and that are $500,000 or more to follow Complete Streets principles. This includes identifying areas that do not have separated bike lanes on a State route within a population center that has a posted speed of more than 30 mph.
- MassDOT's Complete Streets Funding Program provides technical assistance and construction funding to eligible municipalities. Eligible municipalities must pass a Complete Streets Policy and develop a Prioritization Plan. Program guidance states facilities for bicyclists must be appropriate for the land use, roadway classification, traffic speed, composition, and volume context.

Source: Kittelson & Associates, Inc.

SECTION 5: DESIGNING SEPARATED BIKE LANES ON HIGHER SPEED ROADS

Source: Kittelson & Associates, Inc.

This section presents tradeoffs and other key information needed to make design decisions about separated bike lanes on higher speed roads, including the form of separation, directional and width characteristics, and driveway and intersection designs.

Vertical Separation

This section describes the tradeoffs of different forms of vertical separation most appropriate for higher speed roads. 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, and they have the potential to reduce bicyclist fatal and severe injuries on higher speed roads.

Table 1 outlines several types of vertical elements generally recommended in the FHWA Separated Bike Lane Planning and Design Guide. The selection of vertical 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.

Source: Kittelson & Associates, Inc.

TABLE 1. FORMS OF SEPARATION ON HIGHER SPEED ROADS

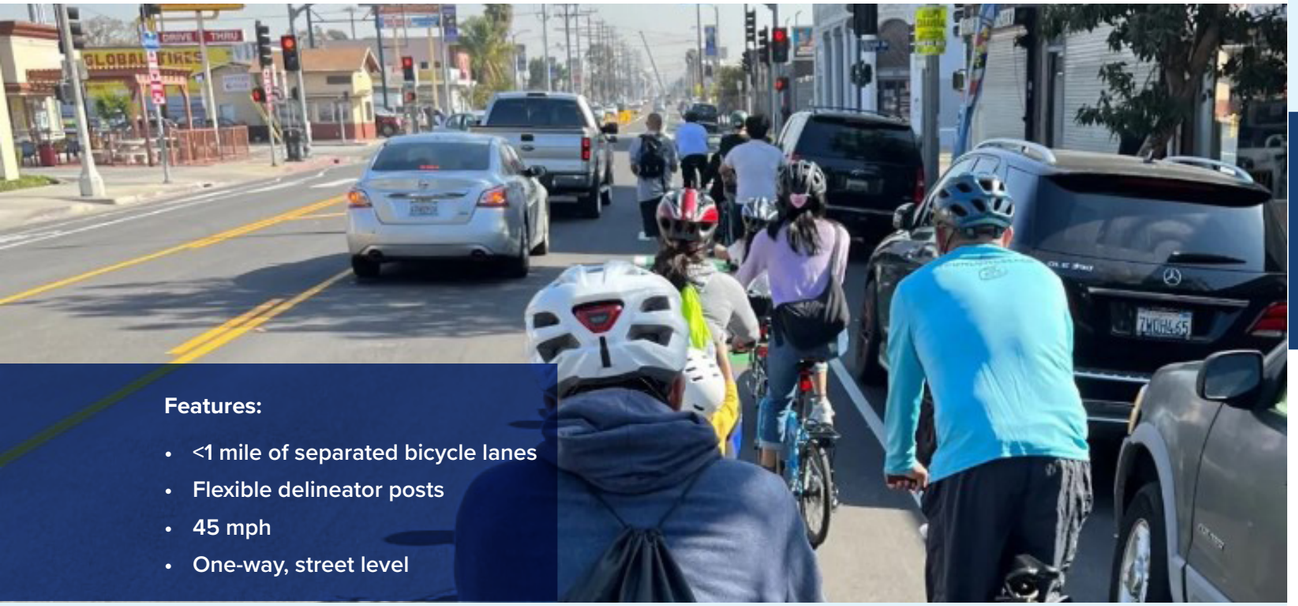
FORM OF SEPARATION	KEY THINGS TO KNOW
Delineator Posts  *Source: Virginia Department of Transportation (VDOT)*	• Common separators due to low cost, visibility, ease of installation • Modify driver behavior • Do not provide crash protection • Less durable than other separators • Consider converting these types of buffers to a more permanent style when design and budgets allow • May need to change barrier type as speed increases to increase bicyclist comfort
Parking Stops  *Source: National Transportation Safety Board*	• Inexpensive, low linear barrier • High level of durability • Provides near-continuous separation • Provides better barrier for safety and comfort than delineator posts
Parked Cars  *Source: Oregon Department of Transportation (ODOT)*	• Can provide an additional level of protection and comfort for bicyclists • Less common on higher speed roads • Additional vertical elements, such as delineator posts, should be paired with this design • Must provide an access aisle for accessible parking

FORM OF SEPARATION	KEY THINGS TO KNOW
Barriers  *Source: Public Domain*	• Provides highest level of crash protection among these separation types • Requires little maintenance • May require additional drainage and service vehicle solutions • Crash cushion should be installed where the barrier end is exposed
Raised Median/Curb  *Source: VDOT*	• More expensive to construct • Provides a continuous raised buffer that is attractive and requires little long-term maintenance
Raised Bike Lane  *Source: Kittelson & Associates, Inc.*	• Provides high level of comfort for bicyclists • More expensive to construct than on-street separated bike lanes • Different pavement types, markings, or buffers may be necessary to keep bicyclists and pedestrians separated at sidewalk level • 3” mountable curb may be used to permit access of sweeping equipment if placed at an intermediate level

VERTICAL SEPARATION FOR HIGHER SPEED ROADS

Combining separation types can achieve a more robust separation at a lower overall cost than a single separation type. For example, delineator posts can be alternated with parking stops or other low, linear barriers to provide both horizontal and vertical elements. Details on suggested spacing and width dimensions for separators can be found in Chapter 5 of the FHWA Separated Bike Lane Planning and Design Guide.

Some types of separation may be more appropriate for higher speed roads. Flexible delineators, raised curbs, and raised medians are all frequently used. Though effective as separators, parking stops and parked cars along higher speed roads are unusual and therefore used less frequently.



Features:

- <1 mile of separated bicycle lanes
- Flexible delineator posts
- 45 mph
- One-way, street level

Source: Joe Linton/Streetsblog

CASE STUDY: ANAHEIM STREET (LOS ANGELES, CA)

Anaheim Street is a principal arterial road located in Harbor City, a suburban neighborhood in southern Los Angeles. This corridor borders Ken Malloy Harbor Regional Park and provides access to several industrial complexes located south of the corridor. In 2019, bicycle lanes with painted buffers were added to both sides of Anaheim Street from I Street to near Vermont Avenue/Gaffey Street. Plastic flex posts were then added as vertical separation to complete the less than one mile of separated bicycle lanes in 2020. The adjacent roadway is 45 mph, with five lanes of vehicle traffic.

Vision Zero data is not available for this corridor. However, Anaheim Street directly east of this corridor was identified in the first set of 40 Priority Corridors in the 2017 Vision Zero Action Plan. LADOT has installed safety improvements on 2.2 miles of Anaheim Street (between Figueroa Street and Henry Ford Avenue), with opportunities to expand the City's dedicated bike network on Anaheim Street.

CASE STUDY: FRIARS ROAD (SAN DIEGO, CA)

Friars Road is a principal arterial road located in San Diego's Mission Valley, home to several shopping malls and big box stores that attract high volumes of people. Friars Road serves as a major east-west route for all modes of transportation, with bicycle lanes along its entire length and two miles of separated bicycle lane from Sea World Drive to west of Fashion Valley Drive. Friars Road contains interchanges that make bicycle crossings difficult at Mission Center Road, Qualcomm Way, and Mission Village Drive. These interchanges do not intersect with the separated bicycle lane on Friars Road, but the high vehicle volumes and five vehicle travel lanes result in high vehicle speeds along all of Friars Road. The two-way separated bike lane has a raised curb to separate bicyclists from vehicles traveling at 45 to 55 mph.

The two miles of separated lanes were completed in 2013, though safety and congestion concerns remain. Vision Zero data reports four severe injury and fatal crashes along the two-mile corridor, including one bicyclist-vehicle crash (severe injury), from 2014 to 2021. New mixed-use developments promise additional multimodal improvements, including improved bicycle connections to Friars Road.

Features:

- 2 miles of separated bicycle lanes
- Raised curb
- 45-55 mph
- Two-way, street level

Table 2 is a summary matrix of the pros and cons for the separation types recommended for higher speed roads. Separation types were compared by cost, perceived safety, durability, maintenance, traffic compatibility, aesthetics, construction impacts, and required width. The evaluation of the different separation types is based on guidance found in the FHWA Separated Bike Lane Planning and Design Guide and practitioner perception.

COST

The cost of separated bicycle lanes can vary significantly depending on the separation type. One estimate provides a range of $50,000–$500,000 per mile for facilities in Austin, TX, but the range may be even wider in other locations.[29] Flexible delineator posts and parking stops are less expensive and involve less labor compared to raised medians or grade separation. While affordable materials can reduce upfront installation costs, they may carry lower perceptions of safety and durability.

PERCEIVED SAFETY

Almost all users feel safer with separation. Findings suggest that even painted buffers offer some level of increased comfort. Buffers with vertical separation, even as minimal as flexible delineator posts, yield significant increases in perceived comfort for bicyclists and potential bicyclists with safety concerns.[30] On higher speed roads, cyclists may feel safer separated from vehicle traffic by permanent buildouts with rigid elements such as bollards, a raised curb, or median, but these could increase the severity of potential vehicle crashes.

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

30. McNeil, N., Monsere, C. M., & Dill, J. (2015). Influence of bike lane buffer types on perceived comfort and safety of bicyclists and potential bicyclists. Transportation research record, 2520(1), 132-142.

DURABILITY

Though affordable materials can reduce the upfront cost of the installation, their separators may not be as durable and may require frequent maintenance and replacements. Parking stops are an exception. Parking stops and similar low, linear barriers are inexpensive buffer solutions that have a high level of durability and are a good solution when minimal buffer width is available.

MAINTENANCE

Regular maintenance of separated bike lanes on higher speed roads is critical for bicyclists' safety and for the utility of the bicycle lane. Compared to separated bicycle lanes on slower urban streets, bicyclists on higher speed roadways are likely to be even less able or willing to exit the bicycle lane into vehicle lanes to avoid any debris, roadkill, poor maintenance conditions, or lane closure. The ease of regular sweeping, plowing (if applicable), and general maintenance is more dependent on the width of the facility than the type of separation. Depending on the width of the facility, maintaining agencies may need to purchase specific equipment to sweep or plow the facility. Any closures of bike lanes should also be proactively communicated to travelers with clear temporary traffic control plans to provide a safe detour route. More details about addressing maintenance concerns are available in the section "Maintaining Separated Bike Lanes on Higher Speed Roads."

STORMWATER MANAGEMENT

It is important to consider the impacts to the stormwater system when selecting a separation type, particularly on higher speed roads where ponding may create a safety risk to drivers in adjacent lanes. Flexible delineator posts and parked cars do not obstruct the movement of water and do not require changes to the existing stormwater system. Other separation types, like, barriers, medians, and parking stops, may impact drainage and should be spaced to allow stormwater to flow as needed. Raised separated bicycle lanes have the greatest impact on the stormwater system and may require the street and stormwater system to be reconstructed when they are installed in the lane previously used by vehicles.

RUN-OFF-ROAD CRASH CONCERNS

Generally, rigid-point objects (like concrete bollards) may be perceived as safer by bicyclists but may not be compatible adjacent to higher speed vehicles because they increase the severity of fixed-object crashes. Flexible delineator posts, raised median/curb, and raised lanes do not pose any concerns to higher speed vehicle traffic.

AESTHETICS

Most separation types appropriate for higher speed roads are neutral in aesthetic. Delineator posts are damaged easily and can become ragged in appearance, which negatively changes the overall aesthetic of the roadway. Aesthetics, though a consideration, are not as crucial as other factors.

CONSTRUCTION NEEDS AND IMPACTS

Several separation types can be installed quickly and unobtrusively. In general, resurfacing projects are excellent opportunities to efficiently install separated bicycle lanes. Separation types like flexible delineator posts and parking stops can be installed with minimal additional effort. Other separation types, such as barriers and raised medians/curbs, must be poured in place and/or doweled into the road. Raised lanes likely require full roadway reconstruction. On some new construction projects, raised lanes can be installed behind the curb. Higher speed roads may have wider right-of-way and more space to install separated bike lanes behind the curb.

WIDTH REQUIRED

The separation type may be constrained by available width. Raised curb, raised lanes, and parking stops are low-profile solutions that require separation widths of approximately 2 feet or less. Flexible delineator posts, bollards, and concrete barriers are compact separation types and require approximately 3 feet for installation. A bicycle lane separated by parked cars may only be appropriate when on-street parking already exists, because a parking lane requires an additional 7 to 8 feet and will not work for spatially constrained roads. If space allows, larger buffers or horizontal separation should be considered. Greater horizontal separation in conjunction with vertical separation elements provide the greatest comfort for bicyclists on higher speed roads.

STRATEGIES TO LOWER DESIGN SPEED

One of the most effective strategies to improve bicyclists' safety and the safety of all road users is to reduce vehicle speeds. Vehicle speeds can be reduced by narrowing the travel lanes and adding wider bicycling facilities, adding on-street parking to the inside of the separated bike lanes, and reducing the number of travel lanes. Reducing speeds helps to reduce crash severity, especially in crashes involving bicyclists or pedestrians. The reduction and elimination of serious and fatal injury crashes is the main priority of the Safe Systems Approach adopted by USDOT.

More information on the speed reduction strategies can be found in the FHWA Speed Management Toolkit, the FHWA Road Diet Informational Guide, and NCHRP Research Report 1036: Roadway Cross Section Reallocation.

VERTICAL SEPARATION BEST PRACTICES—KEY TAKEAWAYS

- Horizontal and vertical separation (vertical barriers) are essential on higher speed roads.
- Horizontal separation can be as important as vertical separation. Bicyclists feel more comfortable when further offset from vehicles.
- Separation types can be used in combination to realize the full benefits of several treatments at a lower overall cost.
- One of the most effective strategies to improve bicyclists' safety is to reduce vehicle speeds.

TABLE 2. FORMS OF SEPARATION MATERIALS

	Flexible Delineator Posts	Parking Stops	Parked Cars	Concrete Barriers	Raised Median/ Curb	Raised Lane
COST	●	●	◐	◐	◐	○
PERCEIVED SAFETY	○	◐	●	●	●	●
DURABILITY	○	◐	●	●	●	●
MAINTENANCE	Depends on width	Depends on width	Depends on width	Depends on width	Depends on width	Depends on width
STORMWATER MANAGEMENT	●	◐	●	◐	◐	○
RUN-OFF ROAD CRASH CONCERNS	●	◐	◐	◐	●	●
AESTHETICS	○	◐	◐	◐	◐	●
CONSTRUCTION IMPACTS	●	●	●	◐	◐	○
RECOMMENDED SEPARATION WIDTH[31]	3’	3’	7’–8’ with 3’ buffer	3’	1.33’	2’ buffer preferred

Pro ● Con ○ Mixed ◐

31. FHWA Separated Bike Lane Planning and Design Guide. https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/separated_bikelane_pdg/separatedbikelane_pdg.pdf

Source: Kittelson & Associates, Inc.

Design Guidance for Intersections and Driveways

Intersections are where most bicycle-vehicle collisions occur and where riders feel the most stress. On higher speed roads, designers should maintain separation on the bike facility for as long as possible through the intersection. Physical vertical barriers and signals can separate bicycles and vehicles in time and space. In general, designs should aim to reduce speeds of vehicles turning, increase visibility of people bicycling, and reduce potential vehicle-bicycle conflicts.[32]

The following resources have been compiled to assist local agencies in planning and designing separated bicycle lanes on higher speed roads at intersections and driveway crossings:

- FHWA Corridor Access Management
- FHWA Separated Bike Lane Planning and Design Guide
- FHWA Traffic Analysis and Intersection Considerations to Inform Bikeway Selection
- FHWA Improving Intersections for Pedestrians and Bicyclists
- NACTO Don’t Give Up at the Intersection
- MassDOT Separated Bike Lane Planning and Design Guide
- NCHRP Report 926: Guidance to Improve Pedestrian and Bicyclist Safety at Intersections

32. https://nacto.org/wp-content/uploads/2019/05/NACTO_Dont-Give-Up-at-the-Intersection.pdf

Source: Michael Sacuskie, City of Modesto.

ACCESS MANAGEMENT

Bicycle-vehicle conflicts can be minimized by improving access management. Driveways that intersect with separated bicycle lanes create a potential crash risk due to the conflict between turning motor vehicles and through-bicyclists. Access management strategies can reduce the burden on drivers on higher speed roadways who are looking for a gap in traffic while also crossing a separated bike lane and monitoring for bicyclists.[33]

State and local governments use access management techniques to control access to a roadway. FHWA provides guidance on controlling the design of roadway entry and exit points that cross a separated bicycle lane. Reducing driveway density has been shown to reduce crashes along two-lane rural roads by 5 to 23 percent and to reduce fatal and injury crashes along urban and suburban arterials by 25 to 31 percent.[34] Strategies include:

- Reduce driveway density through driveway closure and/or relocating or consolidating duplicative access points.
- Manage the spacing and alignment of access points to reduce conflicting movements.
- Use regulatory signage or medians to limit bicycles and vehicles to movements that minimize conflict, such as right-in/right-out only.

ONE-WAY VERSUS TWO-WAY SEPARATED BIKE LANES

Designers should carefully consider the pros and cons of implementing one-way versus two-way protected bicycle lanes on higher speed roads. The decision should be based on traffic lane configurations, turning movement conflicts, driveway density, and the surrounding context. Considerations include:

- Two-way separated bicycle lanes may provide more direct access to high-use locations without bicyclists having to cross a large, higher speed street.
- Two-way facilities may save a few feet of cross section if right-of-way is limited on the roadway.
- Two-way separated bicycle lanes can cause potential issues at driveways and intersections. Bicyclists approach these crossings from a direction that may not be as visible to drivers and pedestrians, who may not be anticipating contraflow bicycle traffic. One-way separated bike lanes are preferred from an intuition and driver expectation perspective in these situations.
- Two-way facilities may not be as comfortable for cyclists on higher speed roadways closest to vehicle lane, because they will be sandwiched between opposing bicycle traffic on one side and higher speed vehicles on the other. A more substantial vertical barrier may be needed for bicyclist comfort.
- Some of the risks associated with two-way facilities at crossings can be alleviated with separate signal phases or restricted vehicle movements out of driveways. (For example, right-turn only.)

33. https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/separated_bikelane_pdg/separatedbikelane_pdg.pdf

34. https://safety.fhwa.dot.gov/provencountermeasures/corridor_access_mgmt.cfm

CASE STUDY: JEFFERSON BOULEVARD VIADUCT (DALLAS, TX)

Jefferson Boulevard Viaduct is a minor arterial road that connects Oak Cliff, a suburban neighborhood, to downtown Dallas, TX. Previously a one-way road with four vehicle lanes, the road was reduced to three travel lanes with a two-way separated bike lane in 2014. The bicycle lane features flex posts that separate bicyclists from the three adjacent vehicle lanes (all marked 40 mph).

The separated lane addresses safety and connectivity issues. This corridor now provides bicycle access to downtown, where there was previously limited connection. The project was first designated as a demonstration/early implementation project in the 2011 Dallas Bike Plan and Bike Plan Addendum, which both emphasized connections across the Trinity River.

Additionally, this corridor includes segments on the bicycle, motorcycle, motor vehicle, and pedestrian High Injury Network. In 2012, a bicyclist was seriously injured on the Jefferson Boulevard Viaduct, which sparked Bike Friendly Oak Cliff to advocate for a separated facility. Recent media coverage has shown both vehicles parked and traveling in the bicycle lane. In response, Dallas implemented a possible fine to drivers who park in bike lanes in 2022.

Features:

- **1.5 miles of separated bicycle lanes**
- **Flexible delineator posts**
- **40 mph**
- **Two-way, street level**

Features:

- 1.5 miles of separated bicycle lanes
- Parking stops
- 45 mph
- Two-way, street level

Source: City of Modesto

CASE STUDY: NINTH STREET (MODESTO, CA)

Ninth Street is a minor arterial road featuring three higher speed vehicle lanes in suburban Modesto, CA. In 2015, City Council approved a two-way separated bicycle lane on Ninth Street and a road diet on neighboring College Avenue. This separated lane, completed in 2016, connected two campuses of Modesto Junior College to new bicycle lanes on Briggsmore Avenue and expanded the citywide bicycle network. Only one of the three motor vehicle lanes runs beside the separated bicycle lane, which uses flex posts and curb for separators. Although Modesto's Non-Motorized Transportation Plan did not initially call for separated bike lanes on Ninth Street, adding them aligned with plan goals, and Modesto has generally used resurfacing projects as opportunities to add bike lanes. Separated bike lanes in Modesto have been overwhelmingly popular, with more than 70 percent of public meeting participants in favor of the new designs. Local students have reported that using the separated bike lane is faster than commuting by vehicle between campuses.

CASE STUDY: SLAUGHTER LANE (AUSTIN, TX)

Slaughter Lane is a major arterial road located in suburban south Austin, TX. This corridor provides access to residences and businesses, as well as to commuters traveling through the area. In 2018, the City of Austin completed a Corridor Mobility Plan for the entire Slaughter Lane corridor, which spans 10 miles and includes 56 intersections. Since the beginning of 2019, Vision Zero data has reported 17 traffic crashes on the four-mile segment of Slaughter Lane between Cullen Lane and Brodie Lane, including six pedestrian or bicyclist-vehicle crashes (five serious injuries, one fatal). Three of the serious pedestrian-vehicle crashes have occurred between November 2022 and March 2023, with no bicycle-pedestrian crashes during this period. The corridor also includes segments on the bicycle, motorcycle, motor vehicle, and pedestrian High Injury Network.

Construction to bring separated bicycle lanes to the segment of Slaughter Lane between Cullen Lane and Brodie Lane was funded by the 2016 Mobility Bond and began in November 2021. Once completed, the one-way separated bicycle lanes on both sides of Slaughter Lane are expected to stretch nearly four miles. The adjacent roadway, located in suburban Austin south of downtown, is marked 45 mph with four to six lanes of vehicle traffic.

The new protected bicycle lane replaces a buffered bike lane (paint only) with a 5- to 6-inch raised curb.

Key Lesson Learned: Early in the installation process, media coverage and residents reported instances of blown vehicle tires on the curbs. The City revised its curb profile to add a smoother side profile and tapered front end that would reduce frontal impact on vehicle tires. The curb profile included a smoother side profile and tapered front end (for better front-impact outcome) and is 6 inches instead of the 5 inches used on lower speed streets due to corridor speed context. The City may also add thermoplastic paint to the ends of the bicycle curbs to increase visibility of the vertical barrier for drivers.

Features:

- 4 miles of separated bicycle lanes
- Curb-separated
- 45 mph
- 38,000 AADT (2021)
- One-way, street level

Source: Austin Corridor Program Office

VISIBILITY AT CROSSINGS

Crossings or places where vehicles will be crossing the bike lane can occur at a side street or driveway. In general, crossings on higher speed roads should be as short and infrequent as possible, and the vertical protection present should extend as long as possible. Where crossings are necessary, design choices should preserve the visibility of bicyclists. Designers can do this through the following:

- **Maintaining adequate sight distance:** It is important to maintain sight distances that allow drivers and bicyclists to safely see each other and react appropriately to any conflicting movements. Landscaping can reduce sight distance if not regularly maintained.[35] Although unlikely on higher speed roads, on-street parking can be limited near intersection conflict points to increase visibility of bicyclists. NACTO provides specific guidance on determining sight distances, which are longer with high vehicles speeds on higher speed roads. Bicyclists may also be traveling faster compared to urban streets and may need longer braking distances ahead of a crossing if a vehicle in front of them is turning across the bike lane.[36]
- **Communicating bicyclists' right of way:** Two-way bicycle lanes can also result in unexpected bicycle movements because drivers may not be aware of contraflow direction of travel. Planning should consider additional signage, clear road striping, or restricted vehicle movements (for example, no left turns) to clearly communicate the presence and right-of-way of bicyclists to drivers. Street lighting should also be included at crossings so bicyclists and signage are visible even at night.
- **Delineating the bicycle lane through intersections:** At crossings, planners should continue the delineation of the bicycle path through the intersection. It is preferable to place the paint markings on the outside of the bicycle lane width to maintain the clear width of the bike lane through the intersection.[37] Planners may also consider adding green paint to further increase visibility of the bicycle lane from the surrounding roadway or where there are high numbers of vehicles turning across the lane at higher speeds.

35. https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/separated_bikelane_pdg/separatedbikelane_pdg.pdf

36. https://nacto.org/wp-content/uploads/2019/05/NACTO_Dont-Give-Up-at-the-Intersection.pdf

37. https://www.mass.gov/lists/separated-bike-lane-planning-design-guide

CASE STUDY: AIRPORT WAY (RENTON, WA)

Airport Way is a principal arterial road located in suburban Renton, WA. This corridor provides access to Boeing, a large area employer. More broadly, Airport Way is part of the Lake Washington Loop trail, a popular recreational and commuter route. Phase 3 of the Lake Washington Loop Trail Project extended the junction of Logan Avenue North and the Cedar River Trail along Airport Way to the intersection of Rainier Avenue. Airport Way was proposed as a shared-use path in the 2019 City of Renton Trails and Bicycle Master Plan but was then changed to a separated bike lane.

The two-way separated bike lane is 0.5 miles long and 12 feet wide. Bicyclists are separated from five lanes of vehicle traffic marked 35 mph by flex posts with plastic curb stops. Construction began in May 2021 and was completed in May 2022. Community members were interested in this project due to the essential connection Airport Way provides to nearby trails.

Features:

- 0.5 miles of separated bicycle lanes
- Flexible delineator posts and plastic curb stops
- 35 mph
- Two-way, street level

Source: Joe Linton/Streetsblog

CASE STUDY: VALLEY BOULEVARD (POMONA, CA)

The two-way separated bicycle lane on Valley Boulevard is the first protected bicycle facility in Pomona, CA. It extends 1.5 miles from Humane Way to Temple Avenue and provides safe connections between west Pomona neighborhoods and many educational facilities, including Cal Poly Pomona. The addition of the separated bicycle lane was part of Pomona's larger resurfacing effort to add nearly 10 miles of bicycle lanes on four additional streets in Pomona. This effort was funded by an active transportation grant from Metro and a combination of State sales and gas taxes. Key project partners included Cal Poly Pomona, the Pomona Unified School District, and International Polytechnic High School. A majority (1.35 miles) of the 1.5-mile stretch includes a mostly continuous raised curb, a treatment selected because there are few driveways along the southern side of Valley Boulevard. The gaps are located at the few driveways and transit stop bus islands.

MIXING ZONES AND DECELERATION LANES

A mixing zone is an area where, upon approaching an intersection, bicyclists and right-turning motor vehicles merge into one travel lane. Mixing zones are not recommended on higher speed roads, as fast-moving vehicles could enter the mixing zone with no protection for bicyclists. If unavoidable, it is recommended to provide an extended deceleration lane for vehicles ahead of the mixing zone with the bicycle lane.

A protected intersection design is a better solution for higher speed roads. NCHRP Research Report 926: Guidance to Improve Pedestrian and Bicyclist Safety at Intersections found that protected intersections slow speeds of vehicles and bicycles, giving users more time to identify potential conflicts. Protected intersections improve safety for both bicyclists and people walking, with shorter crossings and better visibility between drivers, bicyclists, and pedestrians. However, there may also be concerns of people with vision disabilities detecting when they are crossing a bike lane or when a bicyclist may be approaching. Planners should consider accessibility features to improve comfort and safety for all users.

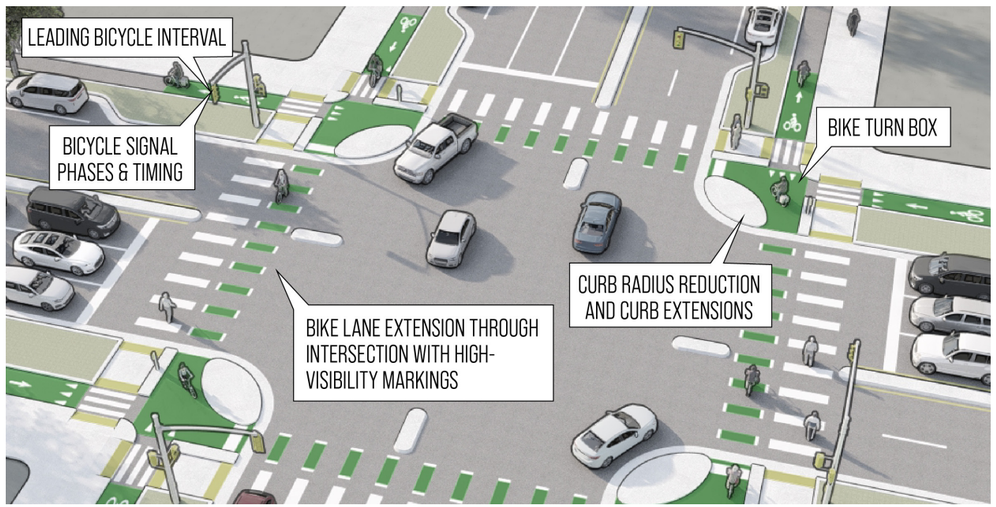
This design continues physical separation up to and through the intersection, eliminating vehicle-bicycle conflict in the merging and mixing zone designs. The continued separation reduces potential conflicts to the single location where turning traffic crosses the bicycle lane. This single conflict point can be eliminated by providing a separate signal phase for turning traffic. Alternatively, planners can implement a setback bicycle crossing (see next section), additional signage, a reduced turning radius, and/or another tool to slow turning traffic.[38]

Removing the separated bike lane through the intersection will change the bike facility to one that fewer people feel comfortable using. If there is not space at an intersection for a separated bike lane, planners can consider adding a shared use path to get cyclists through the intersection.

Figure 2 shows the critical elements of a protected intersection.

38. https://www.mass.gov/lists/separated-bike-lane-planning-design-guide

FIGURE 2. ELEMENTS OF PROTECTED INTERSECTION



Source: Joe Linton/Streetsblog

CASE STUDY: RESEDA BOULEVARD (LOS ANGELES, CA)

The Reseda Boulevard Complete Streets Project upgraded the existing bicycle lanes to separated bicycle lanes. These revised bicycle lanes extend 2.9 miles, from Victory Boulevard to Parthenia Street in Los Angeles, CA, closing a connection gap between Vanowen Street and Valerio Street. The Los Angeles Department of Public Works and the Transportation Department (LADOT) prioritized this project due to the history of traffic deaths and serious injuries: according to the City's project presentation, 110 people were killed or seriously injured between 2009 and 2019; nearly half of these were pedestrians and cyclists.

Construction began in 2020 and is expected to conclude in Spring 2023. The design features mixing zones between vehicles and bicyclists at intersections (Figure 3).

FIGURE 3. MIXING ZONE

Source: LADOT

SIGNALIZED INTERSECTIONS

Fully separate signal phases for bicycles and motor vehicles are the preferred option at intersections on higher speed roads. Separate signal phases provide a green phase for bicyclists and pedestrians and a red arrow for motor vehicles, followed by a red bicyclist and pedestrian phase and a green arrow for motor vehicles.[39] Bicycle signals can reduce stress for bicyclists and make it easier to cross an intersection by clarifying and eliminating potential conflicts with turning vehicles. Bicycle signals can be activated either actively (through bicyclists pushing a button) or passively (bicyclists are detected and do not have to push a button).[40] Bicycle signals can also have leading bicycle intervals to give people biking a head start at signalized intersections, further increasing their visibility in the intersection.

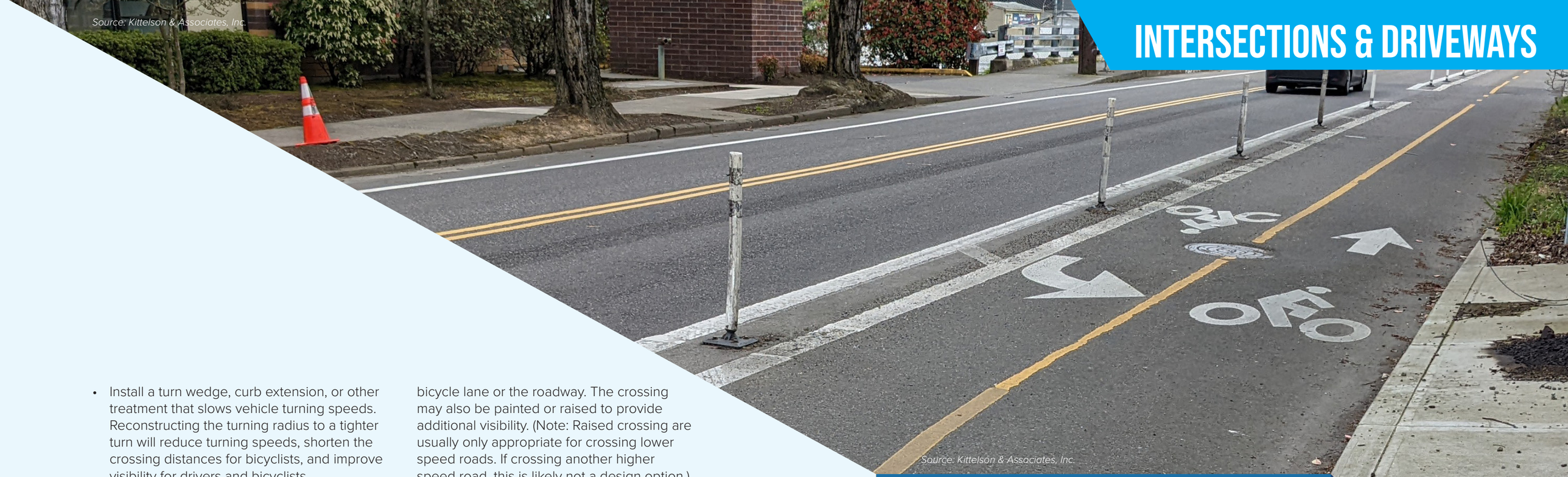
Unprotected left turns by drivers on higher speed roadways are potentially very dangerous for bicyclists in the intersection. Drivers making unprotected left turns are likely to be looking for gaps in oncoming higher speed traffic, then accelerating through the turn across the bicycle lane when they perceive a safe gap in motor vehicle traffic. Strategies to reduce potential conflict points between bicyclists and turning vehicles include the following:[41]

- Implement a separate signal phase for motor vehicles and bicyclists, with a protected left turn that does not have conflict with bicycles crossing.
- Restrict vehicle turning movements (for example, no turn on red).
- Install signs, such as "TURNING VEHICLES YIELD TO BICYCLES AND PEDESTRIANS."
- Increase the visibility of the bicycle lane with marking or green paint.

39. https://nacto.org/wp-content/uploads/2019/05/NACTO_Dont-Give-Up-at-the-Intersection.pdf

40. NCHRP 926

41. https://www.mass.gov/lists/separated-bike-lane-planning-design-guide

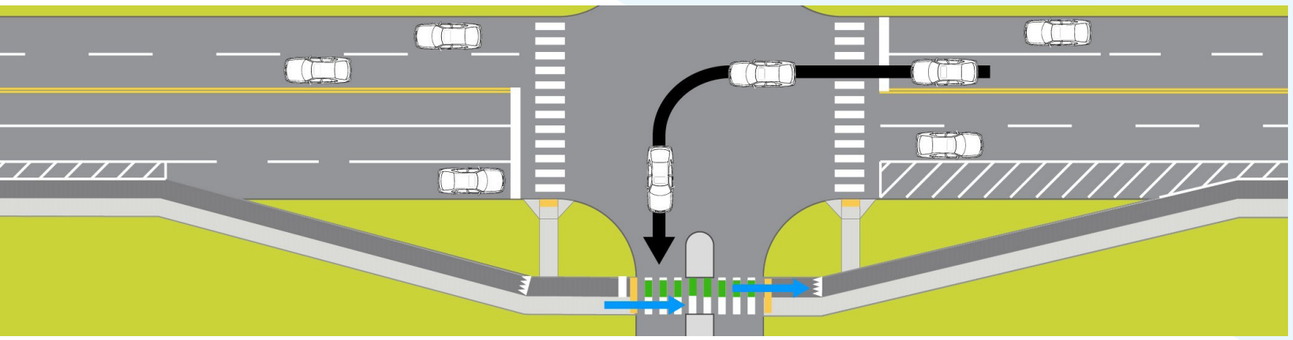


Source: Kittelson & Associates, Inc.

Source: Kittelson & Associates, Inc.

- Install a turn wedge, curb extension, or other treatment that slows vehicle turning speeds. Reconstructing the turning radius to a tighter turn will reduce turning speeds, shorten the crossing distances for bicyclists, and improve visibility for drivers and bicyclists.
- Implement leading bicycle intervals to provide bicyclists and pedestrians with a head start when crossing at a signalized intersection.
- Implement a recessed crossing (Figure 4) if fully separate bicyclist and vehicle signal phases are not possible. The setback of the crossing allows a vehicle to look for a gap in vehicle traffic before completing the turn, as well as additional space to yield to bicyclists in the bicycle lane that does not block the bicycle lane or the roadway. The crossing may also be painted or raised to provide additional visibility. (Note: Raised crossing are usually only appropriate for crossing lower speed roads. If crossing another higher speed road, this is likely not a design option.)
- Consider a bridge or underpass if crossing a higher speed roadway and a signalized crossing is not viable. (Note: This is an unlikely option due to cost and space requirements.)
- Avoid transitions from separated bicycle lanes to sharing a road on a higher speed road. Consider transitions for bicyclists to turn down a side street, move onto a widened sidewalk, or connect with a parallel shared-use path.

FIGURE 4. RECESSED CROSSING



Source: Adapted from Massachusetts Department of Transportation

INTERSECTIONS AND DRIVEWAYS BEST PRACTICES—KEY TAKEAWAYS

- Improve access management to minimize bicycle-vehicle conflicts.
- Crossings on higher speed roads should be as short and infrequent as possible, with vertical protection extended for as long as possible.
- Mixing zones are not recommended on higher speed roads due to fast-moving vehicles entering the mixing zone with no protection for bicyclists. If necessary, provide an extended deceleration lane for vehicles ahead of the mixing zone with the bicycle lane.
- Separate traffic signals should be considered for vehicles and bicycles. Left turns should be restricted or controlled with protected phasing to the extent possible.

Source: Mapillary, user: carlheinz

Source: Kittelson & Associates, Inc.

6. MAINTAINING SEPARATED BICYCLE LANES ON HIGHER SPEED ROADS

Regular maintenance of separated bicycle lanes on higher speed roads is critical for bicyclists' safety. Bicycle lanes accumulate debris, snow, water, and ice from the adjacent roadway, which can be dangerous for bicyclists. Compared to separated bike lanes on slower urban streets, bicyclists on higher speed roadways are likely to be even less able or willing to exit the bike lane into vehicle lanes to avoid any debris, roadkill, or poor maintenance condition.

It is important for local jurisdictions and States to plan and budget for operations and maintenance costs early in the planning process. Long-term, sustainable deployments need careful planning and commitments from a variety of stakeholders to sustain safe operations of a separated bicycle lane on a higher speed road. Special considerations include:

- managing stormwater
- asset management (including repairing and replacing vertical separators and road striping)
- street-sweeping requirements
- seasonal maintenance (including snow-clearing procedures)

This section provides the best practices for maintaining and operating separated bicycle lanes on higher speed roads. Please note many operations and maintenance challenges apply to other non-higher speed road contexts. In all road contexts, these challenges are generally solvable with proactive planning, coordination, and design and strategic selection of separation types. Chapter 4 of the FHWA Separated Bike Lane Design Guide provides additional guidance on separated bicycle lane operations and maintenance.

Stormwater Management

Incorporate stormwater management in a holistic design process. Major storm events are becoming more intense due to climate change, underscoring the importance of managing stormwater.[42]

Sustainable stormwater management can improve air and water quality, reduce the urban heat island effect, improve safety, reduce vehicle speeds, and provide a better experience for bicyclists.[43]

Improve safety of the separated bicycle lane with proper drainage. Stormwater management reduces ponding on the roadway and bicycle lane. Water must be properly drained from bicycle facilities during and after

42. https://www.washingtonpost.com/climate-environment/2022/10/11/rain-increasing-climate-change-us/

43. https://nacto.org/publication/urban-bikeway-design-guide/bicycle-boulevards/green-infrastructure/

precipitation events to avoid icy conditions or deterioration of pavement due to standing water. NACTO's Urban Street Stormwater Guide provides specific best practices and a variety of green stormwater infrastructure options. Larger, higher speed roadways have more impermeable surface area, causing more rapid runoff. Slow draining of this runoff can pose significant challenges, especially in flatter, flood-prone areas or areas with large amounts of impervious surfaces nearby.

Evaluate stormwater management in vertical separation design decisions. Planners may consider environmentally friendly options such as landscaped medians that can both absorb precipitation while also serving to physically separate bicyclists from vehicular traffic (Figure 5). For non-continuous vertical separation types, such as parking stops, planners should space the vertical separators far enough apart to allow stormwater to run off the road to the curb and not pond against the vertical separator or on the roadway. Alternative stormwater drainage may be needed for continuous vertical separators like jersey barriers, curbs, or raised lanes.

Consider alternative stormwater management treatments. Other green infrastructure considerations, which are typically more common in urban areas but may apply to some higher speed road contexts, include:

FIGURE 5. LANDSCAPED MEDIAN—MANHATTAN (NEW YORK CITY, NY)

Source: Gnarly (Wikis Take Manhattan 2009 participant), Wikimedia Commons, CC BY-SA 3.0

- **Bioswales** placed between vehicular traffic and the bicycle lane can use vegetation to absorb and slow stormwater runoff. Bioswales can improve the aesthetics of a roadway and lower traffic speeds on higher speed roads when used in curb extensions or medians.[44] Bioswale vegetation is also typically low in height to maintain visibility at intersections.
- **Permeable pavements** may be considered for new construction to allow stormwater to naturally absorb into the pavement, preventing ponding and the icy conditions of freeze/thaw cycles. However, permeable pavement has specific maintenance needs: regularly vacuuming any debris on the surface will ensure it can continue to function, and snowplows will need to be fitted with rubber plows to avoid damaging the surface. Moisture drains through the permeable surfaces, meaning there is less need for salting and brining of the surface. But salt or sand used on the adjacent higher speed roadway can land on the permeable pavement and cause damage, so they should be cleaned off the bicycle lane regularly.[45]

Asset Management

Keep an accurate inventory of equipment. Equipment on separated bicycle lanes on higher speed roads will need to be logged, monitored, inspected, and, if necessary, replaced on a regular basis. Agencies may be familiar with tracking, installing, or replacing the vertical separator devices they have already deployed on separated bicycle lanes in lower speed contexts. The challenge for separated bicycle lanes on higher speed roads is maintaining the inventory and keeping track of the various separation types as bicycle lanes are implemented in different contexts. Equipment may be different for different road contexts: for example, road 1 may use planter type A, while road 2 may use planter type B, while road C may forgo the planter entirely in favor of flexible delineators or curb stops.

Develop strategies to understand the unique maintenance needs of different separators. Maintenance needs vary by vertical separation type. Flexible delineators may need to be repaired or replaced more often, while planters or a median would require landscaping. Local agencies should consider the durability of the separation type and the safety of maintenance staff tasked with regularly repairing, replacing, or landscaping separation types on a higher speed road.

It may be easy for an agency to become accustomed to maintaining one type of bicycle lane and separator. One potential strategy to learn how to effectively maintain different separators is to introduce them incrementally. By introducing one or two devices at a time, this "crawl-walk-run" approach allows an agency to understand the different constraints and lifecycles of various equipment at a more deliberate, controlled speed.

Agencies could also consider piloting treatments in a quick-build approach to better understand a separator's maintenance needs. Quick-build projects let the communities try out adjustments to their roads before committing to them permanently. The fast and cheap installations provide bicyclists with immediate relief and local policymakers with flexibility, as they can test a treatment before fully committing to it. After the pilot, local governments can use public and agency feedback to decide whether to convert the quick builds into permanent fixtures or not.

44. https://nacto.org/publication/urban-bikeway-design-guide/bicycle-boulevards/green-infrastructure/
45. https://www.mass.gov/doc/chapter-7-maintenance/download

A quick-build, temporary bike lane. Source: Kittelson & Associates, Inc.

Leverage the public to improve response times to maintenance requests. Maintenance, repairs, and replacement of separated bicycle lane equipment on higher speed roads should be included upfront in the budget. Some agencies have used crowdsourcing mobile and web applications—many similar to a call-in 311 system—to gather information on maintenance needs from the public. Mobile application examples include State-developed apps (DelDOT, Utah DOT, YDOT) or 311 mobile applications for broader City functions, including road maintenance. Agencies will need enough dedicated maintenance staff to make timely responses to these needs. Agencies may also use these crowdsourcing applications to collect and track data on hotspots where equipment might be routinely damaged. Patterns of maintenance needs can indicate larger issues that necessitate other improvements or changes to the roadway design.

Communicate bicycle lane closures and provide safe detour. Any closure of the bicycle lane for maintenance should be proactively communicated to users. A safe alternative route should also be provided. On higher speed roads, it is particularly dangerous for cyclists to have to exit the bicycle lane into a vehicle lane to get around a construction zone. Temporary traffic control plans should have special considerations for separated bicycle lanes on higher speed roads for users maneuvering through a work zone.

FHWA's Guidelines for Work Zone Designers Pedestrian and Bicycle Accommodation (2018) provides guidance on planning safer work zones. Key principles include:

- **Accessibility:** Provide convenient access for everyone, including bicyclists, pedestrians, people with disabilities, and emergency responders.
- **Continuity:** Maintain a safe bicycle route through the entire corridor for the length of the construction project.
- **Economic feasibility:** Develop a temporary plan to accommodate bicycle lanes at a reasonable cost.
- **Separation:** Use physical vertical barriers to separate vehicle traffic from bicyclists. The anticipated speed of motor vehicle traffic in the work zone is usually the starting design consideration in choosing the appropriate Test Level barrier system for a project. Barrier systems are currently classified according to the Crash Test Level criteria in which they have been successfully crash-tested. For higher speed roads, Test Level 2 barriers are done at 43 mph using a 2,420-lbs car and a 5,000-lbs pickup truck.[46]

Street Sweeping

Incorporate bicycle lane sweeping into regular sweeping operations. Bicycle lanes should be regularly cleared of dirt, leaves, trash, and other debris. On separated bicycle lanes on higher speed roadways, debris may also collect in between the vertical separation elements and creep into the bicycle lane. Planners should coordinate with street-sweeping staff or contractors to ensure bicycle lanes are included in routine operations.

Consider sweeping requirements when designing the width of the bicycle lane. Smaller sweeping vehicles may be required to clean debris from tighter spaces created by separated bicycle lane installation. When designing a bike lane, the width of the separated bike lane (for example, a one-way versus a two-way lane) should balance the width requirements of the sweepers and the width requirements of the most practical treatment for the roadway context. Widths of 8 feet or more are generally compatible with smaller plows and sweepers, but narrower (4-5 feet) one-way bicycle lane designs likely require narrow sweepers.[47]

Where narrow sweepers are necessary, local agencies can consider partnering with stakeholders (such as municipalities, counties, States, developers, utility companies, or other institutions) to purchase them or meet other maintenance needs.[48] In urban areas, Business Improvement Districts can help pay for new equipment.

46. https://www.workzonesafety.org/files/documents/training/fhwa_wz_grant/uw_wz_designer_guidelines_pedestrian_bicycle_accommodation-508.pdf

47. https://www.mass.gov/doc/chapter-7-maintenance/download

48. https://www.mass.gov/doc/chapter-7-maintenance/download

Features:

- Flexible delineator posts
- 40 mph
- One-way both sides, street level

Source: Nashville Department of Transportation

CASE STUDY: ED TEMPLE BOULEVARD (NASHVILLE, TN)

In 2022, Nashville Department of Transportation purchased a new street sweeper designed to clean the City's narrower bicycle lanes. The Dulevo 850 EU6—Tier4 vehicle has a minimum sweeping width of 59.1 inches and maximum of 72.9 inches. To raise awareness of the new equipment and the bicycle lanes, Nashville DOT also held a public campaign to name the vehicle, allowing residents to vote on their favorites.

Seasonal Maintenance

Seasonal maintenance varies for different geographic regions. Maintenance activities might include vegetation trimming, debris and leaf clearing, and snow removal. Routine seasonal maintenance of bicycle lanes requires coordinated efforts between stakeholders, especially in anticipation of large weather events.

Identify and communicate maintenance roles and responsibilities. Local agencies should consider developing a clear maintenance plan during the planning process. Maintenance plans should identify stakeholders and responsible parties, standard operating procedures for different weather events, maintenance costs, and potential funding sources.[49] Local agencies should also conduct outreach to the public works department or contractors responsible for seasonal maintenance of roadways to prepare staff. Seasonal procedures may change with separated bicycle lanes: for example, whereas an unseparated bicycle lane may only require a single pass during snowplowing, a separated lane may require multiple passes with two different snow-clearing vehicles.

Consider purchasing new snow removal equipment. Depending on the vertical separation type, agencies may be able to remove separators during the winter to make room for larger plows. However, narrow (4 to 5 feet wide) lanes or lanes with bolted or immovable separators, like flexible delineator posts or curb stops, may require downsized snow removal equipment. The National Association of City Transportation Officials has compiled case studies of downsized street maintenance vehicles, including vehicle models, widths, applications, and capabilities.

Identify appropriate deicing applications. There are several materials that can be used to deice roads, though they can present complications for a bicycle lane. Applying road salt or gravel to roadways is not ideal, as these particles may be blown into the bicycle lane by higher speed traffic.[50] Liquid brine solutions may be more accurately applied to the roadways but can cause wear and tear on bikes.[51] It is important to regularly remove roadway debris, grit, dirt, and salt that accumulates on the roadway each season to maintain the facility. Planners should coordinate with public works department or snow removal contractor to revise deicing application procedures and maintenance frequency, as necessary.

Provide storage space for snow removal. Consider providing additional buffer space where possible. A larger buffer between the bicycle lane and the vehicle lanes can provide room for snowplows to operate and plow snow to the side without blocking the bike lane.

49. https://www.mass.gov/doc/chapter-7-maintenance/download
50. https://www.fhwa.dot.gov/reports/mopeap/eapcov.htm
51. https://altago.com/wp-content/uploads/winter-bike-riding-white-paper-alta.pdf

Features:

- 1 mile of separated bike lanes
- Flexible delineator posts
- 45 mph
- One-way both sides, street level

Source: Wikipedia

CASE STUDY: DUPONT PARKWAY (US-13) (SAINT GEORGE'S, DE)

/Dupont Parkway (US-13), also known as Saint Georges Bridge, is a minor arterial road in Saint Georges, DE. This corridor is the main connection between rural/suburban Delaware, Wilmington, and Philadelphia. In 2010, the bridge was closed for significant structural repairs, which included adding one mile of separated bicycle lanes and reducing the number of vehicle lanes from four to two. There is one travel lane and a bike lane in each direction. Bicyclists are separated from vehicles traveling 45 mph by a striped buffer and flex posts. This corridor was selected over other options to cross the Chesapeake and Delaware canal, because there was space to provide a separated facility.

Providing a canal crossing was a goal of the Delaware Bicycle Council and bicycling community for many years. There is a large bicycling community in the area that uses many nearby trails, such as the Michael N Castle Trail. The separated bike lanes on Dupont Parkway have been criticized for the pavement condition and heavy debris associated with winter weather. A Federal contract was awarded in 2022 to complete bridge deck replacement and other pavement repairs to Saint Georges Bridge.

Features:

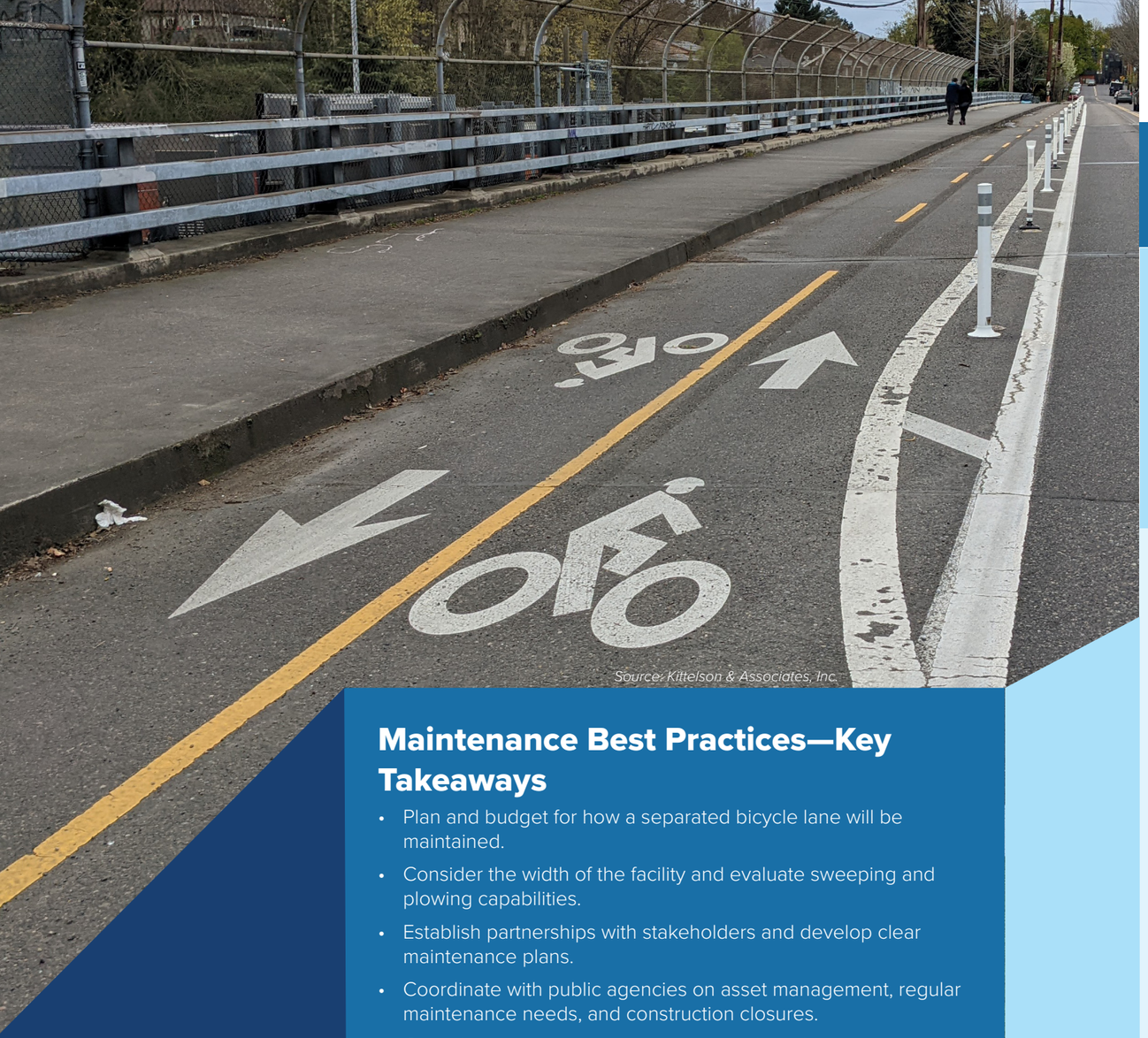
- 6 miles of protected bike lanes
- Flexible delineator posts
- 35 mph
- One-way both sides, street level

Source: Angie Schmitt/Streetsblog

CASE STUDY: E JEFFERSON AVENUE (DETROIT, MI)

E Jefferson Avenue is an arterial road that runs from downtown Detroit through its eastside suburbs. The corridor provides access to a variety of urban and suburban land uses, including apartments, strip malls, and future mixed-used developments. In the spring of 2018, as part of the Jefferson Avenue Transit-Oriented Development Plan, the City of Detroit initiated a road diet on the six-mile stretch of E Jefferson (from downtown to Grosse Pointe) in an effort to improve travel conditions for all users. The road diet converted three vehicle lanes with curbside parking in each direction to two vehicle lanes, a parking lane, and a curbside bicycle lane in each direction. The bicycle lanes are separated from vehicle traffic marked 35 mph by both parking and flex posts.

E Jefferson Avenue was the first facility to use vertical separation in Detroit. Previously, Detroit's network of bicycle lanes was mostly delineated by painted striping. The E Jefferson facility received initial criticism from both car and bicycle commuters. Car commuters expressed concern that the lane reduction would increase commute times into downtown, whereas bike commuters were dissatisfied with the pavement quality, drainage issues, and unprotected intersections along the corridor.



Source: Kittelson & Associates, Inc.

Maintenance Best Practices—Key Takeaways

- Plan and budget for how a separated bicycle lane will be maintained.
- Consider the width of the facility and evaluate sweeping and plowing capabilities.
- Establish partnerships with stakeholders and develop clear maintenance plans.
- Coordinate with public agencies on asset management, regular maintenance needs, and construction closures.
- Consider stormwater management needs in design process.

7. MOVING FORWARD

This toolkit guide builds on existing research and guidance provided in FHWA's Separated Bike Lane Planning and Design Guide to provide planning, design, and maintenance guidance specific to separated bicycle lanes in higher speed contexts. When planning a bike facility on a higher speed road, there must be separation provided between bicyclists and vehicles. Shared lanes or other bike facilities without separation should not be deployed on higher speed roads.

Key Considerations

- **What form of separation is needed on a higher speed road?**
  - Vertical separation is essential on higher speed roads.
  - Horizontal separation can be as important as vertical separation. Bicyclists feel more comfortable when further offset from vehicles.
  - Rigid barriers are better but need to be selected and designed appropriately for higher speed roadways.
  - Separation types can be used in combination to realize the full benefits of several treatments at a lower overall cost.
- **How can separated bike lanes on higher speed roads be maintained through driveways and intersections?**
  - Improve access management to minimize bicycle-vehicle conflicts.
  - Crossings on higher speed roads should be as short and infrequent as possible, with vertical protection extended for as long as possible.
  - Mixing zones are not recommended on higher speed roads, as they would force bicyclists and fast-moving motor vehicle traffic to share space. If necessary, it is recommended to provide an extended deceleration lane for motor vehicles ahead of the mixing zone.
  - Separate traffic signals should be considered for vehicles and bicycles. Left turns should be restricted or controlled with protected phasing to the extent possible.
- **How can agencies sustain safe separated bicycle lane operations on a higher speed road?**
  - Plan and budget for how a separated bike lane will be maintained.
  - Consider the width of the facility and evaluate sweeping and plowing capabilities.
  - Establish partnerships with stakeholders and develop clear maintenance plans.
  - Coordinate with public agencies on asset management, regular maintenance needs, and construction closures.
  - Consider stormwater management needs in the design process.

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