Technical Memorandum: Pattern Book

Date: 08/17/2021 (revised 01/27/2022; revised 03/10/2022, revised 05/10/2022, revised 5/27/2022; revised 06/27/2021)

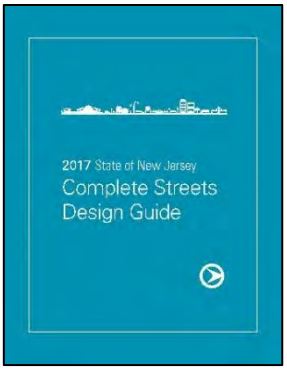
Contents:

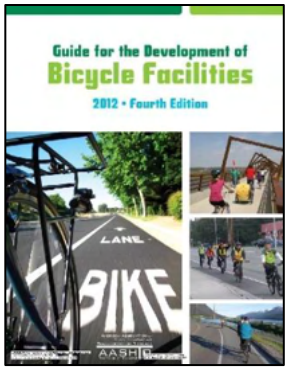
Introduction

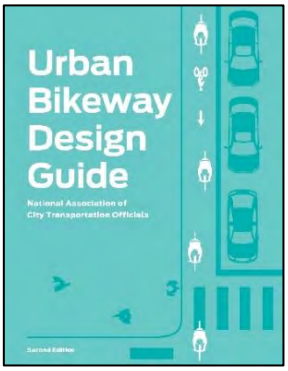
This Pattern Book has been developed as a component of the *BIKEPassaicCounty Plan* to provide general design guidance on several configurations for bicycle facilities that are planned in Passaic County, both on-road and off-road. For each bicycle facility type, the Pattern Book provides a definition, key points to describe the typical application of the facility, typical dimensions, and references to published design guides where additional details can be obtained. The Pattern Book also provides an Order-of-Magnitude Cost Estimate List for a range of bicycle facility configurations.

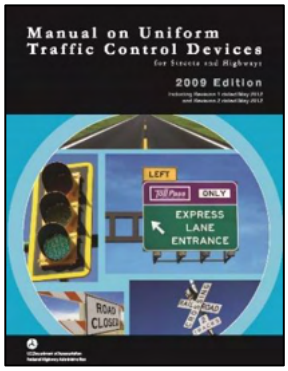
The purpose of this Pattern Book is threefold:

1. To inform the planning of a *BIKEPassaicCounty* Network by providing consistent criteria for facility selection relative to the variable conditions that exist throughout Passaic County,
2. To provide a visual illustration and common palette of planned bicycle facilities in order to enhance communication with municipalities, stakeholders, and the public, and
3. To inform context-sensitive concept plans for priority routes in the *BIKEPassaicCounty* Network.





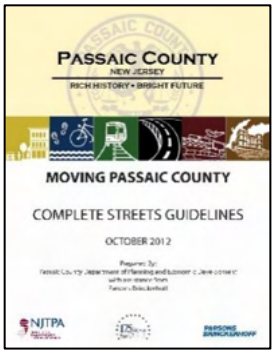


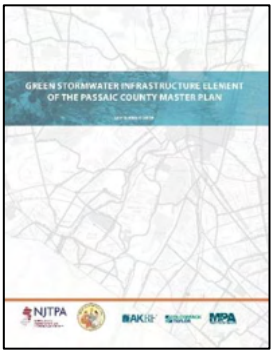


Much of the interest and growth in bicycle facilities and networks in New Jersey over the past 30 years is attributable to the information provided in continually evolving design guides published at the state and national levels. The design guidance presented in this Pattern Book is distilled from such resources including, the State of New Jersey Complete Streets Design Guide, the AASHTO Guide for the Development of Bicycle Facilities, the NACTO Urban Bikeway Design Guide, and the Manual on Uniform Traffic Control Devices (MUTCD). Additional resources are also referenced in this Pattern Book to provide sufficient detail where needed. Recommendations are subject to change as newly published design guidance from appropriate sources evolves over time.

This Pattern Book also serves as a companion to augment the design guidance provided in the Transportation Element (Appendix A: Complete Streets Guidelines) and the Green Stormwater Infrastructure Element (Appendix A2: Green Streets Guidelines) of the Passaic County Master Plan, completed in 2012 and 2018, respectively. As it relates to the Complete Streets Guidelines, this Pattern Book expands the definition of a bicycle lane from a standard four- to five-foot-wide striped area at the outside edge of the street, to include robust configurations (such as buffered or separated bike lanes) that can be more attractive to bicyclists of varying experience and confidence levels. It also provides guidance on shared use path and sidepath facilities, which are attractive to users of all ages and abilities and create value in terms of mobility, recreation, and public health for bicyclists, pedestrians, and other wheeled users. As it relates to the Green Streets Guidelines, this Pattern Book provides guidance on the spatial requirements of bicycle facilities, a vital consideration for balancing the green streets approach to ensure that the vehicle cartway, bicycle facilities, and stormwater management infrastructure are designed to function in concert.

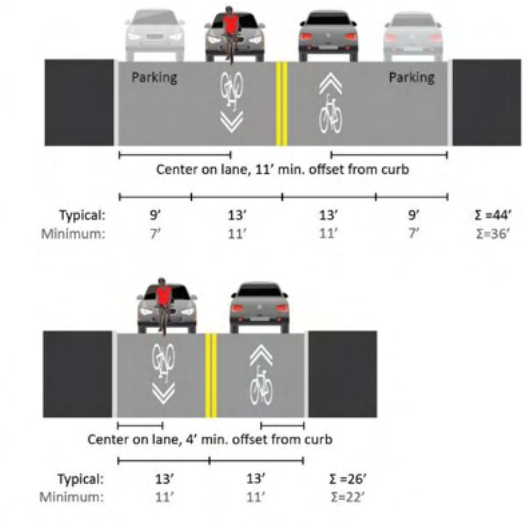
The level of detail provided in this Pattern Book is appropriate for bicycle facility network planning and conceptual planning of priority routes. Future implementation of planned bicycle facilities should include careful and deliberate engineering design to ensure the safety of all users and comply with any and all applicable codes, statutes, and evolving best practices. Intersections, crossings, bicycle parking, wayfinding, and curbside management (such as parking, transit stops, goods movement, and parklets) will be important considerations in future phases of bicycle route design once the *BIKEPassaicCounty* Network has been formalized.





Marked Shared Lanes

Marked shared lanes are streets with special pavement markings (known as shared lane markings or "sharrows") to indicate a shared roadway for motor vehicles and bicycles. Shared lane markings are not exclusive bicycle facilities, but help provide directional guidance to bicyclists, reinforce the legitimacy of bicyclists, and alert motorists to the potential presence of bicyclists.



Shared lane markings
Top: With on-street parking
Bottom: Without on-street parking

Application:

- Low-speed, low-traffic streets (usually single lane each direction with posted speed ≤25 MPH and volume <10,000 ADT)
- Guide bicyclists over short distances between other on-road or off-road bicycle facilities
- Guide bicyclists through intersections
- Not preferred for use over long distance
- Material should be high quality thermoplastic or polymer cement material, such as Endurablend
- Where used, should be placed immediately after an intersection and spaced at intervals of <250 feet thereafter
- Shared lane markings should be centered on the lane (at least 11 feet from the curb in the presence of on-street parallel parking, or at least 4 feet from the curb where these is not on-street parking)
- Green color backing of shared lane marking is experimental and requires application to the Federal Highway Administration (FHWA)

Planning & Design Resources:

- 2017 State of New Jersey Complete Streets Design Guide, Chapter 3, p. 98, NJDOT
- 2012 Guide for the Development of Bicycle Facilities, Chapter 4, p. 4-4, AASHTO
- 2011 Urban Bikeway Design Guide, p. 273, NACTO
- 2012 MUTCD, Section 9C.07

Example of bicyclists on road with shared lane markings in Princeton, NJ

Evolving Practice: Advisory Bicycle Lanes

For roads with a low traffic volume (<6,000 ADT) that are too narrow for conventional bicycle lanes, Advisory Bicycle Lanes are currently being evaluated as a potential solution. Advisory Bicycle Lanes "demarcate a preferred space for bicyclists and motorists to operate on narrow streets that would otherwise be shared lanes. Unlike dedicated bicycle lanes, motor vehicle use is not prohibited in the advisory bike lane and is expected on occasion." (AASHTO Research Roadmap, 2021). The treatment requires an application for experimentation and approval from FHWA to implement. As the research and guidance around Advisory Bicycle Lanes continues to develop, this type of facility may supplant the use of shared lane markings.

Example Advisory Bicycle Lane in Edina, MN (Source: FHWA, Small Town and Rural Multimodal Networks)

Additional Resources:

- 2016 Small Town and Rural Multimodal Networks, pp. 2-17 – 2-24, FHWA
- 2021 AASHTO Council on Active Transportation Research Roadmap Review, p. 74

Bicycle Boulevard

A bicycle boulevard (also known as a community greenway) is a street with low motor vehicle speed and volume that is further enhanced to prioritize bicycle travel and support interconnected bicycle mobility. The principal elements of a bicycle boulevard include direct/efficient routing and access to destinations, signage and pavement markings, traffic calming measures for speed and volume management, and crossing enhancements for bicyclist convenience and safety.

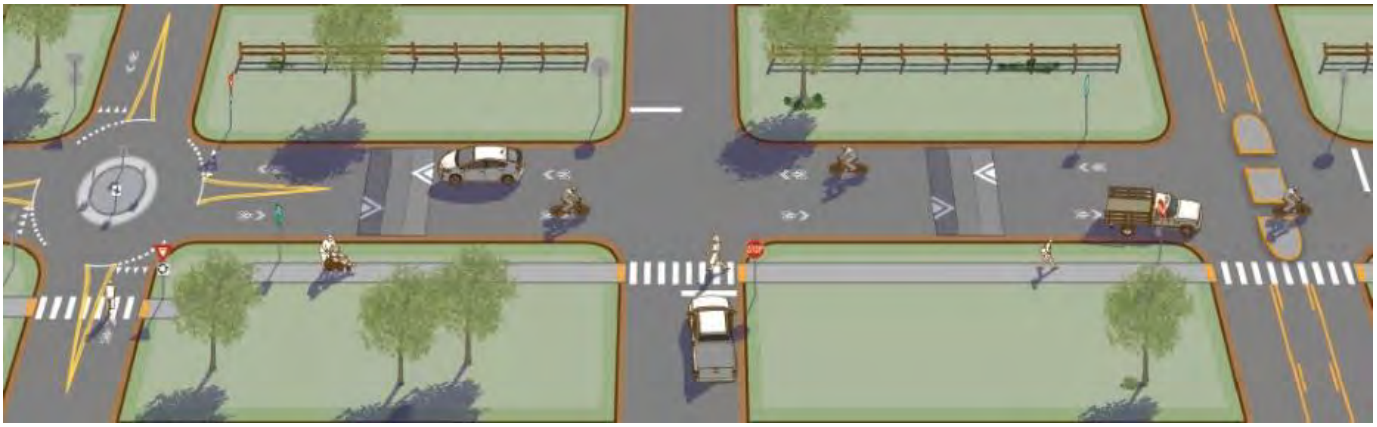
Application:

- Local streets with network connectivity and low motor vehicles speeds (≤25 MPH) and volumes (<2,500 ADT)
- Bicycle boulevards are linear corridors of interconnected, traffic-calmed streets where bicyclists are afforded an enhanced level of safety and comfort
- Include easy-to-follow route signage and pavement markings (shared lane makings) for bicyclists
- Traffic calming interventions are utilized to manage motor vehicle speed and volume, optimizing comfort for bicyclists, and may include facilities such as a chicane, mini roundabout, curb extension, refuge island, speed hump, raised crosswalk, raised intersection, full street closure, or partial street closure, based on local context

Example of a bicycle boulevard in Berkeley, CA that shows pavement markings and a chicane in the foreground, and a speed hump in the background. (Source: Flickr/Payton Chung)

Planning & Design Resources:

- 2017 State of New Jersey Complete Streets Design Guide, Chapter 3, p. 99, NJDOT
- 2012 Guide for the Development of Bicycle Facilities, Chapter 4, page 4-33, AASHTO
- Urban Bikeway Design Guide, Bicycle Boulevards website, NACTO
- 2016 Small Town and Rural Multimodal Networks, p. 2-9, FHWA



Example layout of a bicycle boulevard that shows a refuge island, speed humps, and a roundabout (Source: FHWA, Small Town and Rural Multimodal Networks)

Signed Bicycle Route

Signed bicycle routes are streets that include signage to support bicycling. Bicyclists may operate on all roadways, except where prohibited by statute or regulation. In certain parts of Passaic County, particularly the northwest portion of the county, physical contraints of topography and distance make the provision of dedicated bicycle facilities difficult. Yet, the scenic character of these streets is attractive to bicyclists, especially experienced and confident road bicyclists.

Along these types of routes, most without a designated space or markings for bicyclists, regulatory signage (to alert motorists of bicyclist presence) and wayfinding signage (to enhance bicylist navigation of routes) can be installed following MUTCD guidelines. In addition to signage, it is important to ensure that these routes have good pavement quality, sight distances, and bicycle-compatible drainage grates, bridge expansion joints, and railroad crossings. Consideration should also be made for bicyclist movement through traffic signals and intersections.

Application:

Signed bicycle routes may be considered where:

- Expanding shoulders on both sides of the road would require substantial expense, including regrading of topographic features and/or relocation of utility poles, light poles, drainage appurtenances, swales, etc.
- Streets are unable to accommodate other treatments due to constraints such as vehicle volumes and speeds (see table on page 6), distances between destinations, elevation change along the route, or the expense of shoulder widening.

Planning & Design Resources:

- 2012 Guide for the Development of Bicycle Facilities, Chapter 4, pp. 4-3, 4-34 - 4-37, AASHTO
- Manual on Uniform Traffic Control Devices (MUTCD): Part 9. Traffic Controls for Bicycle Facilities
  - Section 9B.02 Design of Bicycle Signs
  - Section 9B.20 Bicycle Guide Signs

Regulatory Sign R4-11 may be used on roadways where no bicycle lanes or adjacent shoulders usable by bicyclists are present and where travel lanes are too narrow for bicyclists and motor vehicles to operate side by side. (Source: MUTCD Section 9B.06)

Bicycle guide signs can be used to indicate destination, direction, and distance, helping bicyclists to navigate. (Source: MUTCD Figure 9B.4)

Bicycle Lanes on Two-Way Streets

Bicycle lanes are on-road facilities that designate an exclusive space for bicyclists to operate within the street. Bicycle lanes can be implemented in a range of configurations depending upon the context and characteristics of a given street, considering variables such as the street width, traffic speed, traffic volume, direction of travel, and presence of on-street parking. Bicycle lane configurations appropriate for two-way streets include standard bicycles lanes, buffered bicycle lanes, and separated bicycle lanes.

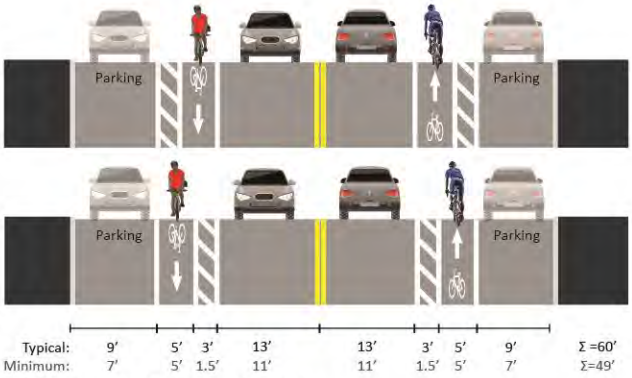
Application:

- The minimum width of a bicycle lane is 5 feet when the lane is adjacent to a vertical element, such as a vertical curb, or on-street parking.
- The minimum width of a bicycle lane may be reduced to 4 feet when there is no vertical curb or on-street parking.
- Selection of the appropriate bicycle facility for a given street should consider speed limit and traffic volume (as indicated in the Bicycle Facility Selection Table below) and street width to provide the most robust bicycle lane possible for the street.
- When placed next to a parking lane, the desirable distance from the curb face to the edge of the bicycle lane is 14.5 feet to keep bicycles out of the door zone.

Planning & Design Resources:

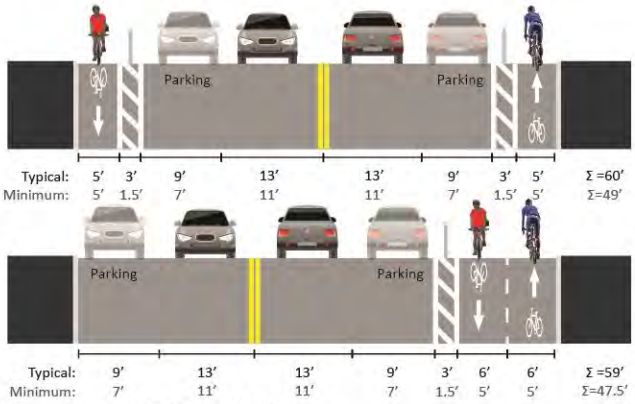
- 2017 State of New Jersey Complete Streets Design Guide, Chapter 3, pp. 91-96, 106-107, NJDOT
- 2012 Guide for the Development of Bicycle Facilities, Chapter 4, p. 4-12, AASHTO
- 2011, Urban Bikeway Design Guide, pp. 4-104 NACTO
- 2016 Small Town and Rural Multimodal Networks, FHWA

Standard Bicycle Lane



Buffered Bicycle Lane

Top: Buffer to parking. Bottom: Buffer to traffic.



Separated Bicycle Lane

Top: One-way. Bottom: Two-way cycle track.

Bicycle Facility Selection Table from 2017 State of New Jersey Complete Streets Design Guide, Chapter 3, p. 106, NJDOT

ADT	85TH PERCENTILE SPEED[1]						
	≤ 20	25	30	35	40	45	≥50
≤ 2,500	ABCDEF	A[2]BCDEF	CDEF	CDEF	CDEF	DEF	F
2,500–5,000	BCDEF	BCDEF	CDEF	CDEF	DEF	DEF	F
5,000–10,000	B[3]CDEF	B[3]CDEF	CDEF	DEF	DEF	EF	F
10,000–15,000	DEF	DEF	DEF	DEF	EF	EF	F
≥15,000	DEF	DEF	DEF	EF	EF	F	F

A: Shared Street/Bicycle Boulevard **B:** Shared-lane Markings **C:** Bicycle Lane **D:** Buffered Bicycle Lane
E: Separated Bicycle Lane **F:** Shared-use Path

[1] If data not available, use posted speed
[2] Bicycle boulevards are preferred at speeds ≤ 25 mph
[3] Shared-lane markings are not a preferred treatment with truck percentages greater than 10%

Bicycle Lanes on One-Way Streets

Bicycle lanes can be provided on one-way streets, following the same dimensional guidance as bicycle lanes on two-way streets. On one-way streets, the standard location for a bicycle lane is to the right of the motor vehicle lane. However, a left-side bicycle lane can be provided if there is a significant number of bicyclist left turns, or if such placement results in a decrease in conflict with parking, transit, deliveries, or other activities on the right side of the street.

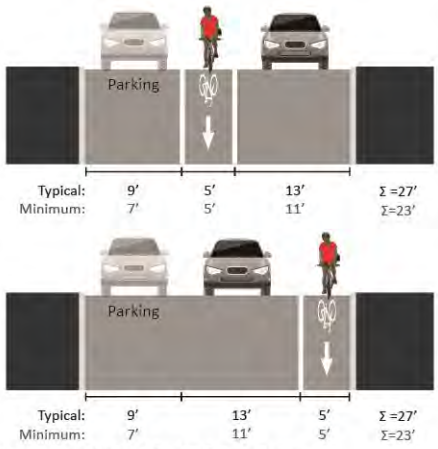
Because one-way streets offer only one direction of travel, bicycle lanes on one-way streets should be coupled with complementary bicycle facilities elsewhere in the network to provide bicycle mobility in the opposite direction.

Application:

- Typically considered for an urban context with grid network of streets
- One-way buffered or separated bicycle lanes may be considered for the left side, if space allows, however there is little published guidance on such a configuration.
- Refer to Bicycle Facility Selection table on page 5.
- Same dimensional guidance as bicycle lanes on two-way streets
- A standard bicycle lane and a contraflow bicycle lane may be coupled on a one-way street. Contraflow bicycle lanes require careful design for separation (centerline or median), signage, and intersection approaches. They are discouraged where parking or other curbside vehicular activities are present on the same side of the street.

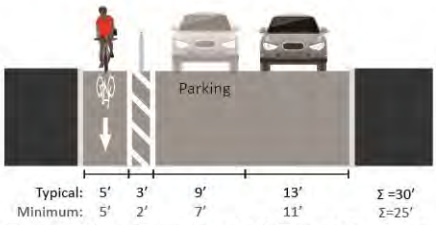
Planning & Design Resources:

- 2017 State of New Jersey Complete Streets Design Guide, Chapter 3, pp. 90-97, NJDOT
- 2012 Guide for the Development of Bicycle Facilities, Chapter 4, pp. 4-12 – 4-14, AASHTO
- Urban Bikeway Design Guide Bike Lanes and Left-Side Bike Lanes, pp. 31-57, NACTO

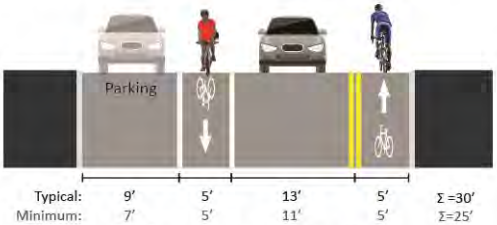


One-Way Bicycle Lane
Top: Right-side bicycle lane.
Bottom: Left-side bicycle lane.

One-Way Buffered Bicycle Lane



One-Way Separated Bicycle Lane



Standard Bicycle Lane and Contraflow Lane

Paired Hybrid Streets

Hybrid streets provide a bicycle lane in one direction with a shared lane in the opposite direction. (The shared lane may include shared lane markings). By pairing hybrid streets at the network level – i.e., ensururing that there are complementary bicycle facilities in close proximity to provide bicycle mobility in the opposite direction – this configuration can provide a dedicated bicycle facility (standard, buffered, or separated bike) on narrow streets that cannot support bicycle lanes in both directions, utilizing the redundancy of the urban grid network to support bicyclist mobility.

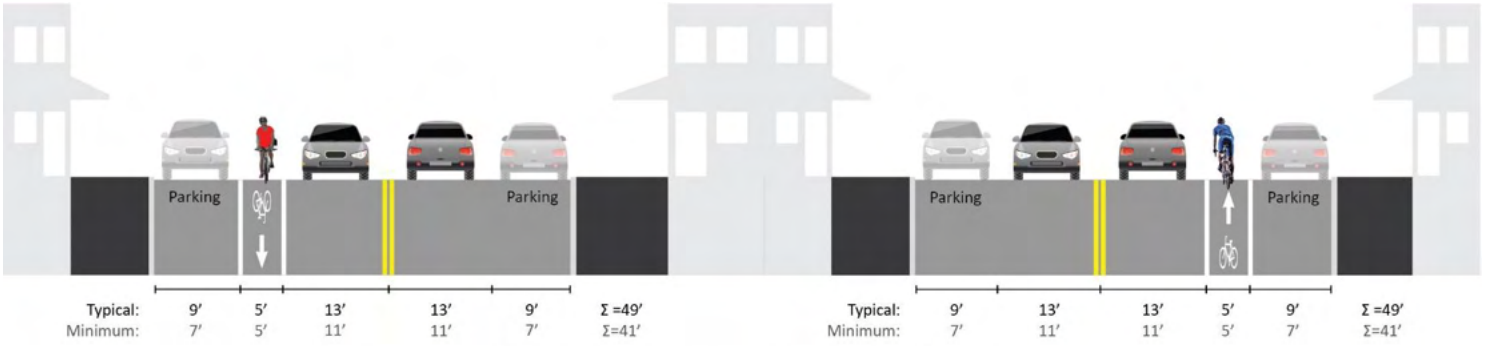
These hybrid designs can be useful in constrained street environments with narrow street width that limit opportunities for traditional bicycle accommodations and designs.

Application:

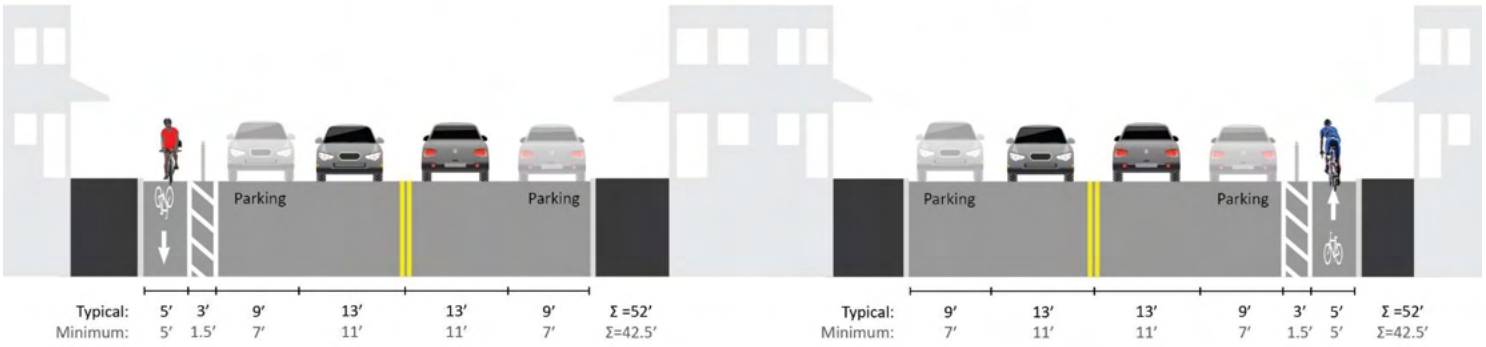
- Typically considered for an urban context with grid network of streets
- Should be coupled with complementary bicycle facilities elsewhere in the network that provide bicycle mobility in the opposite direction
- Can be applied to adjacent two-way or one-way streets
- Note that the AASHTO *Guide for the Development of Bicycle Facilities* (2012) cautions against a bicycle lane in one direction on a two-way street, citing the peril of wrong-way bicycling in the bicycle lane (p. 4-12).
- Signage and pavement markings should be provided to discourage wrong-way riding in the bicycle lane.
- Refer to Bicycle Facility Selection table on page 5.
- Same dimensional guidance as bicycle lanes on two-way streets
- When possible, on two-way streets, the bicycle lane should be oriented in the uphill direction (creating a climbing lane) and the shared lane should be marked in the downhill direction.

Planning & Design Resources:

- 2012 Guide for the Development of Bicycle Facilities, Chapter 4, p. 4-12, AASHTO



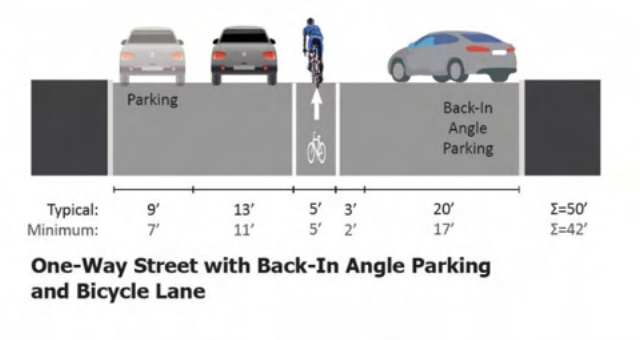
Two-Way Hybrid Street Pairing with with Standard Bicycle Lanes



Two-Way Hybrid Street Pairing with Separated Bicycle Lanes

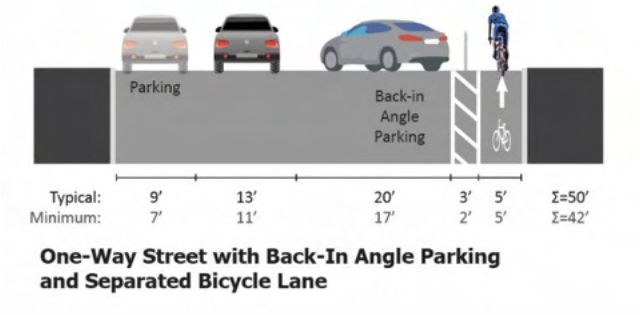
One-way Street with Bicycle Lane and Back-In Angle Parking

On one-way streets that are at least 42 feet wide, it is possible to include a bicycle lane and on-street angle parking. The preferred orientation of the angle parking is back-in (also called head-out) because it provides better visibility for a driver exiting a parking space to recognize oncoming vehicles or bicyclists, and also eliminates the risk of dooring bicyclists in travel. Like other one-way streets with bicycle lanes, this configuration should be coupled with complementary bicycle facilities elsewhere in the network to provide bicycle mobility in the opposite direction.



One-Way Street with Back-In Angle Parking and Bicycle Lane

John Muir Drive in San Francisco, CA.
(Source: SREETSBLOG SF)

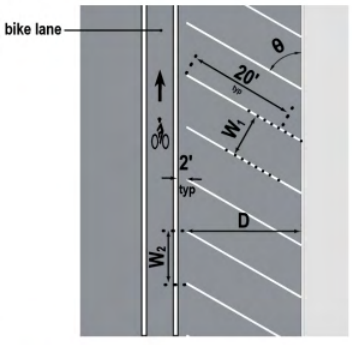


One-Way Street with Back-In Angle Parking and Separated Bicycle Lane

Skillman Avenue at 35th Street is Queens, NY.
(Source: Google Streetview)

Application:

- Typically considered for mix-used and commercial areas where parking turnover is high
- Same dimensional guidance as bicycle lanes on two-way streets
- On streets where it is possible to convert existing parallel parking to back-in angle parking, there is an opportunity to increase the parking capacity of the street. A typical parallel parking space requries 22 feet of curb length; meanwhile, a typical back-in angle parking space at 45 degrees requires 13 feet of curb length. Thus, as a rule of thumb, parking capacity can be increased by a factor of 1.7.
- Striping and plasitc bollards can be installed in the no-parking areas around intersections to ensure that sight triangles at intersections are maintained.



Back in Angle Parking			
θ (Degrees)	W_1 (feet)	W_2 (feet)	D (feet)
0°	7–10	20	7–10
30°	8–9	16–18	16.9–17.8
45°	8–9	11.3–12.7	19.8–20.5
60°	8–9	9.2–10.4	21.3–21.8

W_1 = stall width
W_2 = striping width
D = depth to face of curb
θ = angle

Typical angle parking dimensions from 2021 On-Street Motor Vehicle Parking and the Bikeway Selection Process, p. 4, FHWA

Planning & Design Resources:

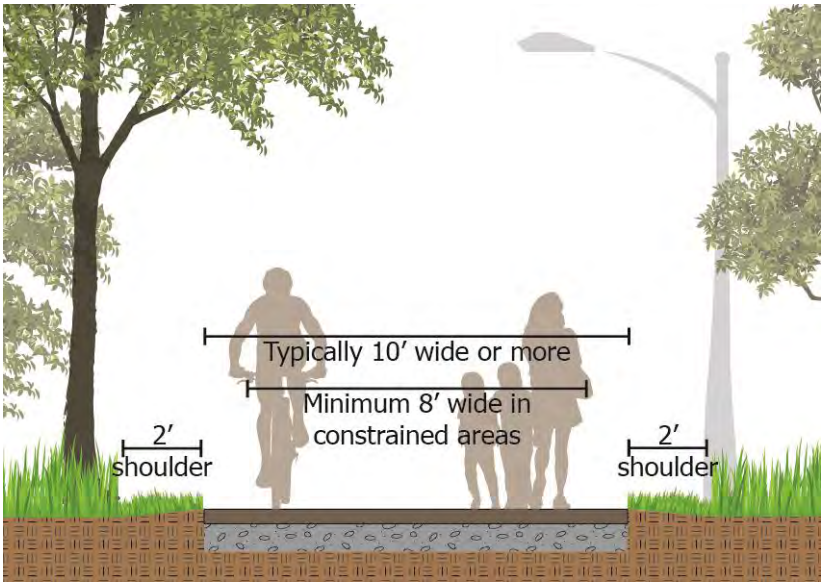
- 2021 On-Street Motor Vehicle Parking and the Bikeway Selection Process, FHWA

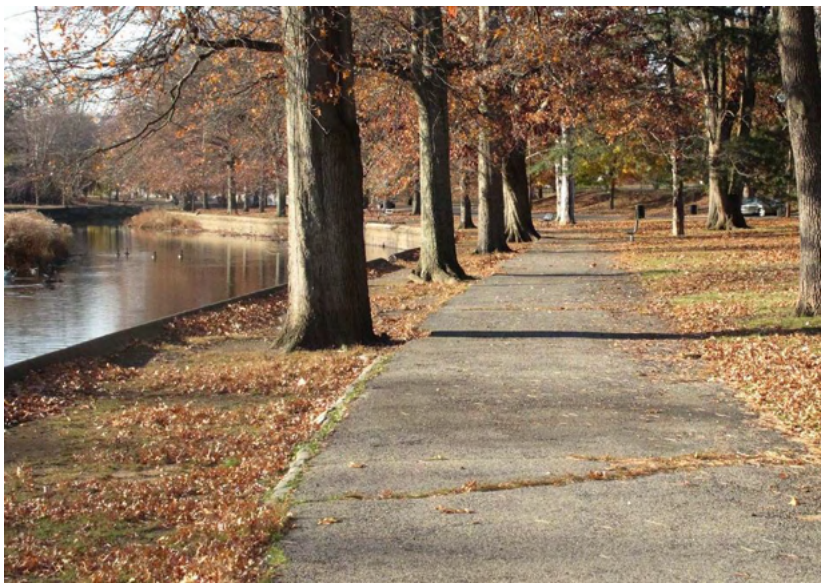
Shared Use Path / Trail

A shared use path consists of a paved travel area that is 10 feet wide or more (minimum 8 feet in constrained areas) in a right-of-way that is independent of the existing roadway network. Shared use paths are designed to accommodate two-way travel for bicyclists, pedestrians, and other non-motorized users, such as in-line skaters, skateboarders, and kick scooter users. Because they are separated from motor vehicle traffic, shared use paths are considered low-stress facilities that are attractive to non-motorized travelers of all ages and abilities.

Application:

- Continuous right-of-way that is independent of the road network
- Scenic/recreation areas
- River/stream frontage
- Rail-to-trail or rail-with-trail facilities
- Utility corridors
- Appropriate New Jersey Department of Environmental Protection (NJDEP) permits must be obtained when facilities impact freshwater wetlands, transition areas, state open waters, flood hazard areas, or other environmentally sensitive locations.
- Lighting should be considered where nighttime use is permitted, especially when the shared use path connects to transit, schools, employment, or shopping areas.
- Horizontal illumination of 0.5 to 2 foot-candles should be considered, with higher levels at intersections or where personal safety is a concern.
- Lighting sources may include pedestrian-scale lights (10-15 feet high) or fixtures mounted to existing street light poles. Lower fixture height and uniform spacing of fixtures can provide uniform distribution of light, avoid disruption/shadows, and improve the sense of security.
- A vertical illumination pattern that maintains a height of 7 feet enables visual recognition of other pedestrians/bicyclists, which may be beneficial in heavily traveled areas.
- Lighting for shared use paths requires careful photometric design and consideration of capital and operating costs, power source, residential light pollution, wildlife impacts, and other factors.





Shared use path example in Westside Park, City of Paterson, Passaic County

Planning & Design Resources:

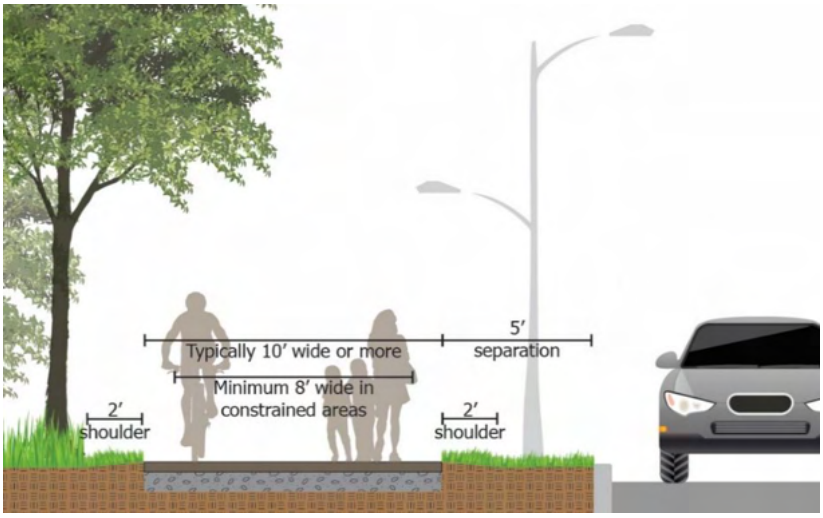
- 2017 State of New Jersey Complete Streets Design Guide, Chapter 3, p. 102, NJDOT
- 2012 Guide for the Development of Bicycle Facilities, Chapter 5, AASHTO
- 2016 Small Town and Rural Multimodal Networks, pp. 4-3 – 4-10, FHWA
- 2016 Lighting Regional Trails: Best Practices and Recommendations, Oregon Metro
- 2017 Empire State Trail Design Guide, pp. 3-18, NYSDOT
- 1998 Time-Saver Standards for Landscape Architecture: Design and Construction Data, Second Edition, McGraw-Hill
- NJDEP Trails, Boardwalk and Bike Paths permitting overview

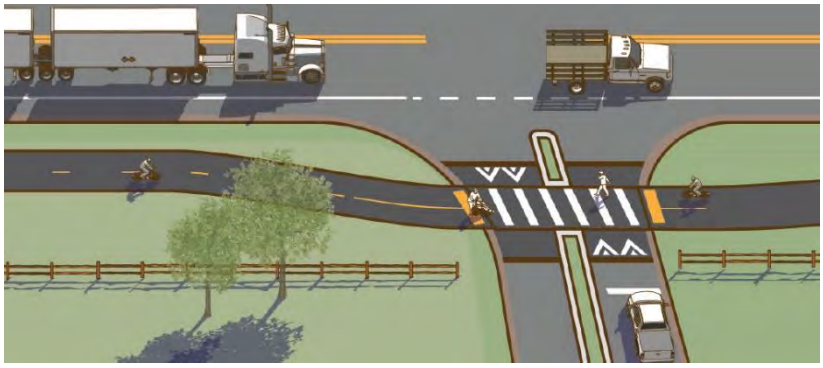
Sidepath

A sidepath is a shared use path (10 feet wide or more, minimum 8-feet in constrained areas) for pedestrians, bicyclists, and other non-motorized users that is constructed adjacent to a roadway, yet physically separated from motor vehicles. In contrast to a standard shared use path, a sidepath has special design considerations to function safely within the roadway right-of-way.

Application:

- Appropriate along roadways with a high level of traffic stress for bicyclists and insufficient width for on-road separated bike lane facilities
- Should be considered where driveways and intersection crossings are infrequent (or can be reduced, if possible)
- Should provide continuity between other sections of on-road and off-road bicycle facilities in the network
- One-way sidepaths can be provided on both sides of the street
- Should be separated from the roadway a minimum of 5 feet (or a barrier or railing should be provided)
- Fixed objects (such as utility/light poles, mail boxes, signs, trash cans, etc.) can constrain the operating width of the sidepath and should be located outside of the shoulder area whenever possible.
- Appropriate NJDEP permits must be obtained when facilities impact freshwater wetlands, transition areas, state open waters, flood hazard areas, or other environmentally sensitive locations.
- Horizontal illumination of 0.5 to 2 foot-candles should be considered, with higher levels at intersections or where personal safety is a concern.
- Lighting sources may include pedestrian-scale lights (10-15 feet high) or fixtures mounted to existing street light poles.
- See Shared Use Path / Trail for additional information on lighting.





Example layout of a sidepath adjacent to a busy roadway as it crosses a perpendicular street. (Source: FHWA, Small Town and Rural Multimodal Networks)

Planning & Design Resources:

- 2017 State of New Jersey Complete Streets Design Guide, Chapter 3, p. 102, NJDOT
- 2012 Guide for the Development of Bicycle Facilities, Chapter 5, AASHTO
- 2016 Small Town and Rural Multimodal Networks, pp. 4-11 – 4-18, FHWA
- NJDEP Trails, Boardwalk and Bike Paths permitting overview

Rail Trails

Rail trails are railroad rights-of-way that are converted to provide shared use path facilities. In general, rail trails are defined in two categories:

- A rail-to-trail is a railroad that is decommissioned and coverted to use as a trail. In Passaic County, the planned 7.15-mile Highlands Rail Trail will be a premier example of a rail-to-trail facility once contructed.
- A rail-with-trail is a railroad that continues rail operations while enabling construction and operation of a shared use path within the railroad right-of-way. This requires careful design and coordination to maintain physical separation of the trail from railroad operations and ensure safety of all users.

Rail-to-Trail example: Merchantville Mile in Merchantville, NJ.

Rail-to-Trail example: Traction Line Trail in Morris Township, NJ.

Application:

- Rail trails are constructed within railroad rights-of-way, offering an opportunity for a high quality shared use path experience, often with significant regional connectivity advantages.
- In general, rail trails should be planned to provide a shared use path – a paved travel area that is 10 feet wide or more (minimum 8 feet in constrained areas). (See Shared Use Path/Trail on page 10 for additional guidance).
- Making use of existing railroad infrastructure, such as bridges, grade-separated crossings, and gentle grades contribute to rail trail connectivity, unique travel experiences, and can attract bicyclists and pedestrians of all ages and abilities.
- Rail trails require extensive planning, funding, and coordination among a variety of stakeholders, including the railroad owners and lessees, the Federal Railroad Administration, utilities, and government agencies at all levels with regulatory, environmental, transportation, funding, use, and maintenance interests.

Planning & Design Resources:

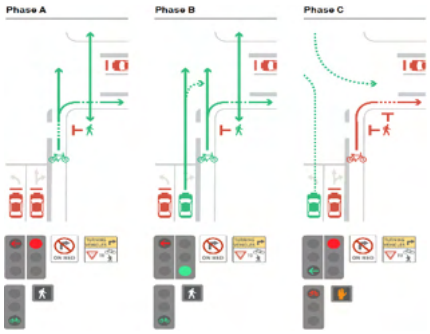
- 2020 Rails with Trails Best Practices and Lessons Learned, U.S. Department of Transportation
- 2017 Rails to Trails Conversions: A Legal Review, Rails-to-Trail Conservancy
- 2012 Guide for the Development of Bicycle Facilities, Chapter 5, AASHTO

Crossings & Intersections

A high quality bicycle network will improve mobility throughout Passaic County and attract more people of all ages, abilities, and backgrounds to bicycling as a means of both transportation and recreation. Inevitably, the bicycle network will need to be designed to respond to the varying conditions at intersections, interchanges, driveways, and other locations where bicyclists, pedestrians, and motorists will cross paths. At the network planning level, it is advisable to anticipate and plan around crossings and intersection configurations that are presently unfriendly or potentially dangerous to bicyclists. However, it is also important not to sacrifice potential bicyclist mobility improvements due to the perception that change at these locations is not feasible. Safety, comfort, and convenience can be improved at challenging intersections.

At crossings and intersections, design measures can be taken to increase the conspicuity of bicyclists and bicycle facilities, give bicyclists the right of way, integrate bicyclist turning- and thorough-movements into signal phasing, reduce the turning speeds and radii of motor vehicles, and balance (as well as help to make predictable) the disparate speeds and movement of motorists, bicyclists, and pedestrians.

Pavement markings through intersection, Hoboken, NJ (Source: Google Streetview)



Lead Bike Interval (LBI) signal phasing diagram (Source: NACTO)

Common treatments at crossings and intersections include pavement markings and signage, signal modifications (signal face visibility, timing/phasing, and actuation), physical separation of bicyclists facilities through construction of curbing or other means (known as protected intersections), and grade separation. Well-designed crossings and intersection are likely to integrate or combine aspects of these treatments to function in concert.

Protected intersection (Source: City of San Luis Obispo, CA)

Grade separated crossing of US Route 22 in Bridgewater, NJ

It is important to note that the design approach to crossings and intersections continues to evolve as bicycle networks and facilities grow in prevalence. Crossings and intersections deserve careful design to ensure safety, functionality, and mobility for all users. Although *BIKEPassaicCounty* is primarily a network and policy level plan, it will likely also inspire future thought and inquiry around crossings and intersections as they relate to both on-road and off-road bicycle facilities. Additional resources for reference in future planning and design of crossings and intersections include the following:

- Don't Give Up at the Intersection: Designing All Ages and Abilities Bicycle Crossings. NACTO, 2019.
- Urban Bikeway Design Guide, 2011, NACTO:
    - Intersections, pp. 105-202
    - Bicycle Signals, pp.203-237
- State of New Jersey Complete Streets Design Guide, 2017, Chapter 3, Intersections, pp. 111-145
- AASHTO Guide for the Development of Bicycle Facilities, 2012:
    - Chapter 4: Design of On-Road Facilities, 4.8 – Bicycle Lanes at Intersections
    - Chapter 5: Design of Shared Use Paths, 5.3 – Shared Use Path Roadway-Intersection Design
- Manual on Uniform Traffic Control Devices (MUTCD): Part 9. Traffic Controls for Bicycle Facilities

Order-of-Magnitude Cost Estimate List

This section provides a list of order-of-magnitude estimated costs for the bicycle facilities described in this Pattern Book. Each cost is presented in either Linear Feet ("LF," to represent a linear facility such as bicycle lane) or Each ("EA," to represent a point such as a shared use path crossing a street).

Unless otherwise noted, the order-of-magnitude estimated costs are derived from the 2020 version of the New Jersey Safe Routes to School website "Estimating Improvement Costs for Walking, Wheeling, and Bicycling (2020)," which has been reviewed by NJDOT and published by the Voorhees Transportation Center. For pavement markings, the estimated costs assume long-life, thermoplastic material. The estimated costs are appropriate for use at a planning level; they are based generally on materials and labor and do not account for the following factors:

- Field conditions
- Evaluation of existing facilities/structures
- Maintenance
- Right-of-way and utility impacts or relocation
- Right-of-way acquisition
- Design and permitting costs
- Evaluation of existing stormwater management or culverts
- Evaluation of existing structures
- Evaluation of existing traffic signals
- Excavation, materials testing, remediation, or disposal

Facility	Unit	Cost (One-Way LF or Each)	Cost (Two-Way LF)
1. Marked Shared Lanes This estimate assumes ±25 shared lane marking symbols installed per mile along a bicycle route in one direction. The cost should be doubled for shared lane markings in two directions.	LF	$0.60	$1.20
A. Shared Lane Markings (each symbol, thermoplastic)	*EA*	*$120*	
2. Bicycle Boulevard This estimate assumes the listed quantities of components A, B, and C below for a bicycle boulevard in one direction (i.e. one-way street). The cost should be doubled for shared lane markings in two directions. The elements listed under item D are additional and require context-sensitive application along a route.	LF	$2.30	
Bicycle Boulevard Components:			
A. Shared Lane Markings (35/mile)	*LF*	*$0.80*	*$1.60*
B. Regulatory Signs (5/mile)	*LF*	*$0.50*	*$1.00*
C. Wayfinding Signs (10/mile)	*LF*	*$1.00*	*$2.00*
D. Additional Traffic Calming Elements:			
Chicane	*EA*	*$30,000*	
Mini Roundabout	*EA*	*$35,000*	
Curb Extension	*EA*	*$20,000*	
Refuge Island	*EA*	*$8,000*	
Speed Hump	*EA*	*$5,000*	
Raised Crosswalk	*EA*	*$8,000*	
Raised Intersection	*EA*	*$100,000*	
Full Street Closure	*EA*	*$200,000*	
Partial Street Closure	*EA*	*$100,000*	

Facility	Unit	Cost (One-Way)	Cost (Two-Way)
3. Bicycle Lanes Bicycle lanes can be configured in various forms, but are primarily composed of pavement striping, symbols, and regulatory signs. This estimate provides different costs for the various types of facilities by aggregating the costs of the various components listed below as A-G. This estimate assumes a bicycle lane in one direction; therefore the costs should be doubled for a bicycle lane in two directions. The exceptions to this are the Two-Way Separated Bicycle Lane and the Bicycle Lane and Contraflow Lane, which provide travel in two directions, and therefore would not need the cost to be doubled.			
3.1. Bicycle Lane with No On-Street Parking Components: A + D + E	LF	$2.50	$5.00
3.2. Bicycle Lane with On-Street Parking Components: 2xA + D + E	LF	$4.10	$8.20
3.3. Buffered Bicycle Lane with No On-Street Parking Components: C + D + E	LF	$5.25	$10.50
3.4. Buffered Bicycle Lane with On-Street Parking Components: A + C+ D + E	LF	$6.85	$13.70
3.5. One-Way Separated Bicycle Lane Components: C + D + E	LF	$5.25	$10.50
3.6. Two-Way Separated Bicycle Lane (linear measure in two directions) Components: B + C + D + E	LF	N/A	$6.05
3.7 Bicycle Lane and Contraflow Lane (linear measure in two directions) Components: 2xA + 2xD + 2xE +F	LF	N/A	$8.00
Bicycle Lane Components:			
A. 4" White Stripe	*LF*	*$1.60*	
B. 4" White Stripe (dashed)	*LF*	*$0.80*	
C. 3'-wide Gore Stripe with Edge Lines	*LF*	*$4.35*	
D. Bicycle Lane Symbol (25/mile)	*LF*	*$0.60*	
E. Regulatory Signs (R3-17 and plaques, 6 per mile)	*LF*	*$0.30*	
F. Double 4" Yellow Stripe	*LF*	*$3.00*	
G. Optional: Delineator Posts *(Source: Tactical Urbanist's Guide to Materials and Design, 2016, John S. and James L. Knight Foundation)*	*LF*	*$8.50*	

Facility	Unit	Cost
4. Paired Hybrid Streets This estimate provides different costs for the various types of facilities by aggregating the costs of the various components listed below as A-G.		
4.1. Hybrid Street with Standard Bicycle Lane Components: 2xA + D +2xF	LF	$4.40
4.2. Hybrid Street with Separated Bicycle Lane Components: B + D + 2xF	LF	$5.55
Hybrid Street Components:		
A. 4" White Stripe	*LF*	*$1.60*
B. 3'-wide Gore Stripe with Edge Lines	*LF*	*$4.35*
C. 3'-wide Gore Stripe with Double Yellow Edge Lines	*LF*	*$6.00*
D. Bicycle Lane Symbol (25/mile)	*LF*	*$0.60*
E. Shared Lane Marking (25/mile)	*LF*	*$0.60*
F. Regulatory Signs (R3-17 and plaques, 6 per mile)	*LF*	*$0.30*
G. Optional: Delineator Posts *(Source: Tactical Urbanist's Guide to Materials and Design, 2016, John S. and James L. Knight Foundation)*	*LF*	*$8.50*
5. One-Way Street with Bicycle Lane and Back-In Angle Parking This estimate provides different costs for the various types of facilities by aggregating the costs of the various components listed below as A-G.		
5.1 One-Way Street with Bicycle Lane and Back-In Angle Parking Components: 2xA + C + D + E	LF	$7.90
5.2 One-Way Street with Separated Bicycle Lane and Back-In Angle Parking Components: B + C+ D + E	LF	$9.05
Bicycle Lane and Back-In Angle Parking Components:		
A. 4" White Stripe	*LF*	*$1.60*
B. 3'-wide Gore Stripe with Edge Lines	*LF*	*$4.35*
C. Bicycle Lane Symbol (25/mile)	*LF*	*$0.60*
D. 4" White Stripe for Angle Parking *(calculated as LF of curbline, not of striping)*	*LF*	*$3.50*
E. Regulatory Signs (R3-17 and plaques, and parking instructions, 12 per mile)	*LF*	*$0.60*
F. Optional: Delineator Posts *(Source: Tactical Urbanist's Guide to Materials and Design, 2016, John S. and James L. Knight Foundation)*	*LF*	*$8.50*
G. Painted/Striped No Parking Area at intersection (requires context sensitive application along route)	*EA*	*$900*

Facility	Unit	Cost
6.1. Shared Use Path (asphalt paved, 10' wide)	LF	$95
6.2. Shared Use Path (crushed stone, 10' wide)	LF	$65
6.3. Sidepath (asphalt paved, 10' wide)	LF	$95
6.4. Street Crossing for Shared Use Path or Sidepath	EA	$10,000
Street Crossing Components:		
A. Warning Signs + Pavement Markings (roadway)	*EA*	*$4,600*
B. Warning + Stop Signs (path)	*EA*	*$1,000*
C. Crosswalk	*EA*	*$900*
E. Curb Ramps	*EA*	*$3,500*
F. Option: Lighting Improvements at Crossing	*EA*	*$20,000*
G. Option: Rectangular Rapid Flashing Beacons (2)	*EA*	*$15,000*
6.5 Lighting along Shared Use Path or Sidepath *(assume $3500 per fixture and 30-foot spacing)*	LF	$117