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BIKEWAY DESIGN GUIDE 2019 DRAFT



CITY OF BEND



Bend Bicycling Vision

Bend is accessible for people of all ages and abilities to travel by bike to work, school, shopping and recreation. Within a short distance of their home, people can access a network of low-stress bikeways. This network of low-stress bikeways is easy for people to understand and navigate. Many of these routes are on low volume local streets and trails, and clear way-finding signs help people navigate these routes to get around town. Where key connections are planned to utilize busy streets, greater separation or protection is provided between bike riders and motor vehicles.

IMPLEMENTATION

This guide sets forth an effective implementation plan by identifying design standards and resources needed to construct, operate and maintain low-stress bikeway facilities. The new standards will apply to new road construction as well as targeted bike specific infrastructure projects. When feasible, low-stress bikeways will be retrofit during annual pavement preservation projects.

Chapter 3

Design of Bike Lanes and Separated Bike Lanes

Arterial and Collector Bikeways

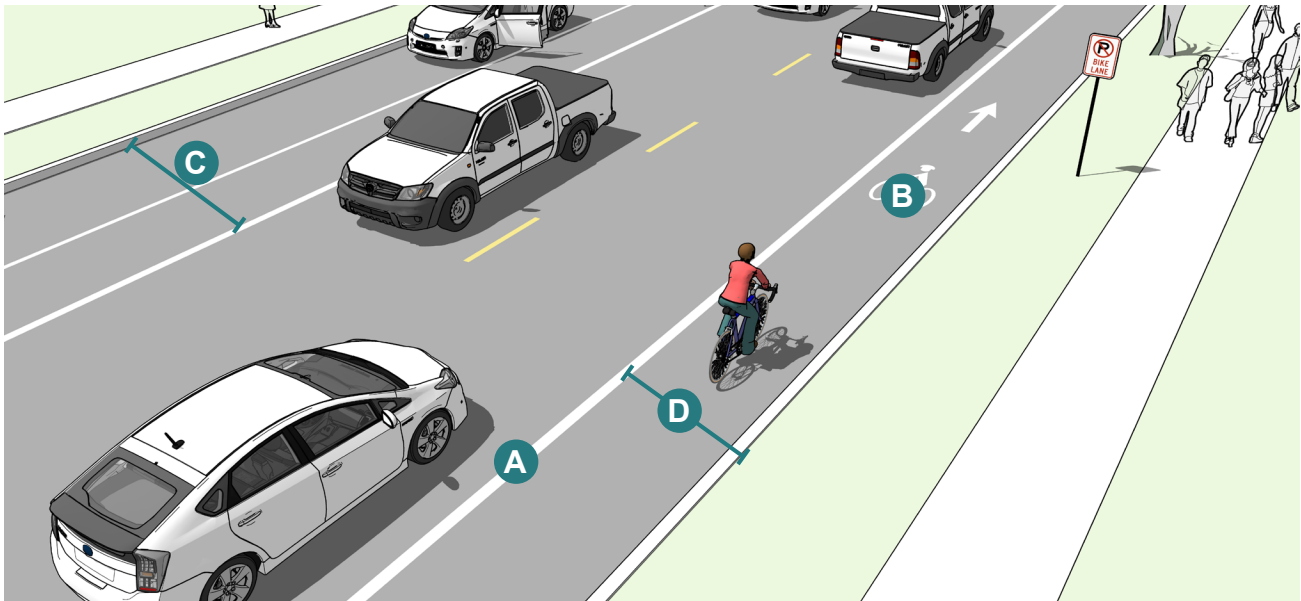
As noted in Chapter 1, providing a network of low-stress bikeways ensures bicycling is a viable transportation option. Isolated, low-stress bikeways can only serve potential bike riders who have access to those isolated segments and who simultaneously have destinations along those isolated segments. Furthermore, high-stress routes eliminate the viability of bicycling along or across those routes for transportation purposes and therefore prevent route connectivity. It is only when low-stress routes are connected to form a network that accessibility via a bicycle exists for transportation purposes.

The city's foundation of low-stress bikeways are shared-use paths and neighborhood greenways. These routes are the most universally usable and serve the broadest set of riders. But there are many arterial and collector roadways in Bend that are slow speed, either commercial or residential in nature, that create key segments on the city's low-stress network.

Key destinations are also located directly on arterial and collector roadways, making key segments of arterials and collectors critical to completing a trip to a likely destination. Because route continuity, coverage, and connectivity are crucial to maximize the number of origin-destination pairings that are viably reached by a bike, key segments of the low-stress network need to be accommodated on the arterial and collector roadway system.

Therefore, bikeway facility designs on arterials and collectors also need to be designed and operated as low-stress. The City's cross-section standard is 52' for new/reconstructed arterial and collector roadways. For speeds 35 mph and less, buffered bike lanes are standard and can provide LTS 1 and LTS 2 facilities at a very low price point. For higher speed arterials and collectors, low-stress bikeway standard is achieved with sidepaths (separated wide sidewalks facilitate biking and walking).

There are many existing arterial and collector roadways that cannot readily provide low-stress bikeways due to width and/or speeds. This chapter provides guidelines on techniques to convert existing high-stress bikeways to low-stress bikeways, as feasible without requiring re-construction. Designs that produce the lowest stress level LTS designation should be applied.



Bike Lane

A basic bike lane is one that is located directly adjacent to motor vehicle travel lanes on an arterial or collector roadway. Basic bike lanes are designated through pavement markings and signs and are typically on the right side of the street, and operate in the same direction as traffic. Designs that produce the lowest stress LTS level should be utilized.

Typical Application

- Basic bike lanes are 6.5' wide and are typically provided on all arterial and collector roadways.
- LTS 1 or LTS 2 can be achieved with basic bike lanes on 2- or 3-lane roadways with speeds 30 mph or lower when the bike lane is wide enough.
- In environments where only an LTS 3 or 4 can be achieved, the roadway cannot be part of the low-stress network, but is still necessary to provide route coverage for Strong and Fearless as well as Enthused and Confident rider types. In these situations, 6.5' bike lanes are standard, but may be reduced to 5.5' in constrained rights-of-way.

Design Features

- **A** Use 8" white line pavement marking to designate bike lane.
- **B** Put bike lane pavement marking at the beginning of each block and at regular intervals along route.
- **C** LTS 1 or 2 can be achieved with at least 15' combined width of on-street parking and bike lane if speeds are 30 mph or lower.
- **D** 6.5' bike lane width is the Bend standard bike lane width.

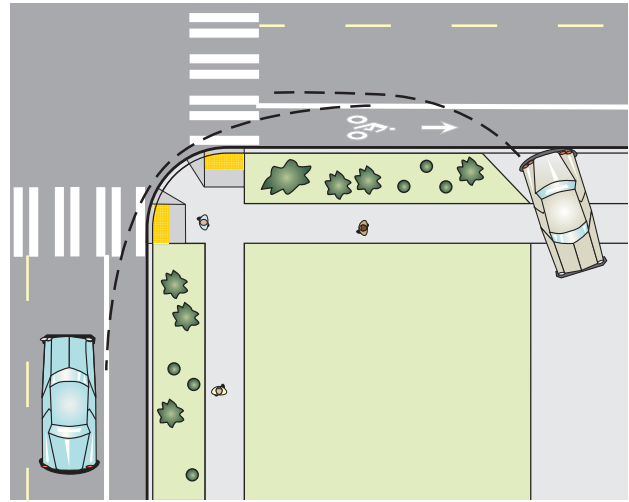
Further Considerations

- Wider bike lane widths facilitate bike passing maneuvers to better accommodate a range of bike rider travel speeds.



Bicycle lanes provide a delineated space, but may be subject to unwanted encroachment by motor vehicles, and therefore provide a lower level of comfort for many people on bikes.

- The City's standard practice is to optimize general purpose travel lane number and travel lane width in order to achieve overall corridor operations and safety goals, including the provision of the low-stress bicycle network density and coverage.
- AASHTO motor vehicle travel lane widths range from 9' to 12' as standard widths, depending on land use context, traffic speeds, number of travel lanes, and mix of traffic.
- Local classified streets do not have lanes. Their roadway surface is undefined (no striping to define lanes) and is therefore a shared space allowing travel in two directions and typically also has on-street parking.
- When travel lanes are created with lane lines on arterial and collector roadways, their widths should be set according to the following lane width guidance:
 - 11' travel lanes are standard.
 - 10' travel lanes can enhance speed compliance on roadways posted 30 mph or less. These lane widths may also provide greater flexibility for other pavement uses such as on-street parking, pedestrian safety islands, or bike lanes. There are several miles of



Bike lane word, symbol, and arrow markings (MUTCD Figure 9C-3) shall be placed outside of the motor vehicle tread path in order to minimize wear from the motor vehicle path. (NACTO 2012)

existing arterial and collector roadways in the city that successfully operate with 10' travel lanes. These include Newport Avenue, Greenwood Avenue and even a short segment of 3rd Street. Each of these roadway examples have a strong commercial context and operate with slow speeds. Although 10' is not a city standard lane width, the City Engineer may consider a 10' lane based on the context of the roadway.

- 12' travel lanes are standard on higher speed roadways (40 mph+), or where other considerations exist such as heavy haul routes or roadway curvature.
- 9' travel lanes may be considered by the City Engineer at low speeds.
- When parking T's are used to mark parking ADA requirements trigger accessible parking requirements.
- Safety and comfort for the low-stress route requires issues such as lane encroachment to be considered during route design. Low-noise producing rumble strips can be considered on the inside of horizontal curves to improve compliance with posted travel speeds, decrease the incidence of people driving into the buffer, and maintain the separation between motor vehicles and

people riding their bikes.

- The City has successfully used low-noise producing rumbles since 2014 along Riverside Boulevard for exactly this purpose.
- Roadway surface inconsistencies pose a threat to safe riding conditions for people on bicycles. Construct manholes, access panels, drainage elements, trenching, and construction joints to ensure surface smoothness tolerances are met and appropriate tire traction is provided.

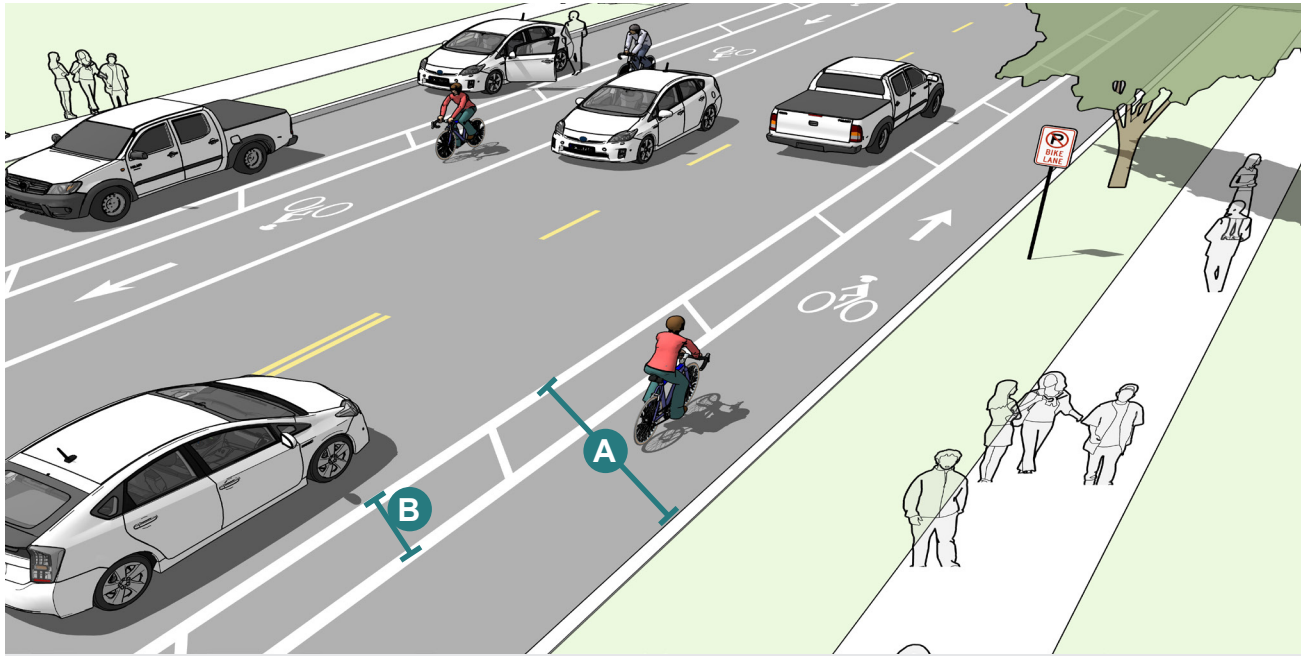
Crash Reduction

Before-and-after studies of bicycle lane installations show a 58 to 60%¹ crash reduction for vehicle/bicycle collisions after bike lane installation.

6.5' bike lane widths have 7.7% fewer crashes than 6' bike lanes.²

1 www.cmfclearinghouse.org/detail.cfm?facid=7840; Validation and Application of Highway Safety Manual (Part D) in Florida, Abdel-Aty et al, 2014

2 www.cmfclearinghouse.org/detail.cfm?facid=8692; Evaluation of Safety Effectiveness of Multiple Cross Sectional Features on Urban Arterials, Park and Abdel, 2016



Buffered Bike Lanes

Buffered bike lanes are basic bicycle lanes paired with a designated buffer space, separating the bicycle lane from the adjacent motor vehicle travel lane and/or parking lane. 88%¹ of Interested but Concerned potential bike riders noted they would be more likely to ride a bicycle if there was separation to motor vehicle traffic.

Typical Application

- Buffered bike lanes are the City standard on streets with posted speeds 35 mph and lower to achieve low-stress facilities as well as provide the lowest stress bikeway feasible.
- Buffers encourage drivers to comply with posted speeds, particularly on streets with several travel lanes or lane widths wider than city standards.
- Buffered bike lanes can achieve an LTS 1 when they are at least 7 feet wide (total overall width) and are located on 30 mph or lower posted roadways.
- Buffered bike lanes can achieve an LTS 2 when they are at least 7 feet wide and are located on 35 mph roadways.

Design Features

- Standard buffered width is 2.5' without diagonal cross-hatching.
- **A** 6.5' bike lane width plus the 2.5' buffer is considered standard for City of Bend.
- **B** Diagonal markings are required when buffer area is 3' or wider.
- Buffers can be configured on the parking side, the travel side or a combination of both.
- Minimum buffer widths are 2'.

¹ McNeil, Monsere and Dill; "The Influence of Bike Lane Buffer Types on Perceived Comfort and Safety of Bicyclists and Potential Bicyclists"



The use of pavement markings to create a buffer space between travel lanes and bike lanes increases separation and comfort. Buffered bike lanes provide a lower-stress facility.

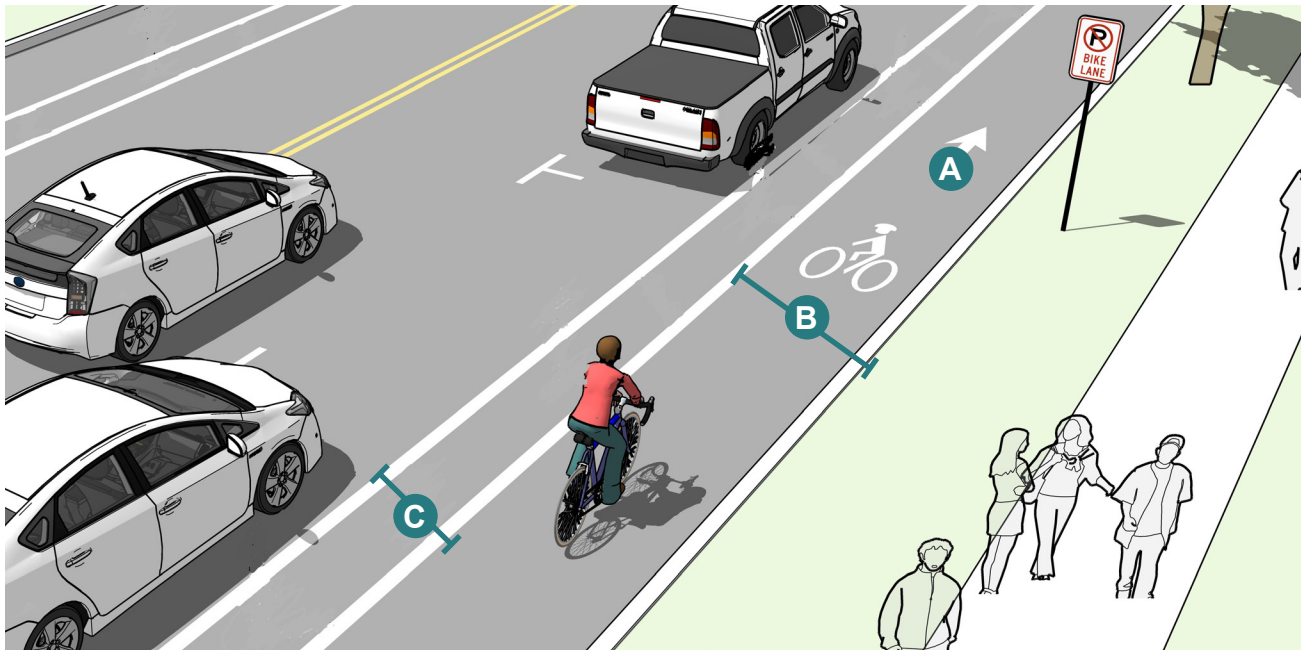
Further Considerations

- Low-noise producing rumble strips can be considered on the inside of horizontal curves to improve compliance with posted travel speeds, decrease the incidence of people driving into the buffer, and maintain the separation between motor vehicles and people riding their bikes. Safety and comfort for the low-stress route requires issues such as speeding and lane encroachment to be considered during route design.
- Buffered bike lane standard overall width is 9' in Bend and doubles as a fully functioning shoulder to allow stalled or disabled vehicles a place outside of travel lanes. This area can also be used to facilitate police enforcement of travel speeds by providing a place for vehicles to be pulled over.

Crash Reduction

A before and after study of buffered bicycle lane installation in Portland, Oregon found a positive response from people bicycling, with 89% of people bicycling feeling safer riding in the buffered bike lane. Also 91%¹ expressed that the facility made bicycling easier.

¹ 2015 Nathan McNeil, Christopher Monsere, Jennifer Dill; "The Influence of Bike Lane Buffer Types on Perceived Comfort and Safety of Bicyclists and Potential Bicyclists"



One-Way Separated Bike Lane Design

Separated bike lanes provide additional protection to moving traffic beyond painted buffers. The City of Bend has adopted parking separated bike lanes as its standard for protection to facilitate street sweeping and snow plowing.

Typical Application

- Streets posted 35 mph or less with on-street parking.
- Parking protected bike lanes are LTS 1.

Design Features

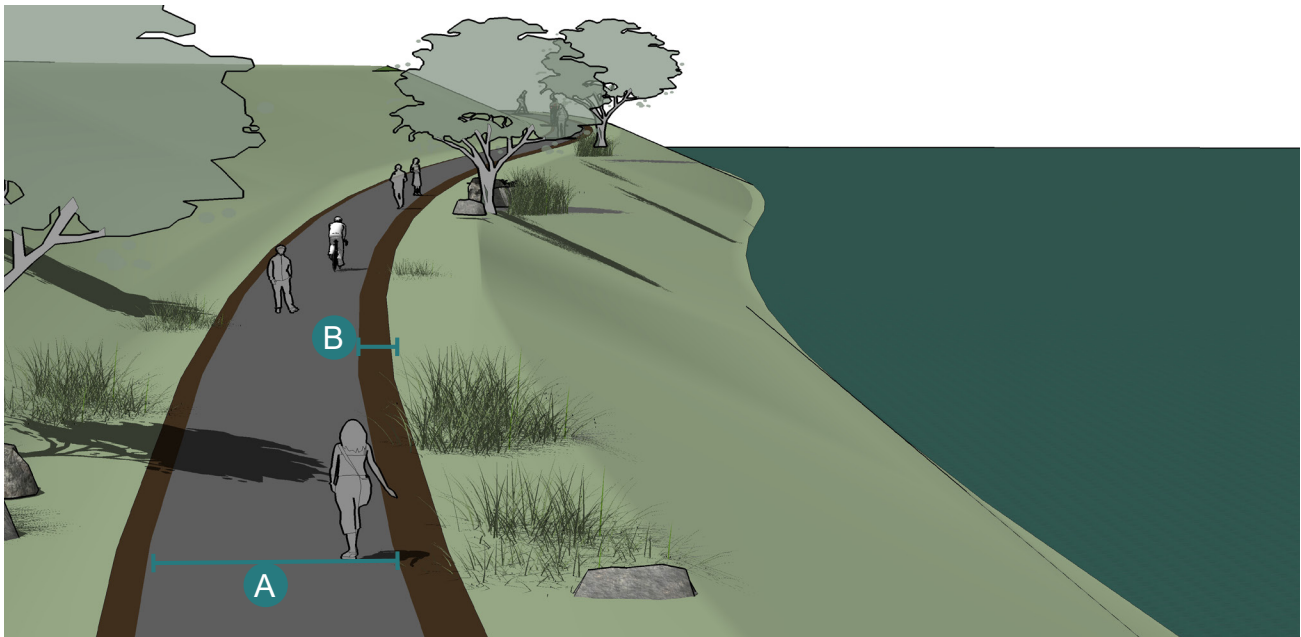
- **A** Pavement markings, symbols, and/or arrow markings must be placed at the beginning of the parking protected bike lane and at intervals along the facility based on engineering judgment to define the bike direction.
- **B** 6.5' bike lane is standard width.
- **C** 2.5' buffer is standard width.

Further Considerations

- Barred green may be used to highlight driveway or intersection conflict zones. Green coloration should be consistently used to prompt habit-forming responses to the conflict zones, but remain limited in scope to ensure it does not become ordinary.
- Where curb-extensions are required, the parking ends, and the bike lane shifts to curb tight along the curb-extension. See page 76 of this Guide for more details (Bike Lanes Adjacent to Through-Right Lanes).
- Special consideration should be given at transit stops and for access to and from parked cars to manage interactions between people walking and bicycling.

Chapter 4

Design of Shared-Use Paths



Shared-Use Path Design

Shared-use paths are separated from motor vehicle traffic by an open space or barrier and are either within the highway right of way or within an independent right of way or easement. The Architectural and Transportation Barriers Compliance Board has published a Proposed Rulemaking in the Federal Register (36 CFR Part 1190) that covers shared-use paths.

Typical Application

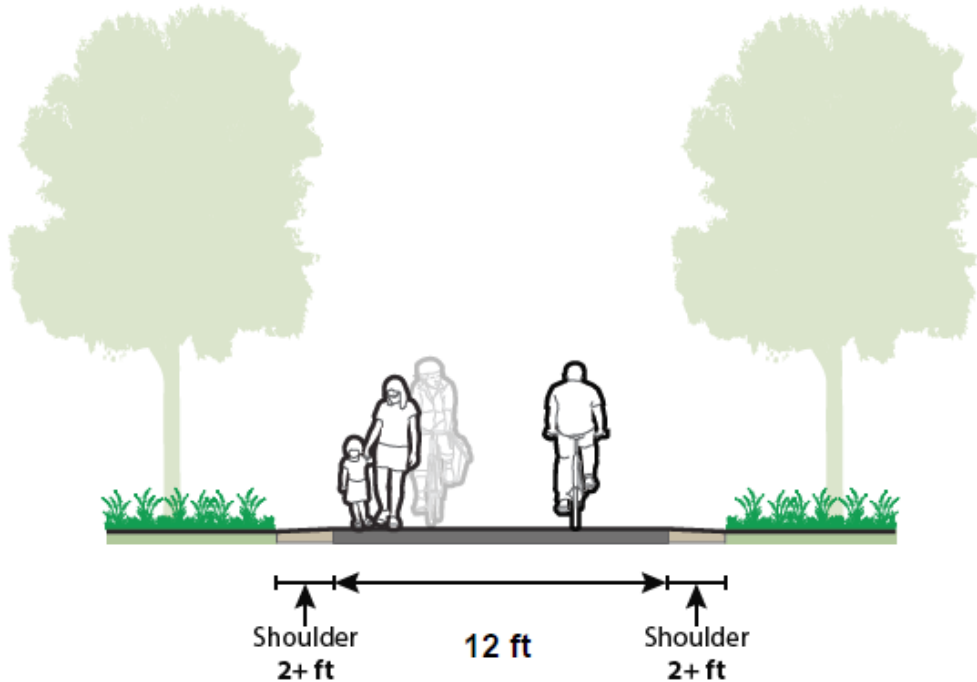
- Within unimproved public rights of way.
- As primary or connector trails within trail rights of way or utility rights of way.
- As short passageways to connect to cul-de-sacs, dead-end streets, or mid-way along long block lengths to decrease out of direction travel.
- As sidepaths, along roadways in lieu of a sidewalk to supplement on-street riding. Sidepaths are the City's standard, low-stress biking facility on arterial and collector roadways posted 40 and 45 mph as well as adjacent to schools, parks and leading to schools and parks.
- As temporary connections when future streets are not yet completed, to keep people moving, while development phases build out.

Design Features

- **A** Widths will vary depending on the circumstances but should be wide enough to serve a variety of users and accommodate variations in speeds.

Standard widths of all shared use pathways are 12' wide. Narrower widths may be allowed by the City Engineer in the course of balancing competing needs for right of way or easement width allocation. Site context, user type, and competing features such as parkstrip width and snow storage needs can be considered in their determination of shared use path width.

- **B** Minimum 2' shoulder. Provide lateral clearance for signs and other furnishings.
- Vertical Clearance: Standard clearance to overhead obstructions is 8'.
- Cross Slope: 2%



- Grade: Typically required to be 5% maximum running grade to avoid use of handrails. Allowances exist for shared-use paths adjacent to a roadway (ADA requirements require the shared-use path follows the grade of road) or for exclusive rights of way and in steep areas.

Where not practicable due to existing terrain or infrastructure, right of way, notable natural feature, etc., ADA compliance allows these grades to be met to the greatest extent practicable. Therefore, on steep hillsides (terrain slopes greater than 5%) the following guidelines are provided: 8% maximum grade for 30 feet; otherwise, 8.3% grade may be used for a maximum of 200 feet and 10% grade may be used for a maximum of 30 feet.

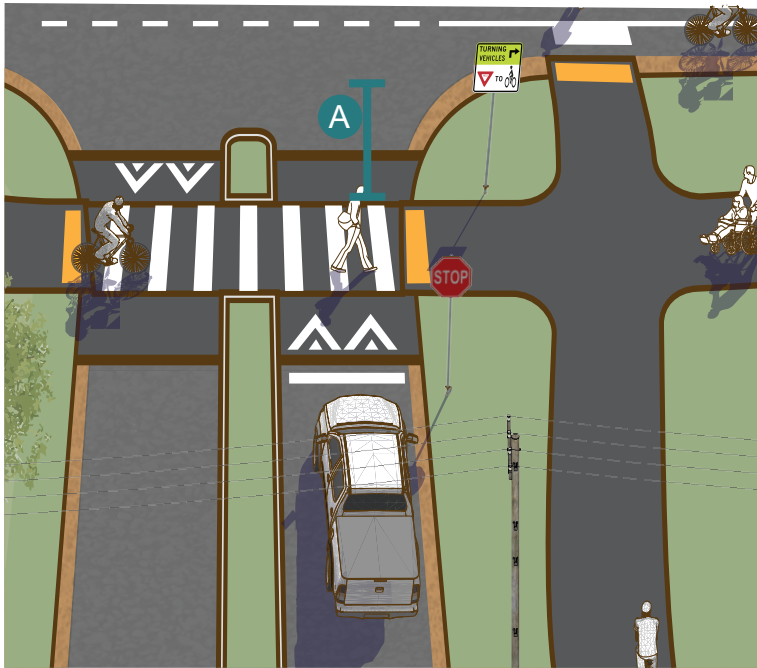
Additionally, if switchbacks are used: the switchback shall accommodate the minimum turning radii of a bicycle of 15 feet, and the path shall be widened through the turn to 15' (10' minimum) to accommodate two-way operations, and dismounted riders pushing their bikes up the hill.

- Lighting at roadway crossings is required

to accommodate safe crossings at night. Lighting is also required for daytime use in tunnels and underpasses. Lighting may be warranted along the shared-use path to increase safety and comfort for night-time riding. All lighting within Bend is required to be shielded and dark sky compliant.

Further Considerations

- Centerline striping is not generally necessary, although horizontal or vertical curves may warrant pavement marking such as a solid yellow line with white directional arrows.
- If used, signs in path environments should be small scale (MUTCD 9B.02) and should be retroreflective for night time travel.
- Terminate the path where it is easily accessible to and from the street system, preferably at a trailhead or controlled intersection to accommodate access to the path.



Sidepath Design

A sidepath is a bidirectional shared-use path located parallel to the roadway, typically within the same right-of-way, or immediately adjacent to right-of-way in an adjacent easement. Sidepaths can offer a high-quality experience for users of all ages and abilities.

Typical Application

Sidepaths are considered where one or more of the following conditions exist:

- The adjacent roadway has high-speed motor vehicle traffic that discourages most people from riding in a basic bike lane on the roadway. Sidepaths achieve low-stress LTS 1 ratings. Sidepaths do not preclude the installation or maintenance of bike lanes.
- To provide continuity between existing segments of shared-use paths.
- For use near schools, neighborhoods, and mixed-use commercial areas, where increased separation from motor vehicles is desired, and there are few roadway and driveway crossings.

Design Features

- Asphalt is standard sidepath paving material. Concrete may be required depending on the land-use context.
- Standard width is 12' but minimums of 7' to 10' are allowed in constrained areas to maintain a minimum 6.5' parkstrip and snow storage area.
- **A** The preferred minimum roadway separation is 6.5 - 16.5' (2.0 - 5.0 m) (Schepers, 2011). Absolute minimum separation width is 5' (1.5 m) (AASHTO Bike Guide 2012, p. 5-11).
- Separation should increase as volumes and speed of adjacent roadway increase (AASHTO Bike Guide 2012, p. 5-11).
- Lateral clearance to landscaping, street furnishings and signs is required. Signs and other street furniture should be placed outside of the minimum path width.



A sidepath provides a continuous path of travel along roadway corridors with few driveways or intersections. Depending on the anticipated volumes and context, the sidepath can be constructed in lieu of sidewalk.

- Standard clearance to overhead obstructions is 8' minimum. Greater clearance makes tunnels or longer confined spaces more comfortable and approachable and the tallest clearance possible should be attained.
- As sidepaths are typically located within public rights of way, their designs are governed by PROWAG guidelines. Grades are required to generally match the grade of the road.
- Sight Lines: It is important to keep approaches to intersections and major driveways clear of obstructions due to parked vehicles, shrubs, and signs on public or private property.

Crash Reduction

A study of crashes on two-way separated facilities found that accident probability decreased by 45%¹ at intersections where the separated facility approach was detected between 2-5 meters from the side of the main road and when the sidepath had crossing priority at intersections.

Intersection treatment is critical for sidepath designs particularly when the two-way separated bike lane or shared-use path is located between 0-2 meters from the side of the main road. Paths at this minimal separation are shown to have a slight increase in collisions at intersections of 3%².

1 www.cmfclearinghouse.org/detail.cfm?facid=3034

2 www.cmfclearinghouse.org/detail.cfm?facid=4033