FARGO-MOORHEAD METROPOLITAN

BICYCLE & PEDESTRIAN DESIGN GUIDE

METROCOG

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INTRODUCTION

Context

This toolbox presents guidance for local planners, engineers, and advocates to improve the walkability and bikability of Fargo-Moorhead and create more comfortable streets for pedestrians and bicyclists of all ages and abilities. Planners and project designers should refer to these guidelines in developing the infrastructure projects recommended by this plan, but they are not a substitute for thorough project-by-project evaluation by a landscape architect or engineer upon implementation.

Future roadway planning, engineering, design and construction will continue to strive for a balanced transportation system that includes a seamless, accessible bicycle and pedestrian network and encourages bicycle and pedestrian travel wherever possible.

There are many reasons to integrate bicycle and pedestrian facilities into typical roadway development policy. The goal of a transportation system is to better meet the needs of people - whether in vehicles, riding a bicycle or walking - and to provide access to goods, services, and activities.

Supporting active modes gives users important transportation choices, whether it is to make trips entirely by walking or bicycling, or to access public transit. In urban or suburban areas, walking and bicycling are often the fastest and most efficient ways to perform short trips.

Convenient non-motorized travel provides many benefits, including reduced traffic congestion, user savings, road and parking facility savings, economic development, and a better environment by helping reduce greenhouse gases.

The design guidelines in this document are for use on Fargo-Moorhead roadways. Projects must not only be planned for their physical aspects as facilities serving specific transportation objectives; they must also consider effects on the aesthetic, social, economic and environmental values, needs, constraints and opportunities in the larger community setting. This is commonly known as Context Sensitive Design, and should be employed when determining which standard is applicable in each scenario.

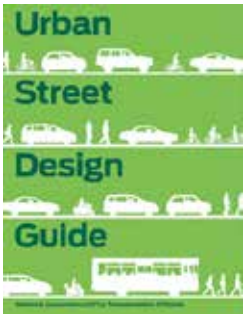
All walkway and bikeway design guidelines in this document meet or exceed the minimums set by the Americans with Disabilities Act Accessible Design Guidelines (ADAAG) and the Public Right of Way Accessibility Guidelines (PROWAG).

All traffic control devices, signs, pavement markings used and identified in this document must conform to the "Manual on Uniform Traffic Control Devices" (MUTCD).

Guidance Basis

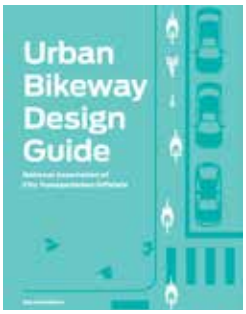
The sections that follow serve as an inventory of pedestrian and bicycle design treatments and provide guidelines for their development. These treatments and design guidelines are important because they represent the tools for creating a pedestrian- and bicycle-friendly, accessible community. The guidelines are not, however, a substitute for a more thorough evaluation by a professional engineer prior to implementation of facility improvements. The following guidelines are incorporated in this Design Guide.

National Guidance

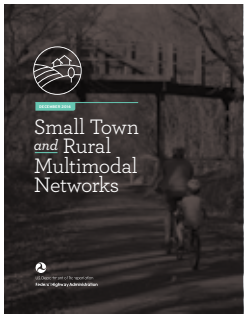


The National Association of City Transportation Officials' (NACTO) **Urban Bikeway Design Guide (2012)** *and* **Urban Street Design Guide (2013)** *are collections of nationally recognized street design standards, and offers guidance on the current state of the practice designs.*

Separated Bike Lane Planning and Design Guide (2015) *is the latest national guidance on the planning and design of separated bike lane facilities released by the Federal Highway Administration (FHWA). The resource documents best practices as demonstrated around the U.S., and offers ideas on future areas of research, evaluation and design flexibility.*



The National Association of City Transportation Officials' (NACTO) **Urban Bikeway Design Guide (2012)** *provides cities with state-of-the-practice solutions that can help create complete streets that are safe and enjoyable for bicyclists. The designs were developed by cities for cities, since unique urban streets require innovative solutions. In August 2013, the Federal Highway Administration issued a memorandum officially supporting use of the document.*



The Federal Highway Administration's **Small Town and Rural Multimodal Networks Report (2016)** *offers resources and ideas to help small towns and rural communities support safe, accessible, comfortable, and active travel for people of all ages and abilities. It connects existing guidance to rural practice and includes examples of peer communities.*

Minnesota Guidance

Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD) *defines the standards used by road managers nationwide to install and maintain traffic control devices on all public streets, highways, bikeways, and private roads open to public traffic.*

The Minnesota Department of Transportation's **Bicycle Facility Design Manual (2020)** *establishes uniform design criteria for Minnesota roadways. The manual should be used in conjunction with the current versions of the MnDOT Road Design Manual and the Minnesota Manual on Uniform Traffic Control Devices.*

The Minnesota Department of Transportation's **Minnesota's Best Practices for Pedestrian and Bicycle Safety (2021)** *identifies proven strategies and treatments. The manual should be used in conjunction with the current versions of the MnDOT Road Design Manual and the Minnesota Manual on Uniform Traffic Control Devices.*

Pedestrian Accommodations Through Work Zones Design Guidance (2021) *defines the guidance for accommodating pedestrians when existing routes are impacted by maintenance or construction. The goal is to create a work zone which allows access and movement for all people regardless of mobility impairment through public work zones.*

North Dakota Guidance

North Dakota Department of Transportation Design Manual (2019) *provides a convenient guide for NDDOT policies, procedures, and design values that are presently recommended for road and bridge designers.*

ND Moves Statewide Active & Public Transportation Plan (2019) *is intended to serve as a guide and resource for accommodating active and public transportation in the development of state and local transportation systems and program. The plan considered needs and improvements over the next 20 years.*

Design Needs of Pedestrians

Types of Pedestrians

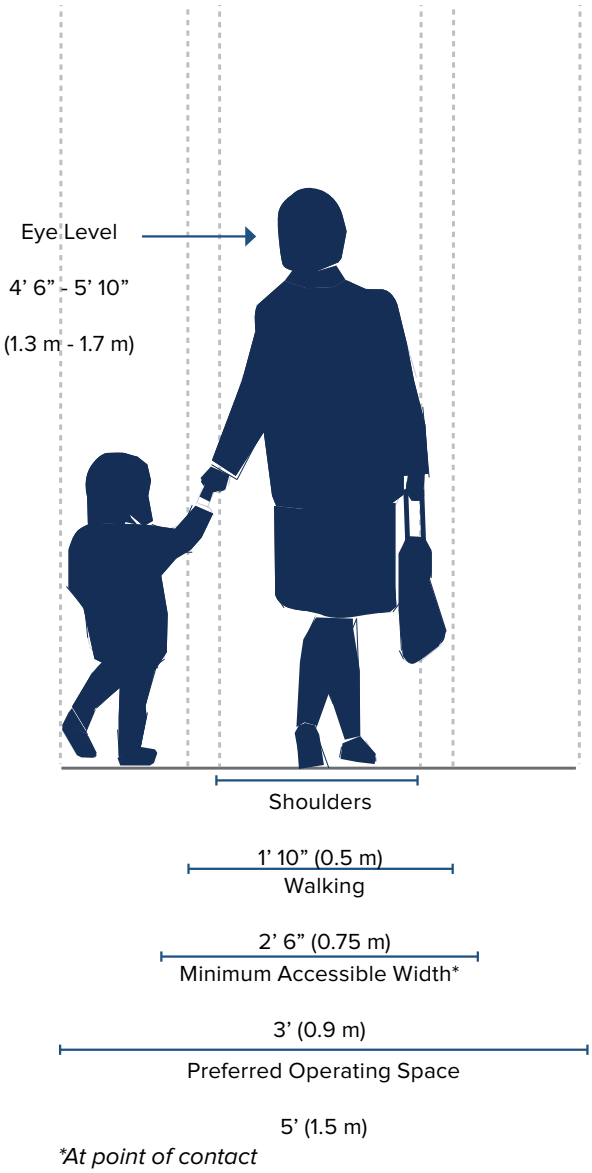
Pedestrians have a variety of characteristics and the transportation network should accommodate a variety of needs, abilities, and possible impairments. Age is one major factor that affects pedestrians' physical characteristics, walking speed, and environmental perception. Children have lower eye height and may walk slower than adults. They also perceive the environment differently at various stages of their cognitive development. Older adults walk more slowly and may require assistive devices for walking stability, sight, and hearing.

Disabled Pedestrian Design Considerations

The table below summarizes common physical and cognitive impairments, how they affect personal mobility, and recommendations for improved pedestrian-friendly design.

DISABLED PEDESTRIAN DESIGN CONSIDERATIONS

Impairment	Effect on Mobility	Design Solution
Physical Impairment Necessitating Wheelchair and Scooter Use	Difficulty propelling over uneven or soft surfaces.	Firm, stable surfaces and structures, including ramps or beveled edges.
	Cross-slopes cause wheelchairs to veer downhill or tip sideways.	Cross-slopes of less than two percent.
	Require wider path of travel.	Sufficient width and maneuvering space.
Physical Impairment Necessitating Walking Aid Use	Difficulty negotiating steep grades and cross slopes; decreased stability and tripping hazard.	Cross-slopes of less than two percent. Smooth, non-slippery travel surface.
	Slower walking speed and reduced endurance; reduced ability to react.	Longer pedestrian signal cycles, shorter crossing distances, median refuges, and street furniture.
Hearing Impairment	Less able to detect oncoming hazards at locations with limited sight lines (e.g. driveways, angled intersections, channelized right turn lanes) and complex intersections.	Longer pedestrian signal cycles, clear sight distances, highly visible pedestrian signals and markings.
Vision Impairment	Limited perception of path ahead and obstacles; reliance on memory; reliance on non-visual indicators (e.g. sound and texture).	Accessible text (larger print and raised text), accessible pedestrian signals (APS), guide strips and detectable warning surfaces, safety barriers, and lighting.
Cognitive Impairment	Varies greatly. Can affect ability to perceive, recognize, understand, interpret, and respond to information.	Signs with pictures, universal symbols, and colors, rather than text.



*At point of contact

PEDESTRIAN CHARACTERISTICS BY AGE

Age	Characteristics
0-4	Learning to walk Requires constant adult supervision Developing peripheral vision and depth perception
5-8	Increasing independence, but still requires supervision Poor depth perception
9-13	Susceptible to “darting out” in roadways Insufficient judgment Sense of invulnerability
14-18	Improved awareness of traffic environment Insufficient judgment
19-40	Active, aware of traffic environment
41-65	Slowing of reflexes
65+	Difficulty crossing street Vision loss Difficulty hearing vehicles approaching from behind

Source: AASHTO. Guide for the Planning, Design, and Operation of Pedestrian Facilities, Exhibit 2-1. 2004.

Design Needs of Runners

Running is an important recreation and fitness activity commonly performed on shared use paths. Many runners prefer softer surfaces (such as rubber, bare earth or crushed rock) to reduce impact. Runners can change their speed and direction frequently. If high volumes are expected, controlled interaction or separation of different types of users should be considered.

RUNNER DIMENSIONS

Design Needs of Strollers

Strollers are wheeled devices pushed by pedestrians to transport babies or small children. Stroller models vary greatly in their design and capacity. Some strollers are designed to accommodate a single child, others can carry 3 or more. Design needs of strollers depend on the wheel size, geometry and ability of the adult who is pushing the stroller.

Strollers commonly have small pivoting front wheels for easy maneuverability, but these wheels may limit their use on unpaved surfaces or rough pavement. Curb ramps are valuable to these users. Lateral overturning is one main safety concern for stroller users.

STROLLER DIMENSIONS

Design Needs of Wheelchair Users

As the American population ages, the age demographics in Fargo-Moorhead may also shift, and the number of people using mobility assistive devices (such as manual wheelchairs, powered wheelchairs) will increase.

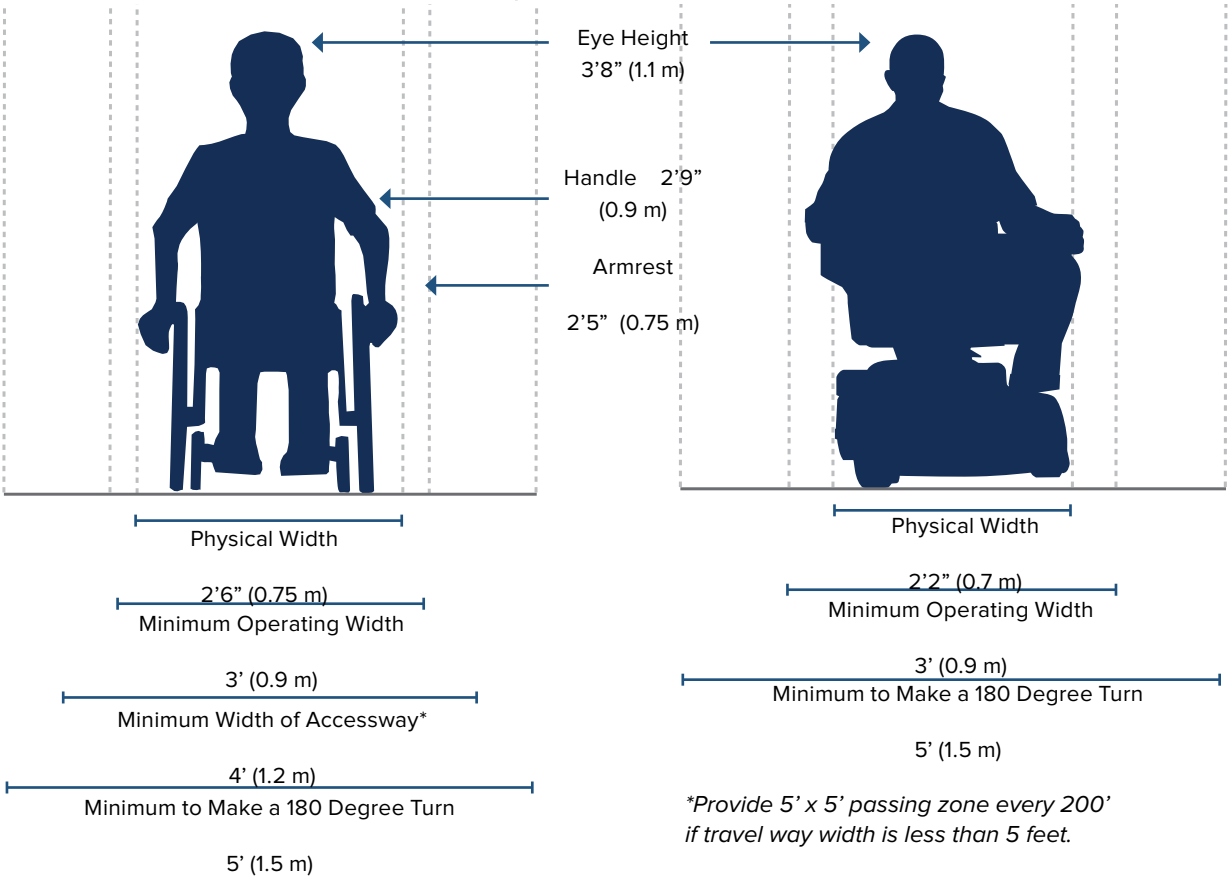
Manual wheelchairs are self-propelled devices. Users propel themselves using push rims attached to the rear wheels. Braking is done through resisting wheel movement with the hands or arm. Alternatively, a second individual can control the wheelchair using handles attached to the back of the chair.

Power wheelchairs use battery power to move the wheelchair. The size and weight of power wheelchairs limit their ability to negotiate obstacles without a ramp. Various control units are available that enable users to control the wheelchair movement, based on their ability (e.g., joystick control, breath controlled, etc).

Maneuvering around a turn requires additional space for wheelchair devices. Providing adequate space for 180 degree turns at appropriate locations is an important element of accessible design.

WHEELCHAIR USER DESIGN

Effect on Mobility	Design Solution
Difficulty propelling over uneven or soft surfaces.	Firm, stable surfaces and structures, including ramps or beveled edges.
Cross-slopes cause wheelchairs to veer downhill.	Cross-slopes of less than two percent.
Require wider path of travel.	Sufficient width and maneuvering space.



**Provide 5' x 5' passing zone every 200' if travel way width is less than 5 feet.*

Design Needs of Bicyclists

The facility designer must have an understanding of how bicyclists operate and how their bicycle influences that operation. Bicyclists, by nature, are much more affected by poor facility design, construction and maintenance practices than motor vehicle drivers. By understanding the unique characteristics and needs of bicyclists, a facility designer can provide quality facilities and minimize user risk.

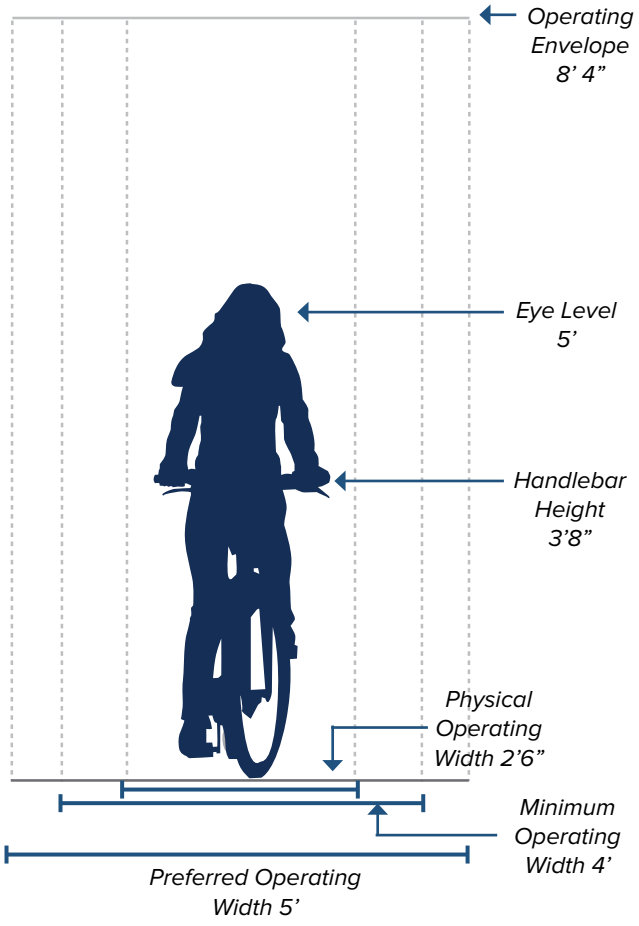
Bicycle as a Design Vehicle

Similar to motor vehicles, bicyclists and their bicycles exist in a variety of sizes and configurations. These variations occur in the types of vehicle (such as a conventional bicycle, a recumbent bicycle or a tricycle), and behavioral characteristics (such as the comfort level of the bicyclist). The design of a bikeway should consider reasonably expected bicycle types on the facility and utilize the appropriate dimensions.

The figure illustrates the operating space and physical dimensions of a typical adult bicyclist, which are the basis for typical facility design. Bicyclists require clear space to operate within a facility. This is why the minimum operating width is greater than the physical dimensions of the bicyclist. Bicyclists prefer five feet or more operating width, although four feet may be minimally acceptable if the pavement is continuous and there is no curbing present.

In addition to the design dimensions of a typical bicycle, there are many other commonly used pedal-driven cycles and accessories to consider when planning and designing bicycle facilities. The most common types include tandem bicycles, recumbent bicycles, and trailer accessories.

BICYCLE RIDER - TYPICAL DIMENSIONS



BICYCLE AS DESIGN VEHICLE - DESIGN SPEED EXPECTATIONS

BICYCLE TYPE	FEATURE	TYPICAL SPEED
Upright Adult Bicyclist	Paved level surfacing	8-12 mph*
	Crossing Intersections	10 mph
	Downhill	30 mph
	Uphill	5 -12 mph
Recumbent Bicyclist	Paved level surfacing	18 mph

** Typical speed for causal riders per MnDOT Bicycle Facility Design Manual.*

PEDESTRIAN TOOLBOX

Introduction

The Pedestrian Toolbox includes pedestrian-oriented infrastructure elements that create a more comfortable and safe pedestrian experience. This toolbox is important because it contains tools for creating a system that meets the needs of the community.

This toolbox will be helpful to city staff in addressing the pedestrian needs and opportunities throughout Fargo-Moorhead. It should be noted that the tools contained in this guide are not exhaustive and should be referenced along with NACTO's *Urban Street Design Guide,* as well as local guidance of Minnesota and North Dakota.

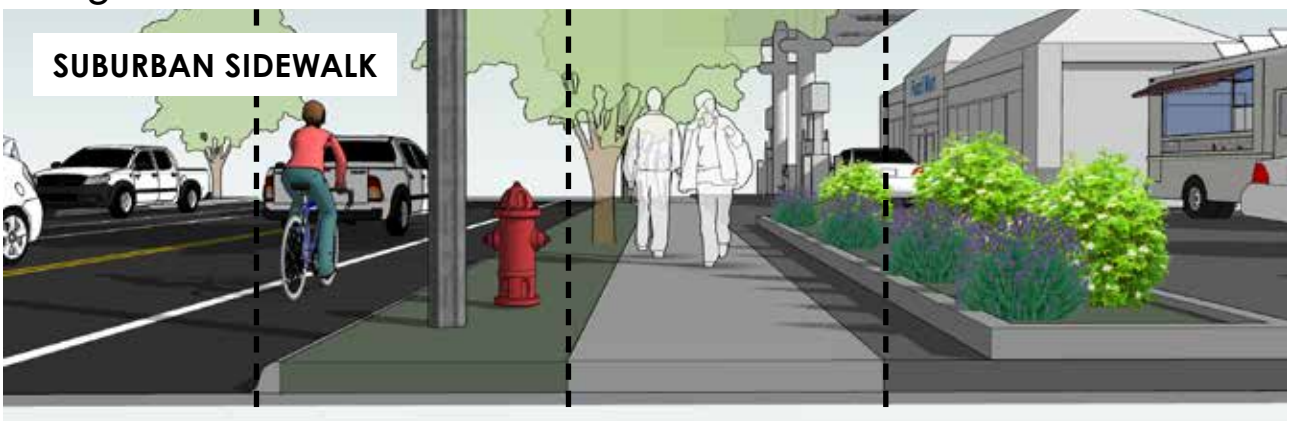
All pedestrian design guidelines in this toolbox meet or exceed the minimums set by the Americans with Disabilities Act Accessible Design Guidelines (ADAAG) and the Public Right of Way Accessibility Guidelines (PROWAG).

Sidewalks

Sidewalk Zones & Widths

Sidewalks are the most fundamental element of the walking network, as they provide an area for pedestrian travel separated from vehicle traffic. Providing adequate and accessible facilities can lead to increased numbers of people walking, improved accessibility, and the creation of social space.

Design Features



Enhancement Zone	Amenity Zone	Pedestrian Through Zone	Frontage Zone
The curbside lane can act as a flexible space to further buffer the sidewalk from moving traffic, and may be used for a bike facility. Curb extensions and bike corrals may occupy this space where appropriate.	The amenity zone, also called the furnishing or landscaping zone, buffers pedestrians from the adjacent roadway, and is also the area where elements such as street trees, signal poles, signs, and other street furniture are properly located. When context and space allows, this is the ideal zone to include stormwater infrastructure and plantings such as bioswales and infiltration basins, as well as shade trees.	The pedestrian through zone is the area intended for pedestrian travel. This zone should be entirely free of permanent and temporary objects. Wide pedestrian zones are needed in areas or where pedestrian flows are high.	The frontage zone allows pedestrians a comfortable "shy" distance from the building fronts, fencing, walls and vertical landscaping. It provides opportunities for window shopping, to place signs, planters, or chairs.

Street Classification	Parking Lane/ Enhancement Zone	Amenity Zone	Primary Pedestrian Zone	Building Frontage Zone*
Local Streets	Varies	4 - 6 ft	6 - 8 ft	2 ft
Pedestrian Priority Areas	Varies	6 - 10 ft	8 ft	2 - 8 ft
Arterials and Collectors	Varies	4 - 6 ft	6 - 8 ft	4 - 6 ft

**Indicates ideal frontage zone space. Actual frontage zone is contingent upon the City's development code and required set backs*

Typical Application

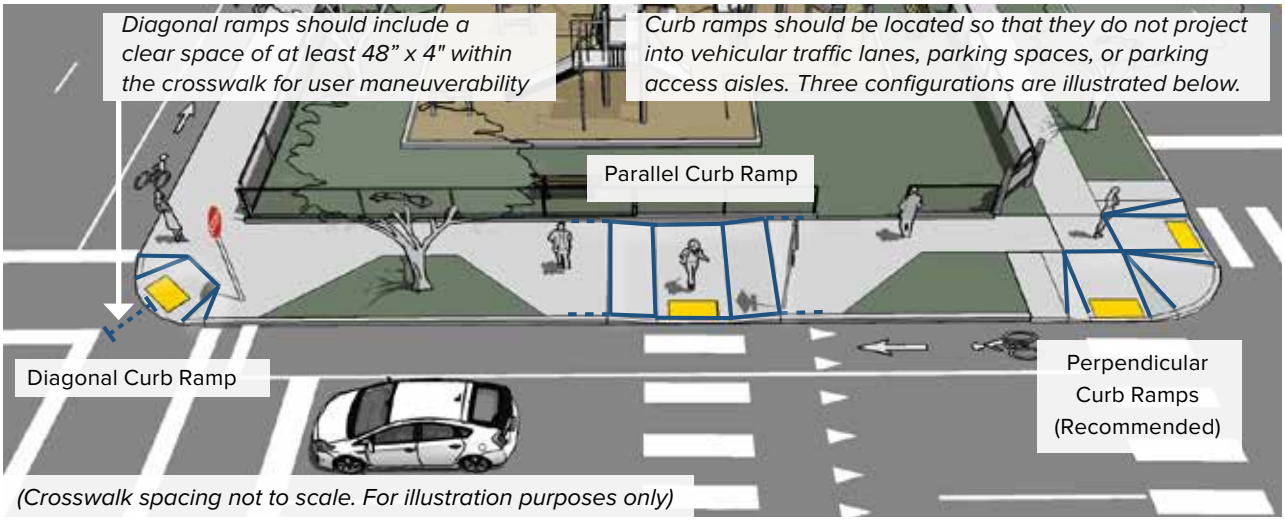
- Wider sidewalks should be installed near schools, at transit stops, or anywhere high concentrations of pedestrians exist.
- At transit stops, an 8 ft by 5 ft clear space is required for accessible passenger boarding/ alighting at the front door location per ADA requirements.
- Sidewalks should be continuous on both sides of urban commercial streets, and should be required in areas of moderate residential density (1-4 dwelling units per acre).
- When retrofitting gaps in the sidewalk network, locations near transit stops, schools, parks, public buildings, and other areas with high concentrations of pedestrians should be the highest priority.

Materials and Maintenance

Sidewalks are typically constructed out of concrete and are separated from the roadway by a curb or gutter and sometimes a landscaped boulevard. Less expensive walkways constructed of asphalt, crushed stone, or other stabilized surfaces may be appropriate. Ensure accessibility and properly maintain all surfaces regularly. Surfaces must be firm, stable, and slip resistant. Colored, patterned, or stamped concrete can add distinctive visual appeal. See 'Sidewalk Maintenance' for more information.

Curb Ramps

Curb ramps are the design elements that allow all users to make the transition from the street to the sidewalk. A sidewalk without a curb ramp can be useless to someone in a wheelchair, forcing them back to a driveway and out into the street for access. There are a number of factors to be considered in the design and placement of curb ramps.



(Crosswalk spacing not to scale. For illustration purposes only)

Typical Application

Curb ramps must be installed at all intersections and midblock locations where pedestrian crossings exist, as mandated by federal legislation (1973 Rehabilitation Act and ADA 1990). All newly constructed and altered roadway projects must include compliant curb ramps. In addition, existing facilities must be upgraded to current standards when appropriate.

The edge of an ADA compliant curb ramp should be marked with a detectable warning surface (also known as truncated domes) to alert people with visual impairments to the boundary between a pedestrian and vehicular route. Visual contrast between the raised tactile device and the surrounding infrastructure is important so that the change is readily evident to partially sighted pedestrians.

Design Features

- The level landing at the top of a ramp should be at least 4 feet long and at least the same width as the ramp itself. The slope of the ramp should be compliant to current standards.
- If the top landing is within the sidewalk or corner area where someone in a wheelchair may have to change direction, the landing must be a minimum of 4'-0" long (in the direction of the ramp run) and at least as wide as the ramp, although a width of 5'-0" is preferred.

Not recommended: Diagonal curb ramp configuration.

Recommended: Directional curb ramps for crossing in both directions.

Further Considerations

Where feasible, separate directional curb ramps for each crosswalk at an intersection should be provided rather than having a single ramp at a corner for both crosswalks. Although diagonal curb ramps might save money, they orient pedestrians directly into the center of the intersection, which can be challenging for wheelchair users and pedestrians with visual impairments. Diagonal curb ramp configurations are not recommended.

Curb radii need to be considered when designing directional ramps. While curb ramps are needed for use on all types of streets, the highest priority locations are on streets near transit stops, schools, parks, medical facilities, shopping areas.

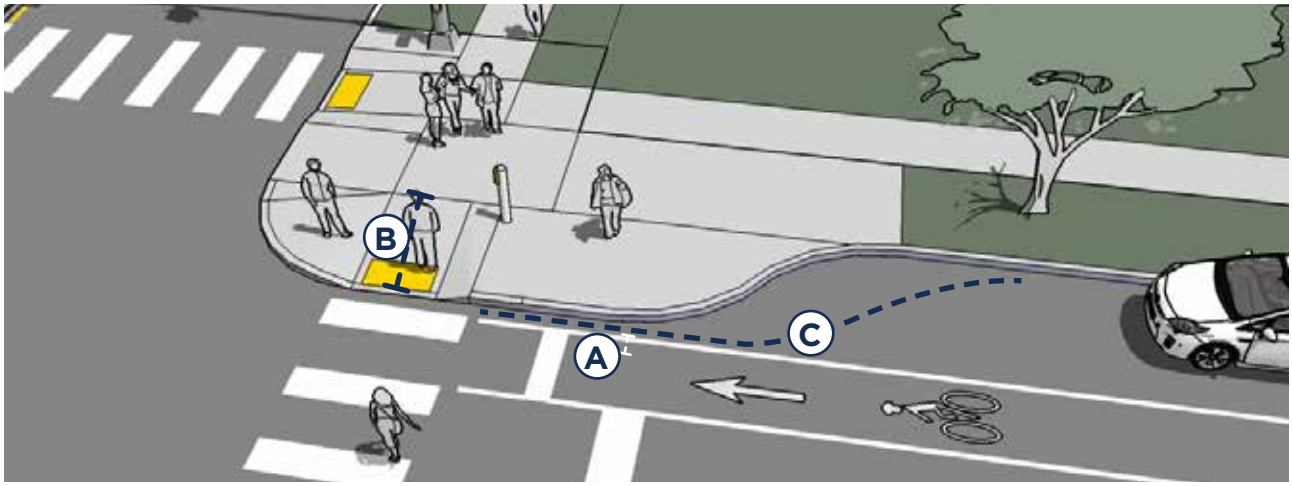
Where feasible, design curb ramps in conjunction with sidewalk stormwater infrastructure and plantings such as bioswales and infiltration basins, as well as shade trees. In this context it is important to not interfere with pedestrian and vehicular sightlines, therefore close attention to these details is critical.

Materials and Maintenance

It is critical that the interface between a curb ramp and the street be maintained adequately. Asphalt street sections can develop vertical differentials where concrete meets asphalt at the foot of the ramp, which can catch the front wheels of a wheelchair.

Curb Extensions

Curb extensions, also called curb bulbouts and neckdowns, minimize pedestrian exposure during crossing by shortening the crossing distance and giving pedestrians a better chance to see and be seen before beginning to cross. Curb extensions are appropriate for any crosswalk where it is desirable to shorten the crossing distance and there is a parking lane adjacent to the curb.



Typical Application

- For purposes of efficient street sweeping and snow plowing, the minimum radius for the reverse curves of the transition is 10 ft and the two radii should be balanced to be nearly equal.
- The curb extension width should terminate one foot short of the parking lane to maximize bicyclist safety when bicycle lanes are not present. This buffer is also preferred when bicycle lanes are present.

Design Features

(A) Where a bike lane runs adjacent to the curb extension, design with a 1‘ buffer from edge of parking lane (preferred).

(B) Crossing distance is shortened by approximately 6-8 feet with a parallel parking lane or 15 feet or more with an angled parking lane.

(C) Curb extension length can be adjusted to accommodate bus stops or street furniture.

Further Considerations

If there is no parking lane, adding curb extensions across a roadway shoulder may be a problem for bicycle travel and truck or bus turning movements. Curb extensions are excellent locations for implementation of stormwater infrastructure.

Materials and Maintenance

Planted curb extensions may be designed as a bioswale or a vegetated system for stormwater management. To maintain proper stormwater drainage, curb extensions can be constructed as pedestrian refuge islands offset by a drainage channel or feature a covered trench drain.

Corner Radii

The size of a curb's radius can have a significant impact on pedestrian comfort and safety. A smaller curb radius provides more pedestrian area at the corner, allows more flexibility in the placement of curb ramps, results in a shorter crossing distance and requires vehicles to slow more on the intersection approach. During the design phase, the chosen radius should be the smallest possible for the circumstances and consider the effective radius in any design vehicle turning calculations.

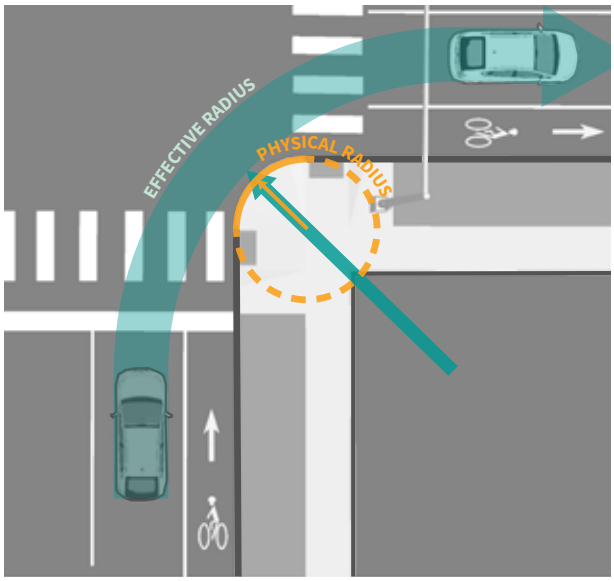
Typical Application

The curb radius may be as small as 3 ft where there are no turning movements, or 5 ft where there are turning movements and adequate street width. Wide outside travel lanes, on-street parking and bike lanes create a larger effective turning radius and can therefore allow a smaller physical curb radius.

Design Features

Corners have two critical dimensions which must be considered together.

- The physical radius controls the pedestrian experience.
- The effective radius is the widest turning arc that a vehicle can take through the corner and is larger than the physical radius.



Recommended: Bidirectional curb ramps for crossing in both directions.

Further Considerations

Several factors govern the choice of curb radius in any given location. These include the desired pedestrian area of the corner, street classifications, design vehicle turning radius, intersection geometry, and whether there is on-street parking or a bike lane (or both) between the travel lane and the curb.

BICYCLE TOOLBOX

Introduction

Facility Selection: Bicycle User Type

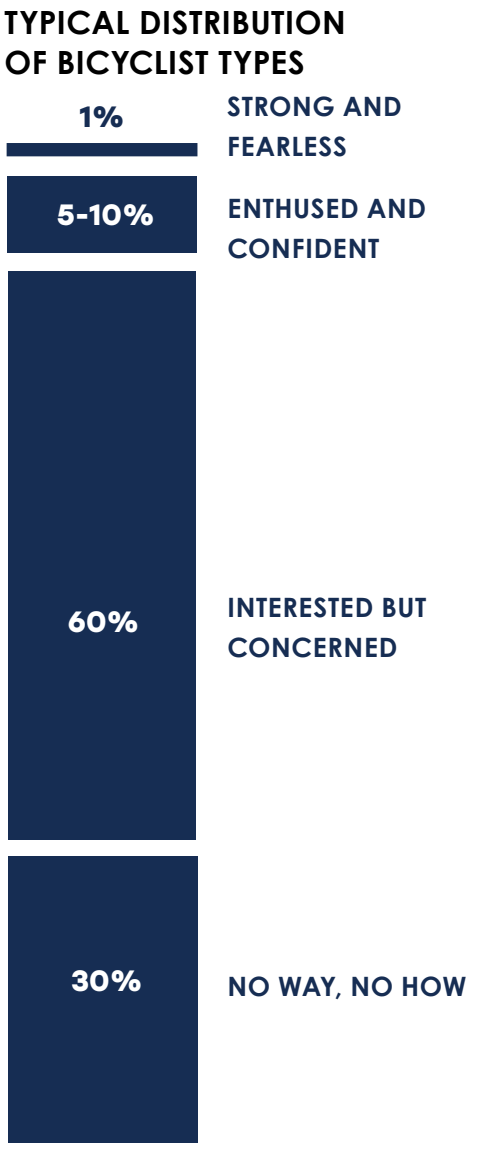
The current AASHTO Guide to the Development of Bicycle Facilities encourages designers to identify their rider type based on the trip purpose (Recreational vs Transportation) and on the level of comfort and skill of the rider (Causal vs Experienced). A user-type framework for understanding a potential rider's willingness to bike is illustrated in the figure below. Developed by planners in Portland, OR* and supported by research**, this classification identifies four distinct types of bicyclists.

Strong and Fearless – This group is willing to ride a bicycle on any roadway regardless of traffic conditions. Comfortable taking the lane and riding in a vehicular manner on major streets without designated bicycle facilities.

Enthused and Confident - This group of people riding bicycles who are riding in most roadway situations but prefer to have a designated facility. Comfortable riding on major streets with a bike lane.

Interested but Concerned – This group is more cautious and has some inclination towards bicycling, but are held back by concern over sharing the road with cars. Not very comfortable on major streets, even with a striped bike lane, and prefer separated pathways or low traffic neighborhood streets.

No Way, No How – This group comprises residents who simply aren't interested at all in bicycling and may be physically unable or don't know how to ride a bicycle, and they are unlikely to adopt bicycling in any way.



** Roger Geller, City of Portland Bureau of Transportation. Four Types of Cyclists. http://www.portlandonline.com/transportation/index.cfm?&a=237507. 2009.*

*** Dill, J., McNeil, N. Four Types of Cyclists? Testing a Typology to Better Understand Bicycling Behavior and Potential. 2012.*

Facility Selection: Comfort

In order to provide a bikeway network that meets the needs of the Fargo-Moorhead's "Interested but Concerned" residents (who comprise the majority of the population), bikeways must be low-stress and comfortable. By using a metric called Level of Traffic Stress (LTS), specific facility types can be matched to the needs of people who bicycle in Fargo-Moorhead. Generally, "Interested but Concerned," users will only bicycle on LTS 1 or LTS 2 facilities.

LEVELS OF TRAFFIC STRESS (LTS)

LTS LEVEL	DESCRIPTION	WHAT TYPE OF BICYCLISTS WILL RIDE ON THIS LTS FACILITY?		
		STRONG & FEARLESS	ENTHUSIASTIC & CONFIDENT	INTERESTED BUT CONCERNED
LTS 1	Presents the lowest level of traffic stress; demands less attention from people riding bicycles, and attractive enough for a relaxing bicycle ride. Suitable for almost all people riding bicycles, including children trained to ride in the street and to safety cross intersections.	YES	YES	YES
LTS2	Presents little traffic stress and therefore suitable to most adults riding bicycles, but demandsmore attention than might be expected from children.	YES	YES	SOMETIMES
LTS3	More traffic stress than LTS2, yet significantly less than the stress of integrating with multilane traffic.	YES	SOMETIMES	NO
LTS4	A level of stress beyond LTS 3. Includes roadways that have no dedicated bicycle facilities and moderate to higher vehicle speeds and volumes OR high speed and high volume roadways WITH an exclusive riding zone (lane) where there is a significant speed differential with vehicles.	YES	NO	NO

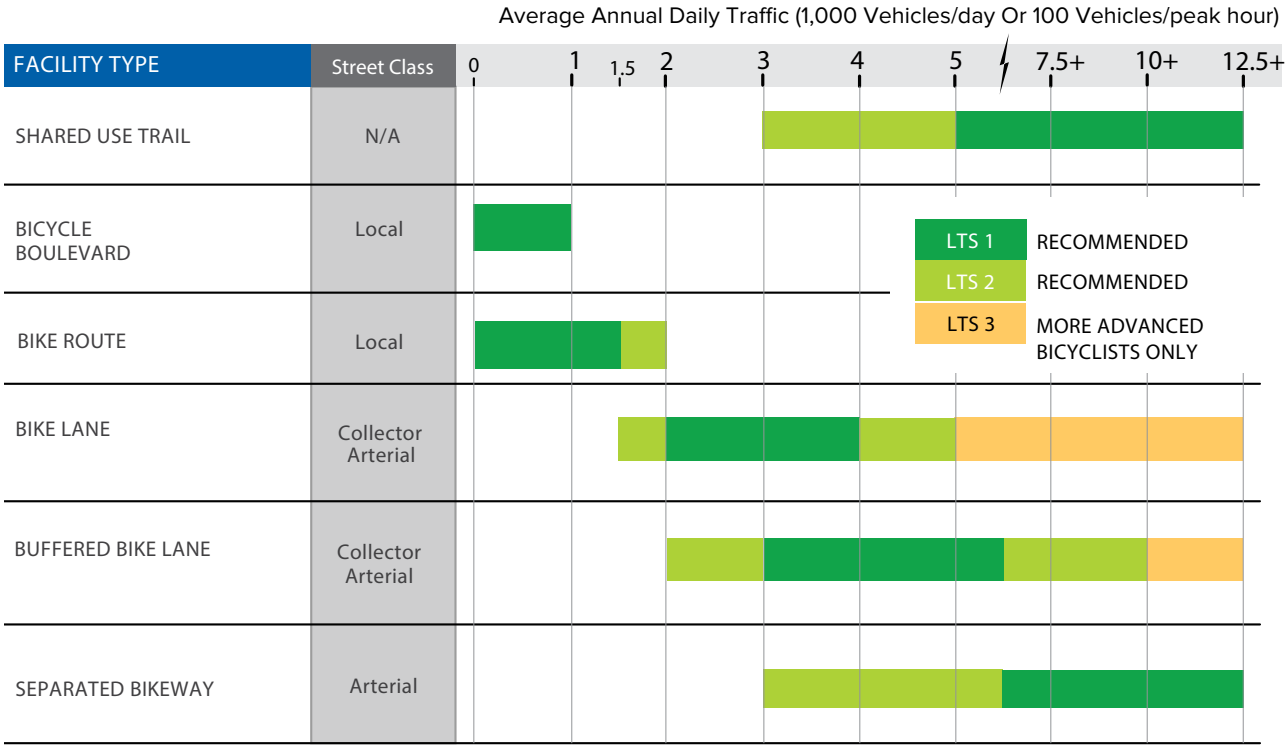
Facility Selection: Bikeways

Selecting the best bikeway facility type for a given roadway can be challenging, due to the range of factors that influence bicycle users' comfort and safety. There is a significant impact on bicycling comfort when the speed differential between bicyclists and motor vehicle traffic is high and motor vehicle traffic volumes are high. This page can help determine when a Separated Bikeway is most appropriate relative to other facility types.

Facility Selection Table

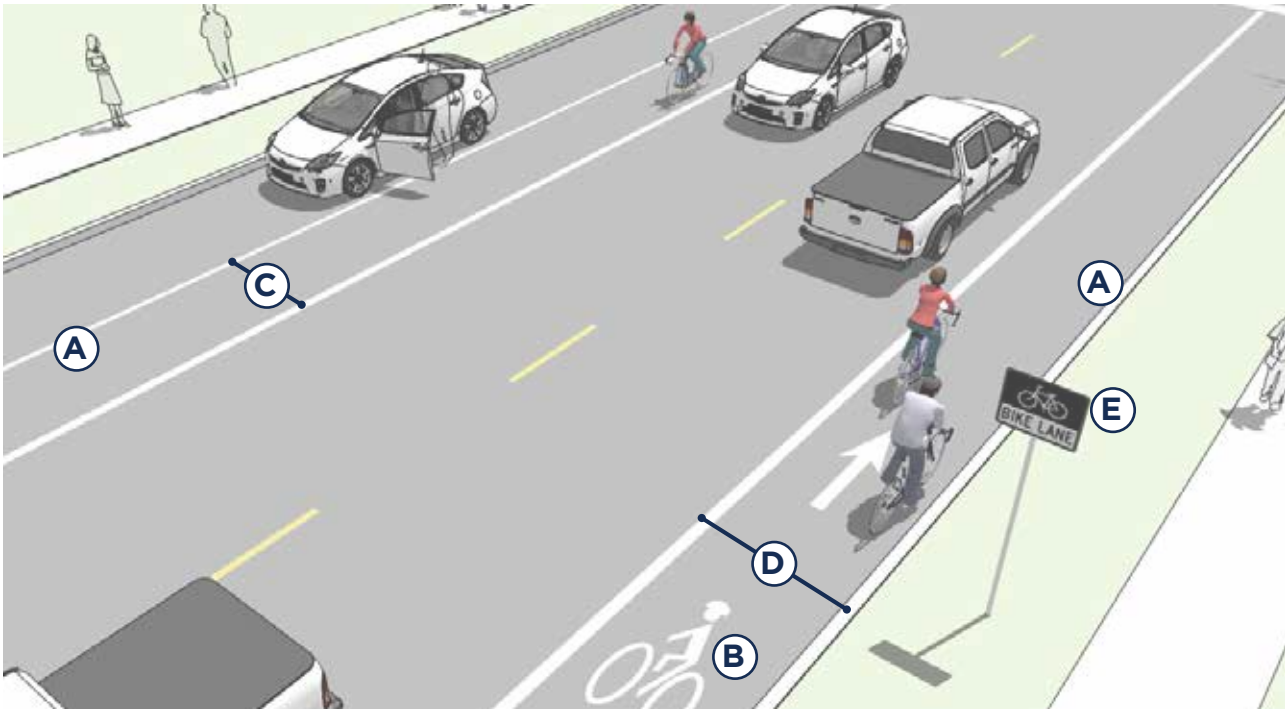
As a starting point to identify a preferred facility, the chart below can be used to determine the recommended type of bikeway to be provided in particular roadway speed and volume situations. To use this chart, identify the appropriate daily traffic volume on the existing or proposed roadway, and locate the facility types indicated by those key variables.

Other factors beyond volume which affect facility selection include traffic speed, traffic mix of automobiles and heavy vehicles, the presence of on-street parking, intersection density, surrounding land use, and roadway sight distance. These factors are not included in the facility selection chart below, but should always be considered in the facility selection and design process.



Standard Bicycle Lanes

On-street bike lanes designate an exclusive space for bicyclists through the use of pavement markings and signs. The bike lane is located directly adjacent to motor vehicle travel lanes and is usually in the same direction as motor vehicle traffic. Bike lanes are typically on the right side of the street, between the adjacent travel lane and curb, road edge or parking lane.



Typical Application

- Bike lanes may be used on any street with adequate space, but are most effective on streets with moderate traffic volumes ≤ 6,000 ADT (≤ 4,000 preferred).
- Bike lanes are most appropriate on streets with lower to moderate speeds ≤ 30 mph.
- Appropriate for skilled adult riders on most streets.
- May be appropriate for children when configured as 6+ ft wide lanes on lower-speed, lower-volume streets with one lane in each direction.

Design Features

(A) Mark inside line with 6" stripe. (MN MUTCD 9C.04) Mark 4" parking lane line or "Ts".

(B) Include a bicycle lane marking (MN MUTCD Figure 9C-3) at the beginning of blocks and at regular intervals along the route. (MN MUTCD 9C.04)

(C) 6 foot width preferred adjacent to on-street parking, (5 foot min.). Buffer preferred when parking has high turnover, see Buffered Bike Lanes.

(D) 5–6 foot preferred adjacent to curb and gutter or 4 feet more than the gutter pan width.

(E) The R3-17 "Bike Lane" sign is optional, but recommended in most contexts.

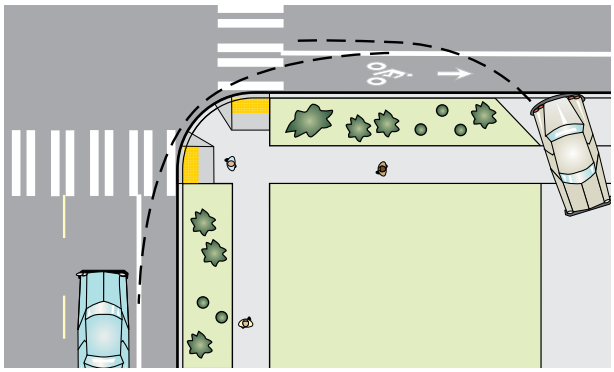
Further Considerations

- On high speed streets (≥ 40 mph) the minimum bike lane should be 6 feet.
- It may be desirable to reduce the width of general purpose travel lanes in order to add or widen bicycle lanes.
- On multi-lane streets, the most appropriate bicycle facility to provide for user comfort may be buffered bicycle lanes or physically separated bicycle lanes.
- Contraflow bike lanes are a special type of bike lane that can be implemented in specific locations where a dedicated bike lane is needed for a particular direction of travel, but the roadway is oriented for one-way travel in the opposite direction, and/or when space constraints preclude a bike facility on nearby parallel routes that would otherwise serve this need. Contraflow bike lanes are effective in providing short, critical connections along bikeways, and special attention needs to be paid to facility transitions to other bikeway types.

MANHOLE COVERS AND GRATES:

- Manhole surfaces should be manufactured with a shallow surface texture in the form of a tight, nonlinear pattern.
- If manholes or other utility access boxes are to be located in bike lanes within 50 ft. of intersections or within 20 ft. of driveways or other bicycle access points, special manufactured permanent nonstick surfaces ensure a controlled travel surface for bicyclists breaking or turning.
- Manholes, drainage grates, or other obstacles should be set flush with the paved roadway. Roadway surface inconsistencies pose a threat to safe riding conditions for bicyclists. Construction of manholes, access panels or other drainage elements should be constructed with no variation in the surface. The maximum allowable tolerance in vertical roadway surface should be 1/4 of an inch.

Bike lanes provided dedicated spaces for bicyclists to ride on the street.



PLACE BIKE LANE SYMBOLS TO REDUCE WEAR

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

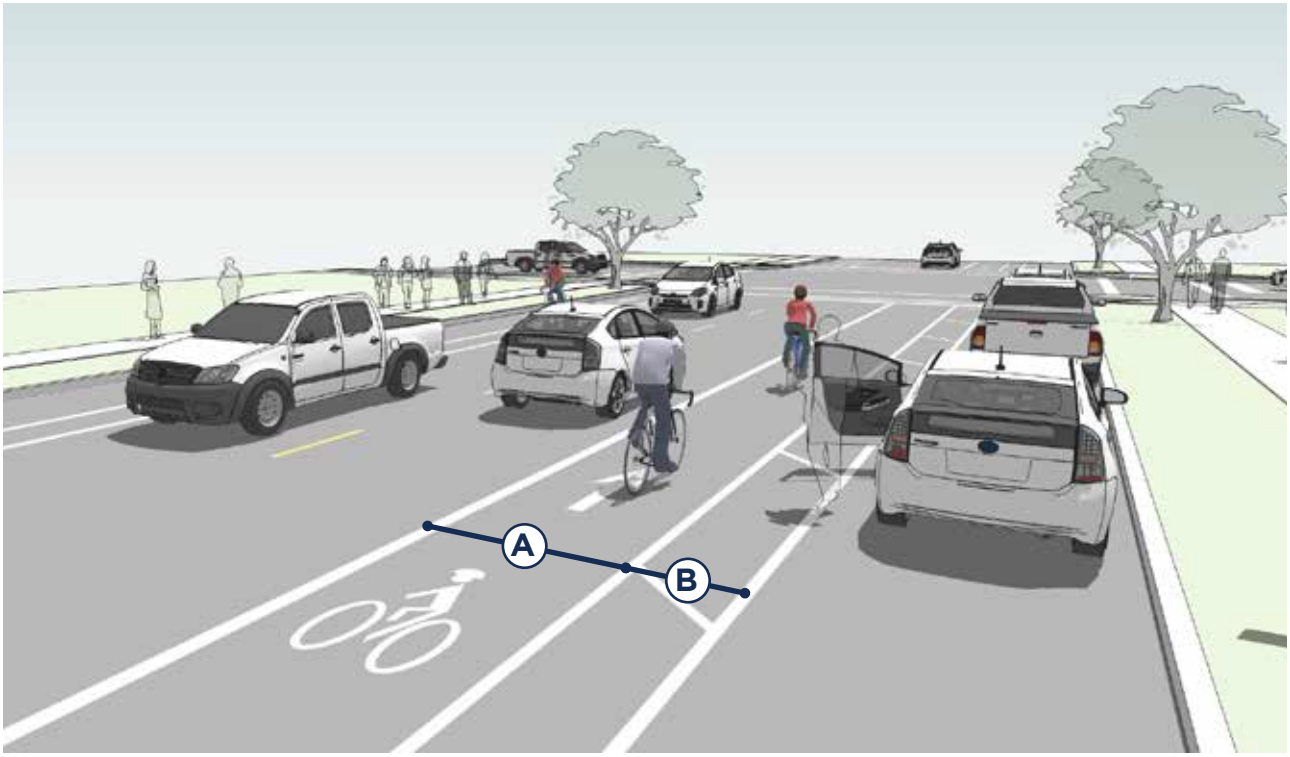
Materials and Maintenance

Bike lane striping and markings will require higher maintenance where vehicles frequently traverse over them at intersections, driveways, parking lanes, and along curved or constrained segments of roadway.

Bike lanes should also be maintained so that there are no pot holes, cracks, uneven surfaces or debris.

Buffered Bicycle Lanes

Buffered bike lanes are conventional bicycle lanes paired with a designated buffer space, separating the bicycle lane from the adjacent motor vehicle travel lane and/or parking lane.



Typical Application

- Anywhere a conventional bike lane is being considered.
- While conventional bike lanes are most appropriate on streets with lower to moderate speeds (≤ 30 mph), buffered bike lanes provide additional value on streets with higher speeds (+30 mph) and high volumes or high truck volumes (up to 6,000 ADT).
- On streets with extra lanes or lane width.
- Appropriate for skilled adult riders on most streets.

Design Features

(A) The minimum bicycle travel area (not including buffer) is 5 feet wide.

(B) Buffers should be at least 2 feet wide. If buffer area is 4 feet or wider, white chevron or diagonal markings should be used.

- For clarity at driveways or minor street crossings, a dotted line may be used.
- Buffers may be applied on the parking side, the travel side, both or alternating depending on the main source of concern.

Buffered bike lanes should consider both vehicular traffic and parked cars.

The use of additional pavement markings delineates space between vehicles and bicyclists.

Further Considerations

- Color may be used within the lane to discourage motorists from entering the buffered lane.
- On multi-lane streets with high vehicles speeds, the most appropriate bicycle facility to provide for user comfort may be physically separated bike lanes.
- NCHRP Report #766 recommends, when space is limited, installing a buffer space between the parking lane and bicycle lane where on-street parking is permitted rather than between the bicycle lane and vehicle travel lane.[1] This buffer is particularly useful in commercial areas where parking turnover is higher.

Materials and Maintenance

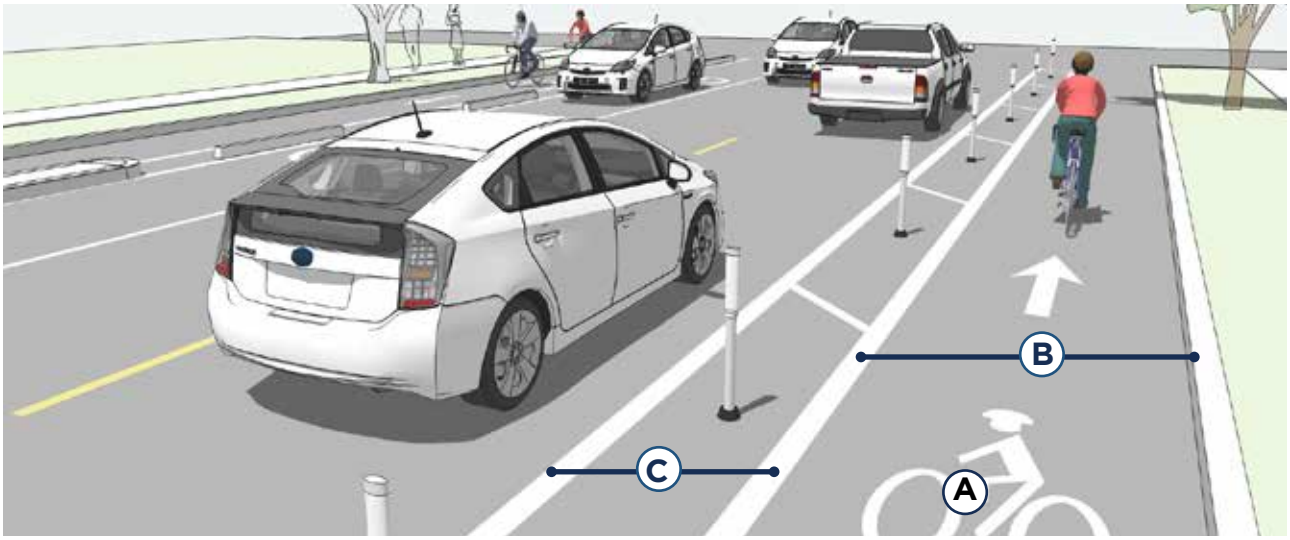
Bike lane striping and markings will require higher maintenance where vehicles frequently traverse over them at intersections, driveways, parking lanes, and along curved or constrained segments of roadway.

Bike lanes should be maintained so that there are no pot holes, cracks, uneven surfaces or debris. Additionally, the bike lane buffer presents an opportunity to be used for snow storage in winter months.

1 National Cooperative Highway Research Program. Report #766: Recommended Bicycle Lane Widths for Various Roadway Characteristics.

Separated Bike Lanes - One-Way

One-way separated bike lanes, also known as protected bikeways or cycle tracks, are on-street bikeway facilities that are separated from vehicle traffic. Physical separation is provided by a barrier between the bikeway and the vehicular travel lane. These barriers can include flexible posts, bollards, parking, planter strips, extruded curbs, or on-street parking. Separated bikeways using these barrier elements typically share the same elevation as adjacent travel lanes, but the bikeway could also be raised above street level, either below or equivalent to sidewalk level.



Typical Use

- Along streets on which conventional bicycle lanes would cause many bicyclists to feel stress because of factors such as multiple lanes, high bicycle volumes, high motor traffic volumes (9,000-30,000 ADT), higher traffic speeds (35+ mph), high incidence of double parking, higher truck traffic (10% of total ADT) and high parking turnover.
- Along streets for which conflicts at intersections can be effectively mitigated using parking lane setbacks, bicycle markings through the intersection, and other signalized intersection treatments.

Design Features

(A) Pavement markings, symbols and/or arrow markings must be placed at the beginning of the separated bikeway and at intervals along the facility based on engineering judgment to define the bike direction. (MN MUTCD 9C.04)

(B) 6'-7' foot width preferred in areas with high bicycle volumes or uphill sections to facilitate safe passing behavior.

(C) When placed adjacent to parking, the parking buffer should be 3 ft wide to allow for passenger loading and to prevent door collisions. When no buffer is present, buffers as narrow as 18 inches may still provide value.

- When placed adjacent to a travel lane, one-way raised cycle tracks may be configured with a mountable curb to allow entry and exit from the bicycle lane for passing other bicyclists or to access vehicular turn lanes.

Parked cars serve as a barrier between bicyclists and the vehicle lane. Barriers could also include flexible posts, bollards, planters, or other design elements. Source: Alta

Further Considerations

- If the buffer area is 4 feet or wider, white chevron or diagonal markings should be used.
- Curbs may be used as a channeling device. Grade-separation provides an enhanced level of separation in addition to buffers and other barrier types.
- Where possible, physical barriers such as removable curbs should be oriented towards the travel lane side of the buffer to provide as much extra width as possible for bicycle use.
- When buffer area allows (minimum 6' width) incorporate stormwater infrastructure and shade trees.
- Gutters, drainage outlets and utility covers should be designed and configured as not to impact bicycle travel.
- For clarity at major or minor street crossings, consider crossing markings for the buffer boundary where cars are expected to cross. See treatment on page 60.
- Special consideration should be given at transit stops to manage bicycle and pedestrian interactions.
- When placed adjacent to a travel lane, one-way raised separated bike lanes may be configured with a mountable curb to allow entry and exit from the bicycle lane for passing other bicyclists or to access vehicular turn lanes.

Materials and Maintenance

Bikeway striping and markings will require higher maintenance where vehicles frequently traverse over them at intersections, driveways, parking lanes, and along curved or constrained segments of roadway. Green conflict striping (if used) will also generally require higher maintenance due to vehicle wear.

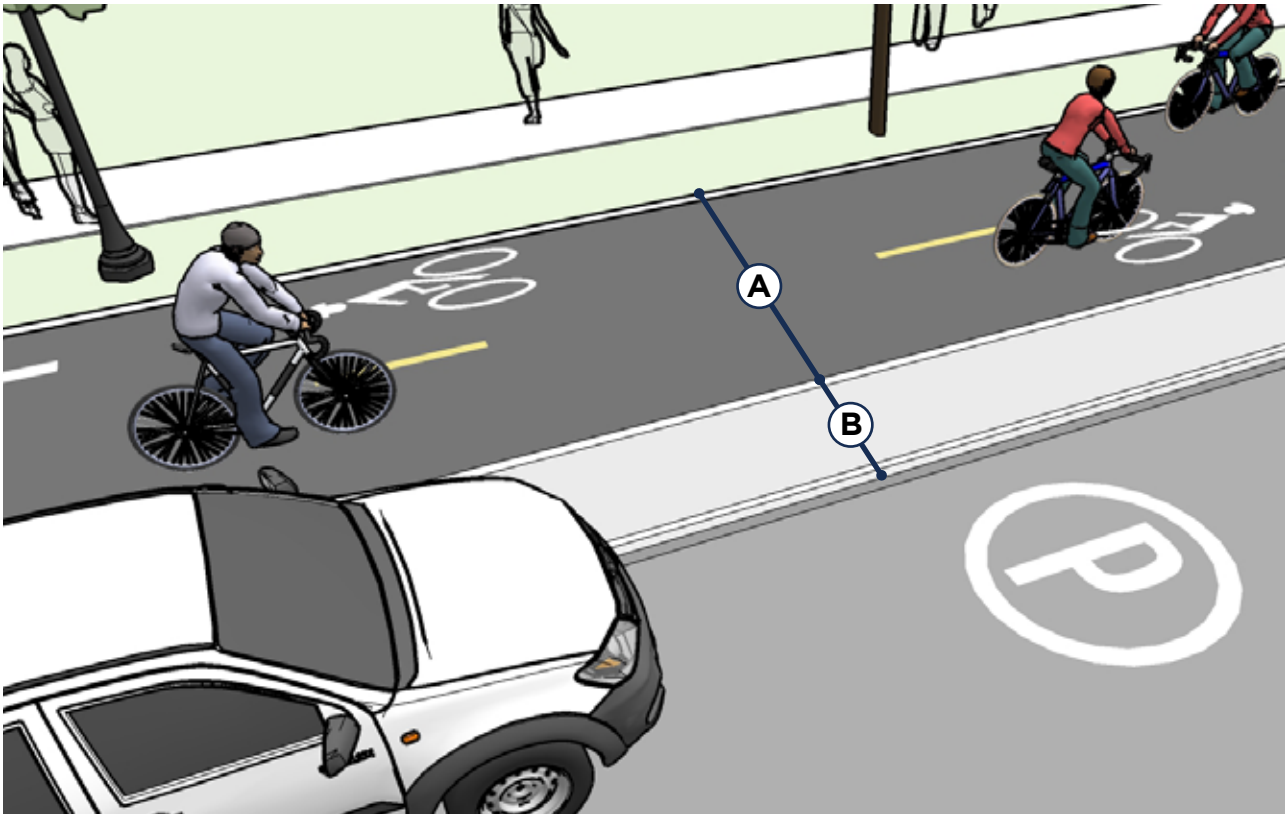
Bikeways should be maintained so that there are no pot holes, cracks, uneven surfaces or debris.

Access points along the facility should be provided for street sweeper vehicles to enter/exit the separated bikeway.

Install composite and reboundable delineator systems, which offer more durability and better withstand winter conditions. Otherwise, delineators should be removed during winter for plowing operations as the buffer area can be used for snow storage.

Separated Bike Lanes - Two-Way

Two-Way separated bike lanes are bicycle facilities that allow bicycle movement in both directions on one side of the road. Two-way separated bikeways share some of the same design characteristics as one-way separated bikeways, but often require additional considerations at driveway and side-street crossings, and intersections with other bikeways.



Typical Application

Works best on the left side of one-way streets.

- Streets with high motor vehicle volumes and/or speeds
- Streets with high bicycle volumes.
- Streets with a high incidence of wrong-way bicycle riding.
- Streets with few conflicts such as driveways or cross-streets on one side of the street.
- Streets that connect to shared use paths.

Design Features

(A) 12 foot operating width preferred (10 ft minimum) width for two-way facility.

- In constrained locations an 8 foot minimum operating width may be considered.

(B) Adjacent to on-street parking a 3 foot minimum width channelized buffer or island should be provided

A two-way facility can accommodate bicyclists in two directions of travel.

to accommodate opening doors. (NACTO, 2012).

- Additional signalization and signs may be necessary to manage conflicts.

Further Considerations

- A two-way separated bikeway on one way street should be located on the left side.
- A two-way separated bikeway may be configured at street level or as a raised separated bikeway with vertical separation from the adjacent travel lane.
- Two-way separated bikeways should ideally be placed along streets with long blocks and few driveways or mid-block access points for motor vehicles.
- Two-way separated bikeways may have implications for signalized and unsignalized intersections that put contra-flow bicyclists in increased levels of risk. This should be strongly considered with any project. Bicycle exclusive signals and other control elements are often recommended with two-way separated bikeways.

Materials and Maintenance

Bikeway striping and markings will require higher maintenance where vehicles frequently traverse over them at intersections, driveways, parking lanes, and along curved or constrained segments of roadway. Green conflict striping (if used) will also generally require higher maintenance due to vehicle wear.

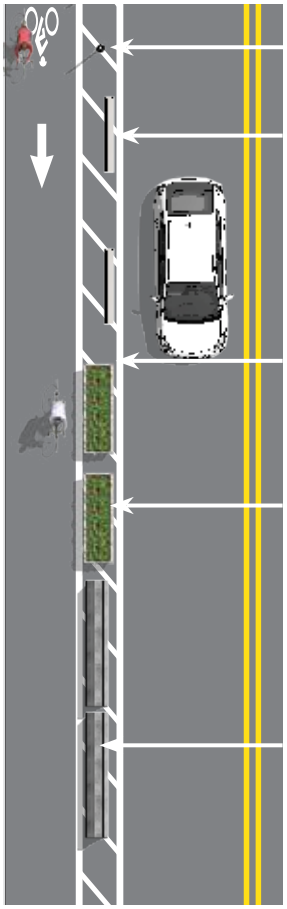
Bikeways should be maintained so that there are no pot holes, cracks, uneven surfaces or debris.

Access points along the facility should be provided for street sweeper vehicles to enter/exit the separated bikeway.

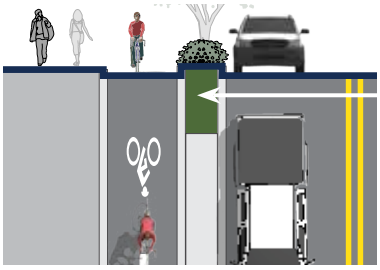
Separated Bike Lane Barriers

Separated bike lanes may use a variety of vertical elements to physically separate the bikeway from adjacent travel lanes. Barriers may be robust constructed elements such as curbs, or may be more interim in nature, such as flexible delineator posts.

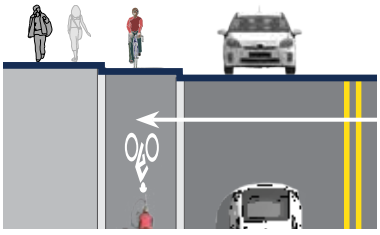
BARRIER SEPARATION



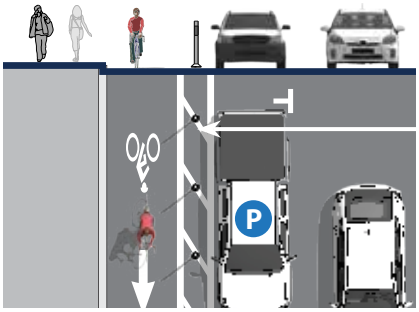
MEDIA SEPARATION



ELEVATION SEPARATION



PARKING SEPARATION



Typical Application

APPROPRIATE BARRIERS FOR RETROFIT PROJECTS:

- Parked cars
- Flexible delineators
- Bollards
- Planters
- Parking stops (for use in areas where winter maintenance is not an issue)

APPROPRIATE BARRIERS FOR RECONSTRUCTION PROJECTS:

- Curb separation
- Medians
- Landscaped medians
- Raised protected bike lane with vertical or mountable curb
- Pedestrian Refuge Islands

Raised separated bikeways are bicycle facilities that are vertically separated from motor vehicle traffic.

Design Features

- Maximize effective operating space by placing curbs or delineator posts as far from the through bikeway space as practicable.
- Allow for adequate shy distance of 1 to 5 feet from vertical elements to maximize useful space.
- When next to parking allow for 3 feet of space in the buffer space to allow for opening doors and passenger unloading.
- The presences of landscaping in medians, planters and safety islands increases comfort for users and enhances the streetscape environment.

Further Considerations

- With new roadway construction, a raised separated bikeway can be less expensive to construct than a wide or buffered bicycle lane because of shoulder trenching and sub base requirements.
- Parking should be prohibited within 30 feet of intersections and driveways to improve visibility.
- When separation width allows, stormwater infrastructure and shade trees should be considered. Minimum 6' width needed for these improvements.

Materials and Maintenance

Separated bikeways protected by concrete islands or other permanent physical separation, can be swept and plowed by smaller street sweeper vehicles.

Access points along the facility should be provided for street sweeper vehicles to enter/exit the separated bikeway.

Bike Boulevards
Bike Boulevard Overview

A Bike Boulevard is a low-speed, low-volume roadway that is designed to enhance comfort and convenience for people bicycling. It provides better conditions for bicycling while improving the neighborhood character and maintaining emergency vehicle access. Bike Boulevards are intended to serve as a low-stress bikeway network, providing direct, and convenient routes across Fargo-Moorhead. Key elements of Bike Boulevards are unique signage and pavement markings, traffic calming and diversion features to maintain low vehicle volumes, and convenient major street crossings.

Treatments depicted may vary per roadway segment or location.

Typical Use

- Parallel with and in close proximity to major thoroughfares (1/4 mile or less) on low-volume, low-speed streets.
- Follow a desire line for bicycle travel that is ideally long and relatively continuous (2-5 miles).
- Avoid alignments with excessive zigzag or circuitous routing. The bikeway should have less than 10% out of direction travel compared to shortest path of primary corridor.
- Local streets with traffic volumes of fewer than 3,000 vehicles per day and with average operating speeds below 30 mph. Utilize traffic calming to maintain or establish low volumes and discourage vehicle cut through / speeding.

Design Features

- Signs and pavement markings are the minimum treatments necessary to designate a street as a bike boulevard.

A painted intersection, planters, and curb extensions to reinforce that the street is intended for local, slow-speed use instead of cut-through vehicle traffic.

An example of an large pavement marking to reinforce that the street is a Bike Boulevard.

- Implement volume control treatments based on the context of the bike boulevard, using engineering judgment. While motor vehicle volumes should not exceed 3,000 vehicles per day, ideal conditions are 1,500 vehicles per day or less.
- Intersection crossings should be designed to enhance comfort and minimize delay for bicyclists of diverse skills and abilities.

Further Considerations

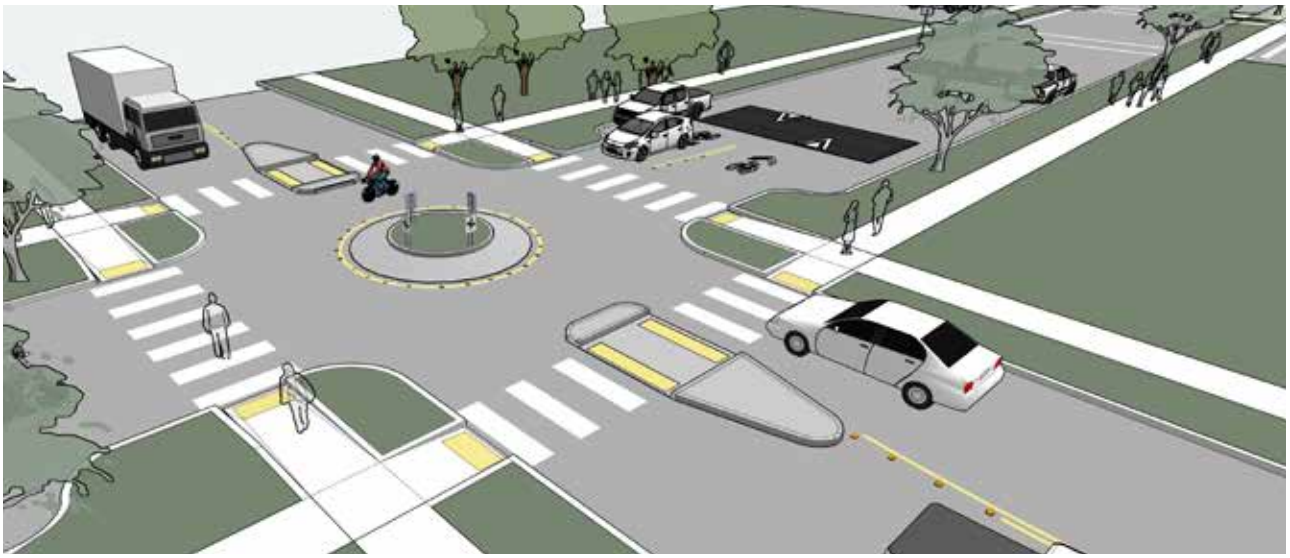
- Bike Boulevards are established on streets that improve connectivity to key destinations and provide a direct, low-stress route for bicyclists, with low motorized traffic volumes and speeds, designated and designed to give bicycle travel priority over other modes.
- Bike Boulevard retrofits to local streets are typically located on streets without existing signalized accommodation at crossings of collector and arterial roadways. Without treatments for bicyclists, these intersections can become major barriers along the Bike Boulevard.
- Traffic calming can slow or deter motorists from driving on a street. Anticipate and monitor vehicle volumes on adjacent streets to determine whether traffic calming results in inappropriate volumes. Traffic calming can be implemented on a trial basis.

Materials and Maintenance

Bike Boulevards require few additional maintenance requirements to local roadways. Signage, signals, and other traffic calming elements should be inspected and maintained according to local standards.

Traffic Calming

Traffic calming devices can help mitigate speeding and cut-through traffic by changing driver behavior through a variety of visual or physical changes to the road environment. Such measures may reduce the design speed of a street and can be used in conjunction with reduced speed limits to reinforce the expectation of lowered speeds.



Typical Application

- Traffic calming measures should be limited to local or minor collector streets, typically with a maximum posted speed of 35 mph.
- Traffic calming measures should be implemented when the safety of all roadway users, especially pedestrians and bicyclists, is at risk due to high vehicular speeds. The risk can be determined by an engineering study.
- Traffic calming measures can be more applicable in areas with high potential for conflict between pedestrian/bicyclist and motor vehicles.
- Traffic calming measures may be most appropriate in areas with predominantly residential or mixed-use land use.
- If applicable, traffic calming measures should not infringe on bicycle space. Where possible, provide a bicycle route outside of the element so bicyclists can avoid having to merge into traffic at a narrow pinch point.
- Traffic calming measures should always consider emergency vehicle response times and turning abilities.

Further Consideration

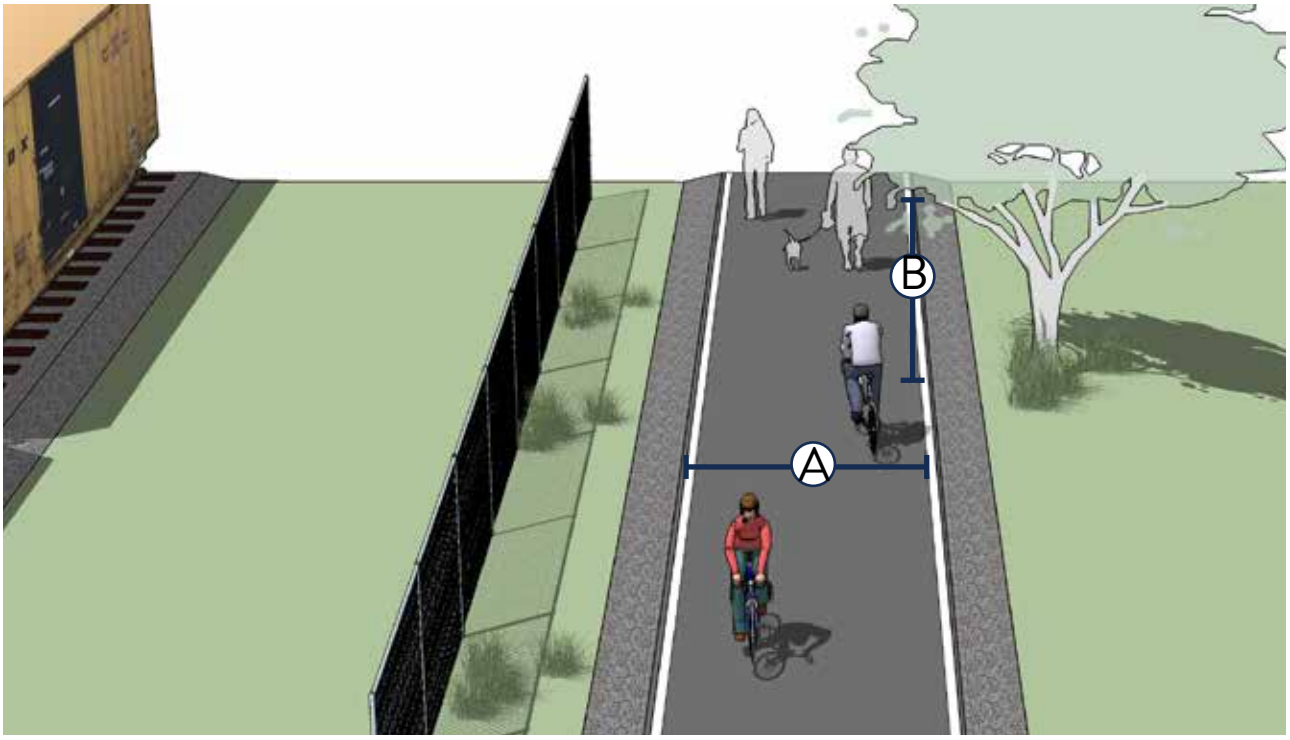
BENEFITS OF TRAFFIC CALMING:

- Improves conditions for bicyclists, pedestrians, and residents on local and minor collector streets.
- Reduced travel speeds decreases the exposure risks between bicyclists/ pedestrians and motor vehicles.
- Reduced travel speeds result in reduced injury severity in the event of a collision.
- Helps achieve a safer and more livable neighborhood while balancing the transportation needs of the roadway.

SHARED USE PATHS

Shared Use Paths

A shared use path provides a travel area separate from motorized traffic for bicyclists, pedestrians, skaters, wheelchair users, joggers, and other users. Shared use paths are desirable for bicyclists of all skill levels preferring separation from traffic. Bicycle paths should generally provide directional travel opportunities not provided by existing roadways. Most shared use paths are designed for two-way travel.



Typical Use

- In waterway corridors, such as along canals, drainage ditches, rivers, and creeks.
- In abandoned rail corridors (commonly referred to as Rails-to-Trails or Rail-Trails.)
- In active rail corridors, trails can be built adjacent to active railroads (referred to as Rails-with-Trails.)
- In utility corridors, such as power line and sewer corridors.
- Along roadways.
- Through parks.

Design Features

Ⓐ 12 ft of width is recommended for heavy use situations with high concentrations of multiple users. A separate track (5' minimum) can be provided for pedestrian use.

- 10 ft is recommended in most situations and will be adequate for moderate to heavy use.
- 8 ft is the minimum width (with 2' ft shoulders) allowed for a two-way bicycle trail and is only recommended for low traffic situations.

LATERAL CLEARANCE

- A 2 ft or greater shoulder on both sides of the trail should be provided.

OVERHEAD CLEARANCE

Ⓑ Clearance to overhead obstructions should be 8 ft minimum, with 10 ft recommended.

STRIPING

- When striping is required, use a 4 inch dashed yellow centerline stripe with 4 inch solid white edge lines.
- Solid centerlines can be provided on tight or blind corners and transitions, and on the approaches to roadway crossings.

Further Considerations

Under most conditions, centerline markings are not necessary. Centerline markings should only be used if necessary for clarifying user positioning or preferred operating procedure: Solid line = No Passing; Dashed line = Lane placement

Trails with a high volume of bidirectional traffic should include a centerline. This can help communicate that users should expect traffic in both directions and encourage users to travel on the right and pass on the left.

Where there is a sharp blind curve, painting a solid yellow line with directional arrows reduces the risk of head-on collisions.

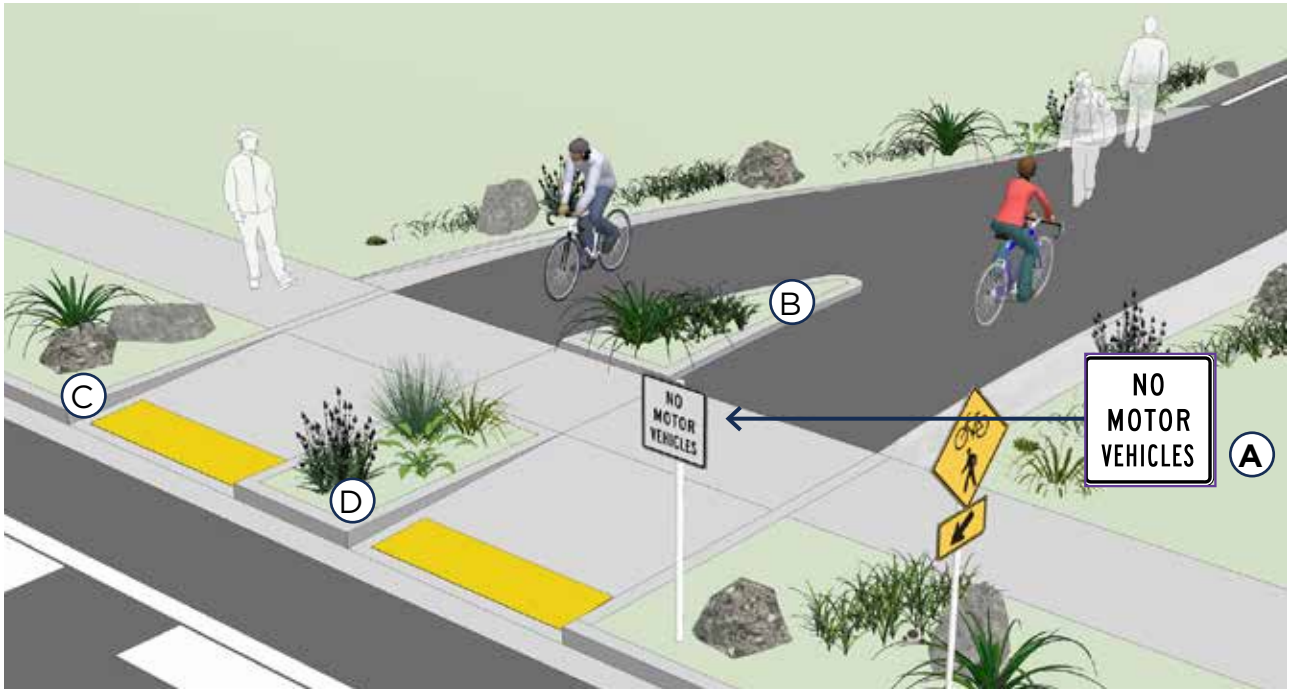
Small scale signs should be used in trail environments.

Terminate the trail where it is easily accessible to and from the street system, preferably at a trailhead, controlled intersection or at the beginning of a dead-end street.

Use of bollards should be avoided when possible as they provide a safety hazard to bicyclists and have caused many serious injury. If bollards are used at intersections and access points, they should be colored brightly and/or supplemented with reflective materials to be visible at night.

Bollard Alternatives

Bollards are physical barriers designed to restrict motor vehicle access to the shared use path. Unfortunately, physical barriers are often ineffective at preventing access, and create obstacles to legitimate trail users. Alternative design strategies use signage, landscaping and curb cut design to reduce the likelihood of motor vehicle access.



Typical Application

- Bollards or other barriers should not be used unless there is a documented history of unauthorized intrusion by motor vehicles.
- If unauthorized use persists, assess whether the problems posed by unauthorized access exceed the risks and issues posed by bollards and other barriers.

Design Features

(A) "No Motor Vehicles" signage (R5-3) to be used to reinforce access rules.

(B) At intersections, split the trail tread into two sections separated by low landscaping.

(C) Vertical curb cuts should be used to discourage motor vehicle access.

(D) Low landscaping preserves visibility and emergency access.

Screening/Barrier Separation Types

Urban trails typically transverse through a range of channel configurations, trail types, and adjacent land uses. As a result, a toolkit of options is required in order to apply appropriate edge conditions to the unique circumstances along the trail. Edge conditions comprise the range of treatments used to transition from the path of travel to space adjacent to the trail. Edge conditions include shoulder buffers, screening, barriers, railing, and other visual and tactile cues to indicate the path of travel. These treatments keep users from venturing off the trail, protect users from hazards, delineate the path of travel where users are separated by direction, mode or speed, and enhance the comfort and attractiveness of the trail.

Design Features

Shoulders should be a minimum of 2 feet wide (3 feet preferred). Shoulders should be sloped at 2% to 5% away to reduce ponding and minimize debris on the trail. Two feet minimum is required where signage or other furnishings will be installed. A shoulder of at least 1 foot should be provided between the trail and any fencing or barrier. Where the shoulder serves as a pedestrian path, a maximum cross slope of 2% is required to remain compliant with ADA regulations.

BARRIERS AND RAILINGS

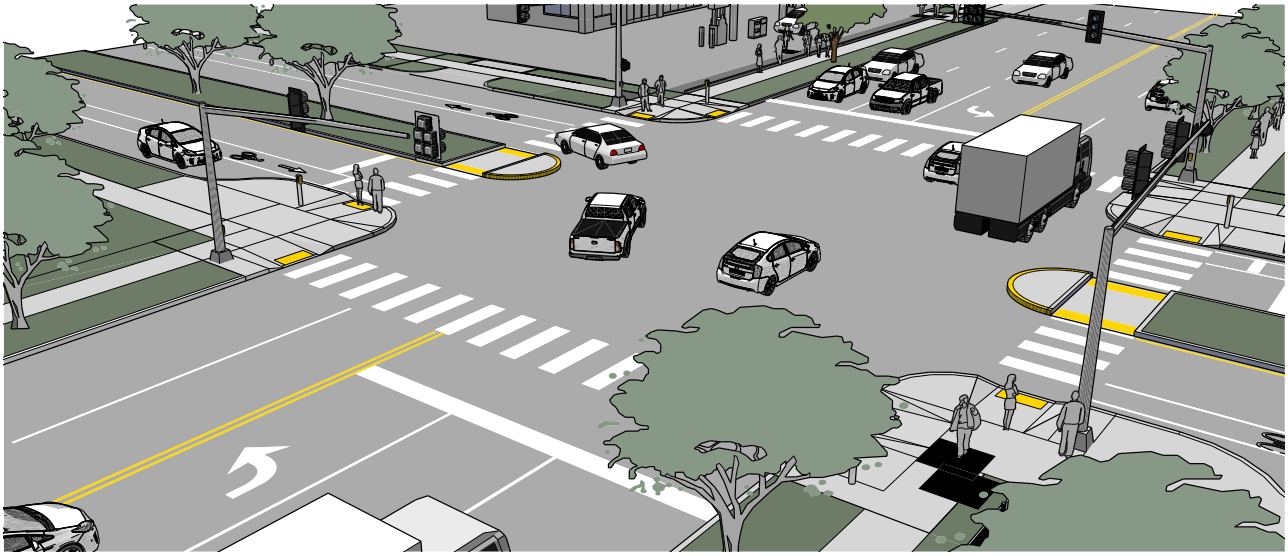
Fences, walls, and railings will likely be a recurring element along the trail to provide separation between the trail and the channel edge, rail lines, or private property. In some areas, railings and/ or security fences will be on both sides of the trail.

ENHANCED CROSSING TREATMENTS

Marked Crosswalks at Intersections

Marked crosswalks signal to motorists that they must stop for pedestrians and encourages pedestrians to cross at designated locations. Installing crosswalks alone will not necessarily make crossings safer, particularly on multi-lane roadways.

Marked crosswalks across the uncontrolled leg of unsignalized intersections should follow the design guidance of marked crosswalks at mid-block locations.



Typical Application

At signalized intersections, all crosswalks should be marked. At unsignalized intersections, crosswalks may be marked under the following conditions:

- At an intersection within a school zone or on a walking route, trail crossings, and at parks, libraries, or community centers.
- At a complex intersection, to orient pedestrians in finding their way across.
- At an offset intersection, to show pedestrians the preferred route across traffic with the least exposure to vehicular traffic and traffic conflicts.
- At an intersection with visibility constraints, to position pedestrians where they can best be seen by oncoming traffic.

Design Features

- The crosswalk should be located to align as closely as possible with the through pedestrian zone of the sidewalk corridor.

- Transverse markings are the most basic crosswalk marking type, but may wear faster as every vehicle drives over the markings.
- Continental markings provide improved visibility and can be located outside of vehicle wheel paths.
- Local climate can present unique challenges for pavement markings due to extreme heat/ cold, snow plows, and de-icing techniques.

Further Considerations

Continental crosswalk markings should be used at crossings with high pedestrian use, particularly where the crossing is not controlled by signals or stop signs, such as a local street crossing of a multi-lane arterial. These type of markings should also be used where vulnerable pedestrians are expected, including crossings near schools. Continental crosswalk markings also require less on-going maintenance and lasts longer than other marking techniques.

Materials and Maintenance

The effectiveness of marked crossings depends entirely on their visibility; maintaining marked crossings should be a high priority. Thermoplastic markings offer increased durability when compared to conventional paint.[1]

1 The appropriate marking material(s) should be determined on a project basis.

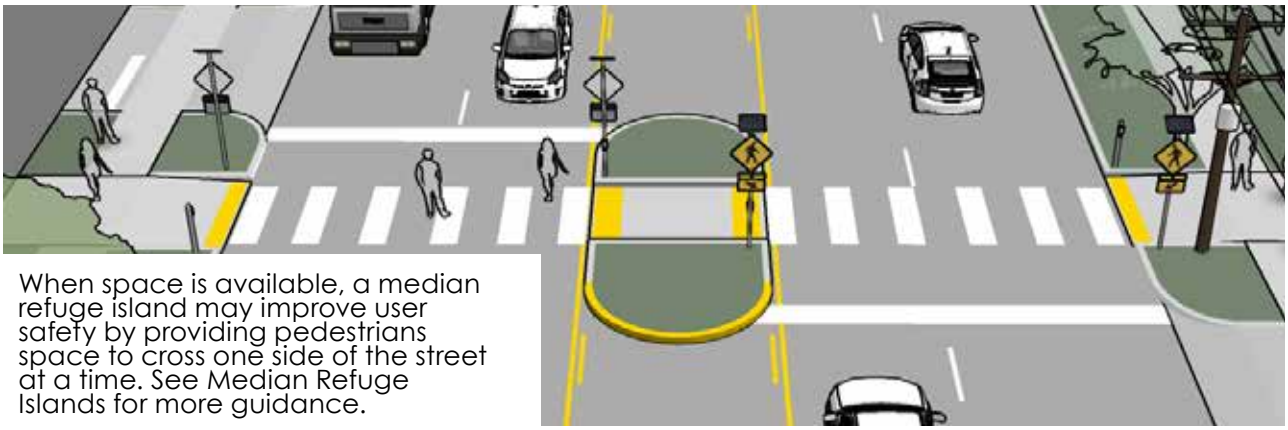
Crosswalk Examples

TRANSVERSE MARKINGS

CONTINENTAL MARKINGS

Marked Crosswalks at Mid-Block

To create a legal mid-block crossing, a marked crosswalk must be provided. High quality mid-block crossings may include warning signage, and other treatments to slow or stop traffic such as curb extensions, median refuges, beacons, hybrid beacons, and signals. Designing crossings at mid-block locations depends on an evaluation of motor vehicle traffic volumes, sight distance, pedestrian traffic volumes, land use patterns, vehicle speed, and road type and width.



When space is available, a median refuge island may improve user safety by providing pedestrians space to cross one side of the street at a time. See Median Refuge Islands for more guidance.

Typical Application

Locations where mid-block crossings should be considered include:

- Long blocks (longer than 600 ft.) with destinations on both sides of the street.
- Locations with heavy pedestrian traffic, such as schools, shopping centers, and shared use path crossings.
- At transit stops, where transit riders must cross the street on one leg of their journey.

Design Features

- Advance stop lines should be placed 20-50 feet in advance of multi-lane uncontrolled mid-block crossings
- Crosswalk markings legally establish mid-block pedestrian crossing
- Pedestrian and stop warning signage (W11-2 and R1-5C) should be installed at the crossing to alert drivers of the potential presence of pedestrians in the roadway

Further Considerations

Uncontrolled crossings of multi-lane roadways with over 15,000 ADT may be possible with features such as sufficient crossing gaps in vehicular traffic (more than 60 per hour), median refuges, or beacons, and good sight distance.

On roadways with low to moderate traffic volumes and posted speeds at or below 30 mph, a raised crosswalk may be the most appropriate crossing design to improve pedestrian visibility and safety.

Median Refuge Islands

Median refuge islands are located at the mid-point of a marked crossing and help improve safety by increasing visibility and allowing pedestrians to cross one direction of traffic at a time. Refuge islands minimize pedestrian exposure at mid-block crossings by shortening the crossing distance and increasing the number of available gaps for crossing.

Median refuge islands can also be configured as an off-set crossing. This requires pedestrians to change their direction of travel while in the median - to face on-coming vehicles - before crossing. Here, pedestrians are more likely to see, and establish eye contact with on-coming motorists before stepping into the roadway.

Typical Application

- Refuge islands can be applied on any roadway with a left turn center lane or median that is at least 6' wide.
- Islands are appropriate at signalized or unsignalized crosswalks.
- The refuge island must be accessible, preferably with an at-grade passage through the island rather than ramps and landings.
- The island should be at least 6' wide between travel lanes and at least 20' long (40' minimum preferred).
- Provide double centerline marking, reflectors, and "KEEP RIGHT" signage in the island on streets with posted speeds above 30 mph.

Design Features

- Cut-through median refuge islands are preferred over curb ramps to better accommodate wheel chairs users.
- Pedestrian warning signage should be placed at the crossing. Advanced warning signage should also be considered where site obstructions may be present on the approach.

Further Considerations

This treatment may be combined with Rectangular Rapid Flashing Beacons (RRFBs). See treatment description for more information.

Materials and Maintenance

Refuge islands may require frequent maintenance of road debris. Trees and plantings in a landscaped median must be maintained so as not to impair visibility, and should be no higher than 30 inches.

Signals and Beacons
Pedestrian Signalization Improvements

Typical Application

Pedestrian signal heads indicate to pedestrians when to cross at a signalized crosswalk. Pedestrian signal indications are recommended at all traffic signals except where pedestrian crossing is prohibited by signage.

Countdown signals should be used at all new and rehabbed signalized intersections.

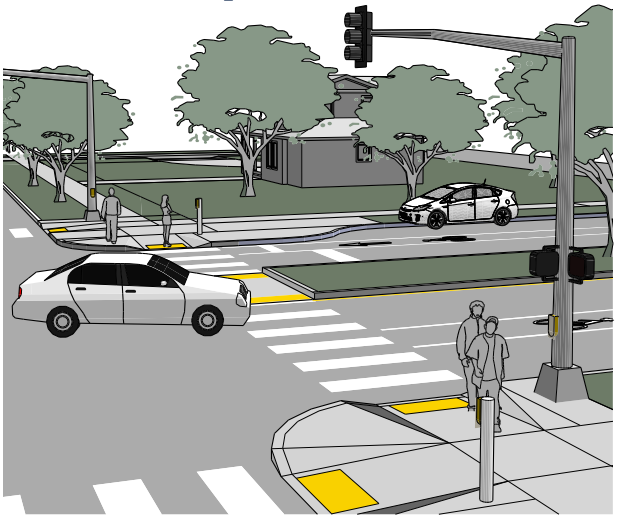
Design Features

Adequate pedestrian crossing time is a critical element of the walking environment at signalized intersections. The length of a signal phase with parallel pedestrian movements should provide sufficient time for a pedestrian to safely cross the adjacent street. The MN MUTCD recommends a walking speed of 3.5 ft per second.

At crossings where older pedestrians or pedestrians with disabilities are expected, crossing speeds as low as 3 ft per second should be assumed. Special pedestrian phases can be used to provide greater visibility or more crossing time for pedestrians at certain intersections.

Large pedestrian crossing distances can be broken up with medians and islands into multiple stages. If the crossing is multi-stage, pedestrian push buttons must be provided. This ensures that pedestrians are not stranded on the median, and is especially applicable on large, multi-lane roadways with high vehicle volumes, where providing sufficient pedestrian crossing time for a single stage crossing may be an issue.

- Consider the use of a Leading Pedestrian Interval (LPI) to provide additional traffic-protected crossing time to pedestrians.
- Accessible Pedestrian Signals (APS) provide crossing assistance to pedestrians with various types of disabilities at signalized intersections



Further Considerations

Pushbuttons should be located so that someone in a wheelchair can reach the button from a level area of the sidewalk without deviating significantly from the natural line of travel into the crosswalk. Pushbuttons should be marked (for example, with arrows) so that it is clear which signal is affected.

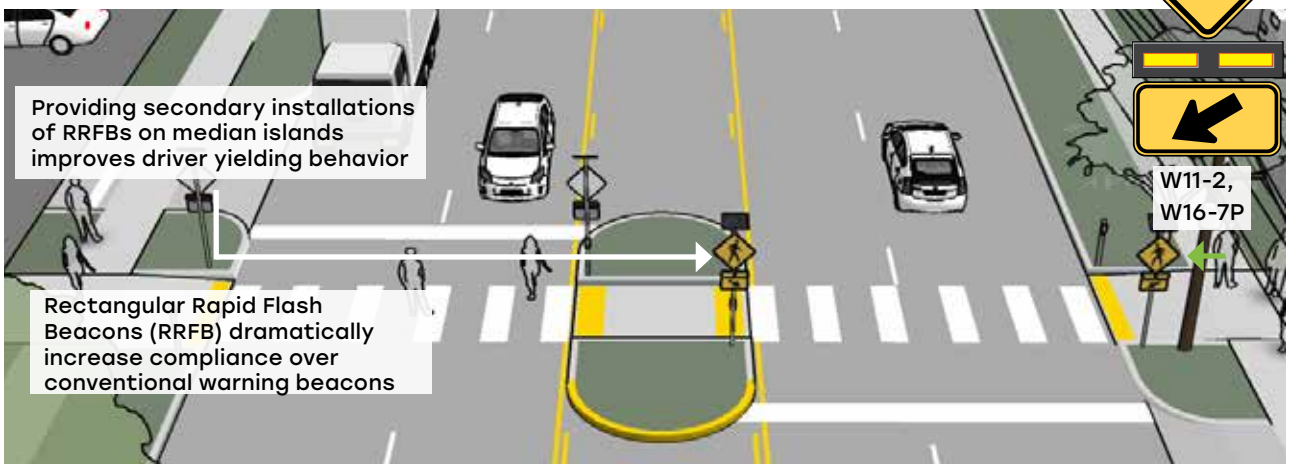
In areas with very heavy pedestrian traffic, consider an all-pedestrian signal phase to give pedestrians free passage in the intersection when all motor vehicle traffic movements are stopped. This may provide operational benefits as vehicle turning movements are then unimpeded.

Materials and Maintenance

It is important to perform ongoing maintenance of traffic control equipment. Consider semi-annual inspections of controller and signal equipment, intersection hardware, and detectors.

Rectangular Rapid Flash Beacons (RRFB)

Rectangular Rapid Flash Beacons (RRFB) are a type of active warning beacon used at unsignalized crossings. They are designed to increase driver compliance on multi-lane or high-volume roadways.



Typical Application

- Guidance for marked/unsignalized crossings applies.
- RRFBs should not be used at crosswalks controlled by YIELD signs, STOP signs, Pedestrian Hybrid Beacons (HAWKs), or traffic control signals.
- RRFBs should initiate operation based on user actuation and should cease operation at a predetermined time after the user actuation or, with passive detection, after the user clears the crosswalk.
- Rectangular Rapid Flash Beacons (RRFB) dramatically increase compliance over conventional warning beacons.

Design Features

- RRFBs are typically activated by pedestrians manually with a push button, or can be actuated automatically with passive detection systems. See Enhanced Crossing Treatment Selection page for more details on appropriate applications.
- Providing secondary installations of RRFBs on median islands improves conspicuity and driver stopping behavior.
- Must be used in conjunction with W11-2, S1-1, or W11-15, (and W16-7P if post-mounted). See FHWA Interim Approval 21 for more information.
- Beacons may be installed as side mounted or in overhead installations.

Further Considerations

Rectangular rapid flash beacons elicit the highest increase in compliance of all the amber warning beacon enhancement options.

A Florida study of the effectiveness of going from a no-beacon arrangement to a two-beacon RRFB installation increased yielding from 18 percent to 81 percent. A four-beacon arrangement raised compliance to 88%. Additional studies of long term installations show little to no decrease in yielding behavior over time.

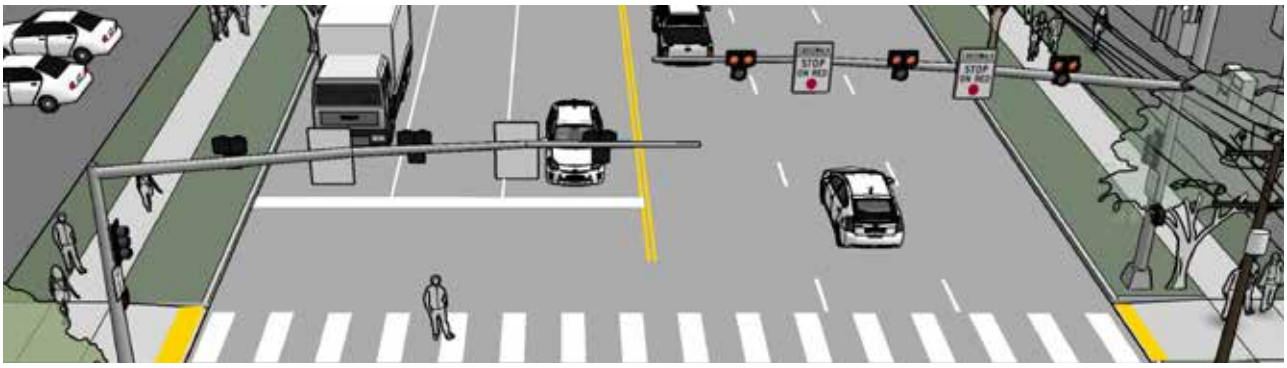
See FHWA Interim Approval 21 (IA-21) for more information on RRFBs.

Materials and Maintenance

RRFBs should be regularly maintained to ensure that all lights and detection hardware are functional.

Pedestrian Hybrid Beacon (PHB)

Pedestrian Hybrid Beacons (PHB) or High-Intensity Activated Crosswalks (HAWK) are used to improve non-motorized crossings of major streets. A hybrid beacon consists of a signal head with two red lenses over a single yellow lens on the major street, and a pedestrian signal head for the crosswalk. Hybrid beacons are only used at marked mid-block crossings or unsignalized intersections. They are activated with a pedestrian pushbutton at each end. If a median refuge island is used at the crossing, another pedestrian pushbutton can be located on the island to create a two-stage crossing.



Typical Application

- Suitable for arterial streets where speeds are above 30-45 mph and there are three or more lanes of traffic (or two lanes with a median refuge).
- Where off-street bicycle facilities intersect major streets without signalized intersections.
- At intersections or midblock crossings where there are high pedestrian volumes.

Design Features

- Hybrid beacons may be installed without meeting traffic signal control warrants based on engineering judgment if roadway speed and volumes are excessive for comfortable pedestrian crossings.
- If installed within a signal system, signal engineers should evaluate the need for the hybrid beacon to be coordinated with other signals.
- Parking and other sight obstructions should be prohibited for at least 100 feet in advance of and at least 20 feet beyond the marked crosswalk to provide adequate sight distance.

Further Considerations

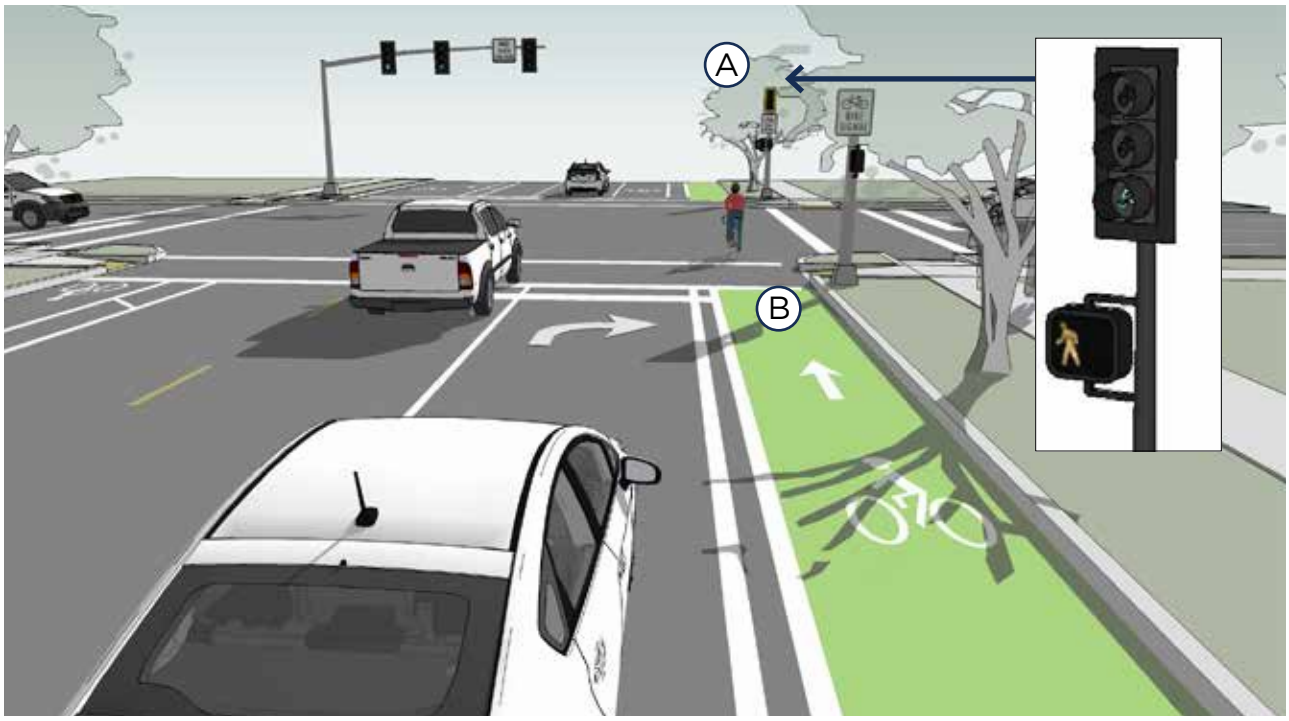
- Hybrid beacon are normally activated by push buttons, but may also be triggered by infrared, microwave, or video detectors. If not on-demand, the maximum delay for activation of the signal should be two minutes, with minimum crossing times determined by the width of the street, but a much shorter delay is strongly preferred.
- Each crossing, regardless of traffic speed or volume, requires review to identify sight lines, potential impacts on traffic progression, timing with adjacent signals, capacity, and safety.
- The installation of hybrid beacons should also include public education and enforcement campaigns to ensure proper use and compliance.

Materials and Maintenance

PHBs are subject to the same maintenance needs and requirements as standard traffic signals. Signing and striping need to be maintained to help users understand any unfamiliar traffic control.

Separated Bicycle Signal Phase

Separated bicycle lane crossings of signalized intersections can be accomplished through the use of a bicycle signal phase which reduces conflicts with motor vehicles by separating bicycle movements from any conflicting motor vehicle movements. Bicycle signals are traditional three lens signal heads with green, yellow and red bicycle stenciled lenses.



Typical Use

- Two-way protected bikeways where contraflow bicycle movement or increased conflict points warrant protected operation.
- Bicyclists moving on a green or yellow signal indication in a bicycle signal should not be in conflict with any simultaneous motor vehicle movement at the signalized location
- Right (or left) turns on red should be prohibited in locations where such operation would conflict with a green bicycle signal indication.

Design Features

(A) An additional "Bicycle Signal" sign should be installed below the bicycle signal head.

(B) Designs for bicycles at signalized crossings should allow bicyclists to trigger signals via pushbutton, loop detectors, or other passive detection, to navigate the crossing.

- On bikeways, signal timing and actuation should be reviewed and adjusted to consider the needs of bicyclists.

A bicycle signal head at a signalized crossing creates a protected phase for cyclists to safely navigate an intersection.

A bicycle detection system triggers a change in the traffic signal when a bicycle is detected.

Further Considerations

- The Federal Highway Administration (FHWA) has approved bicycle signals for use, if they comply with requirements from Interim Approval 16 (I.A. 16). Bicycle Signals are not approved for use in conjunction with Pedestrian Hybrid Beacons.
- Bicyclists typically need more time to travel through an intersection than motor vehicles. Green light times should be determined using the bicycle crossing time for standing bicycles.
- Bicycle detection and actuation systems include user-activated buttons mounted on a pole, loop detectors that trigger a change in the traffic signal when a bicycle is detected and video detection cameras, that use digital image processing to detect a change in the image at a location.

Materials and Maintenance

Bicycle signal detection equipment should be inspected and maintained regularly, especially if detection relies on manual actuation. Pushbuttons and loop detectors will tend to have higher maintenance needs than other passive detection equipment.

Bike Detection and Actuation

Bicycle detection and actuation is used to alert the signal controller of bicycle crossing demand on a particular approach. Proper bicycle detection should meet two primary criteria: accurately detects bicyclists and provides clear guidance to bicyclists on how to actuate detection (e.g., what button to push, where to stand).

Typical Application

- At signalized intersections within bicycle lanes or general purpose travel lanes.
- At signalized intersections within left turn lanes used by bicyclists.
- At signalized intersections within separated bike lanes.
- In conjunction with active warning beacons and pedestrian hybrid beacons.

Design Features

PUSH BUTTON ACTUATION

- User-activated button mounted on a pole facing the street.
- The location of the device should not require bicyclists to dismount or be rerouted out of the way or onto the sidewalk to activate the phase. Signage should supplement the signal to alert bicyclists of the required activation to prompt the green phase.

LOOP DETECTORS

- Loop detectors are bicycle-activated and installed within the roadway to allow the presence of a bicycle to be detected by the signal. This allows the bicyclist to stay within the lane of travel without having to maneuver to the side of the road to a pedestrian push button.
- Loops should be sensitive enough to detect bicycles should be supplemented with pavement markings to instruct bicyclists how to trip them.
- The MN MUTCD provides guidance on stencil markings and signage related to signal detection.

VIDEO DETECTION

- Video detection systems use digital image processing to detect a change in the image at a location. These systems can be calibrated to detect bicycle, although there may be detection issues during poor lighting and weather conditions.

THERMAL DETECTION

- Infrared detection systems typically consist of one or more thermal cameras, a microprocessor to process the thermal imagery, and software to interpret the traffic flow data and communicate with the traffic signal controller. These systems are typically able to extract a significant amount of data from the thermal imagery.

User-activated button mounted on a pole

Bicycle loop detection

MICROWAVE DETECTION

- Remote Traffic Microwave Sensor Detection (RTMS)
- RTMS is a system which uses frequency modulated continuous wave radio signals to detect objects in the roadway. This method marks the detected object with a time code to determine its distance from the sensor.
- The RTMS system is unaffected by temperature and lighting, which can affect standard video detection.

Further Considerations

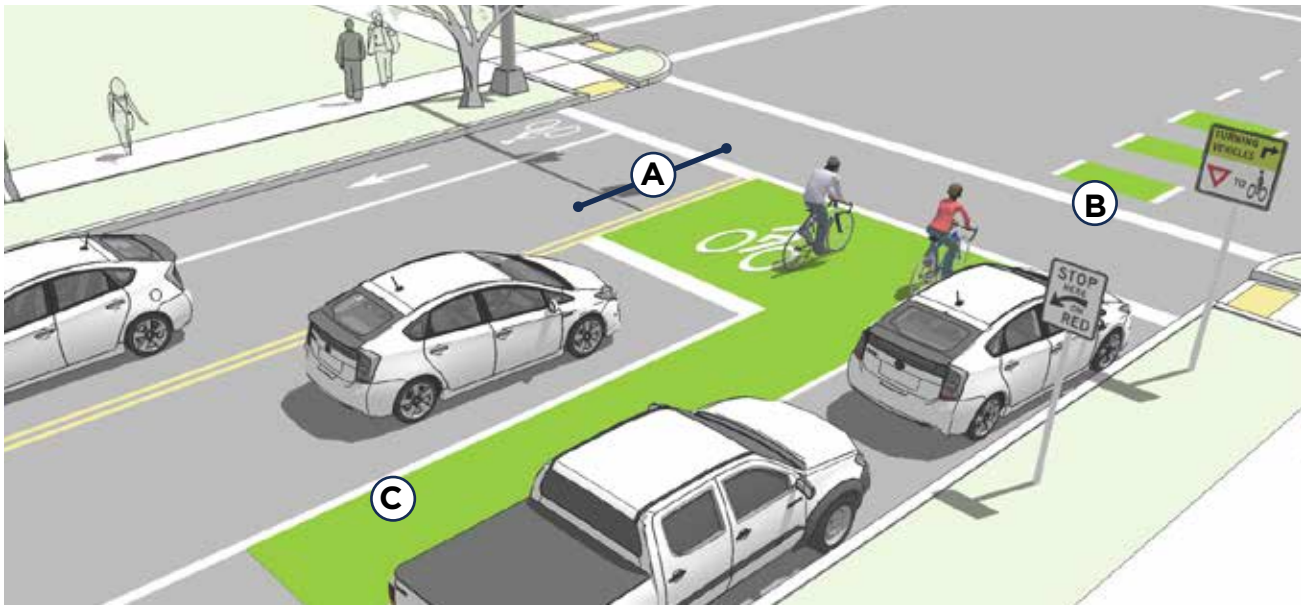
- Bicycle loops and other detection mechanisms can also provide bicyclists with an extended green time before the light turns yellow so that bicyclists of all abilities can reach the far side of the intersection.
- User comprehension of the bicycle detector Pavement markings is low, although some treatments show promise in increasing proper usage. Researchers at Portland State University found that 23.5% of bicyclists correctly positioned themselves over the stand-alone marking, use increased to 34.8% when the marking was paired with a R10-22 sign, and increased further to 48.4% when installed over a green background.

Materials and Maintenance

It is important to perform ongoing maintenance of traffic control equipment. Consider semi-annual inspections of controller and signal equipment, intersection hardware, and detectors.

Intersection Treatments
Bicycle Box

A bicycle box is designed to provide bicyclists with a safe and visible space to get in front of queuing traffic during the red signal phase. Motor vehicles must queue behind the white stop line at the rear of the bike box. On a green signal, all bicyclists can quickly clear the intersection. This treatment received Interim Approval from the FHWA in 2016 (IA-18).



Typical Use

- At potential areas of conflict between bicyclists and turning vehicles, such as a right or left turn locations.
- At signalized intersections with high bicycle volumes.
- At signalized intersections with high vehicle volumes.
- Not to be used on downhill approaches to minimize the right hook threat potential during the extended green signal phase.

Design Features

(A) 14 foot minimum depth from back of crosswalk to motor vehicle stop bar. (NACTO, 2012)

(B) A "No Turn on Red" (MN MUTCD R10-11) sign should be installed overhead to prevent vehicles from entering the Bike Box. A "Stop Here on Red" (MN MUTCD R10-6) sign should be post mounted at the stop line to reinforce observance of the stop line.

(C) A 50 foot ingress lane should be used to provide access to the box.

- Use of green colored pavement is recommended.

A bike box allows for bicyclists to wait in front of queuing traffic, providing high visibility and a head start over motor vehicle traffic.

Further Considerations

- This treatment positions bicycles together and on a green signal, all bicyclists can quickly clear the intersection, minimizing conflict and delay to transit or other traffic.
- Pedestrian also benefit from bike boxes, as they experience reduced vehicle encroachment into the crosswalk.
- Bike boxes require permission from the FHWA to implement, and jurisdictions must receive approval prior to implementation. A State may request Interim Approval for all jurisdictions in that State.[1]
- Bike boxes should not be used to accommodate bicyclist turns at intersections that have substantial parallel green time as bicyclists cannot safely occupy the box when arriving on green.

Materials and Maintenance

Bike boxes are subject to high vehicle wear, especially turning passenger vehicles, buses, and heavy trucks. As a result, bike boxes with green coloring will require more frequent replacement over time. The life of the green coloring will depend on vehicle volumes and turning movements, but thermoplastic is generally a more durable material than paint.

1 *FHWA. Interim Approval for Optional Use of an Intersection Bicycle Box (IA-18). 2016.*

Two-Stage Turn Boxes

Two-stage turn boxes offer bicyclists a safe way to make turns at multi-lane signalized intersections from a physically separated or conventional bike lane. On separated bike lanes, bicyclists are often unable to merge into traffic to turn due to physical separation, making the two-stage turning critical. This treatment received Interim Approval from FHWA in 2017 (IA-20).

Typical Application

- Streets with high vehicle speeds and/or traffic volumes.
- At intersections of multi-lane roads with signalized intersections.
- At signalized intersections with a high number of bicyclists making a left turn from a right side facility.
- Preferred treatment to assist turning maneuvers on bike lanes, instead of requiring bicyclists to merge to make a vehicular left turn.
- Required for protected bikeways to assist left turns from a right side facility, or right turns from a left side facility.

Design Features

- The two-stage turn box should be placed in a protected area. Typically this is within the shadow of an on-street parking lane or protected bike lane buffer area and should be placed in front of the crosswalk to avoid conflict with pedestrians.
- 10 foot x 6.5 foot preferred dimensions of bicycle storage area (6 foot x 3 foot minimum).
- Bicycle stencil and turn arrow pavement markings should be used to indicate proper bicycle direction and positioning. (NACTO, 2012)

Further Considerations

- Consider providing a "No Turn on Red" (MN MUTCD R10-11) on the cross street to prevent motor vehicles from entering the turn box.

- This design formalizes a maneuver called a "box turn" or "pedestrian style turn."
- Design guidance for two-stage turns apply to both bike lanes and separated bike lanes.
- Two-stage turn boxes reduce conflicts in multiple ways; from keeping bicyclists from queuing in a bike lane or crosswalk and by separating turning bicyclists from through bicyclists.
- Bicyclist capacity of a two-stage turn box is influenced by physical dimension (how many bicyclists it can contain) and signal phasing (how frequently the box clears.)

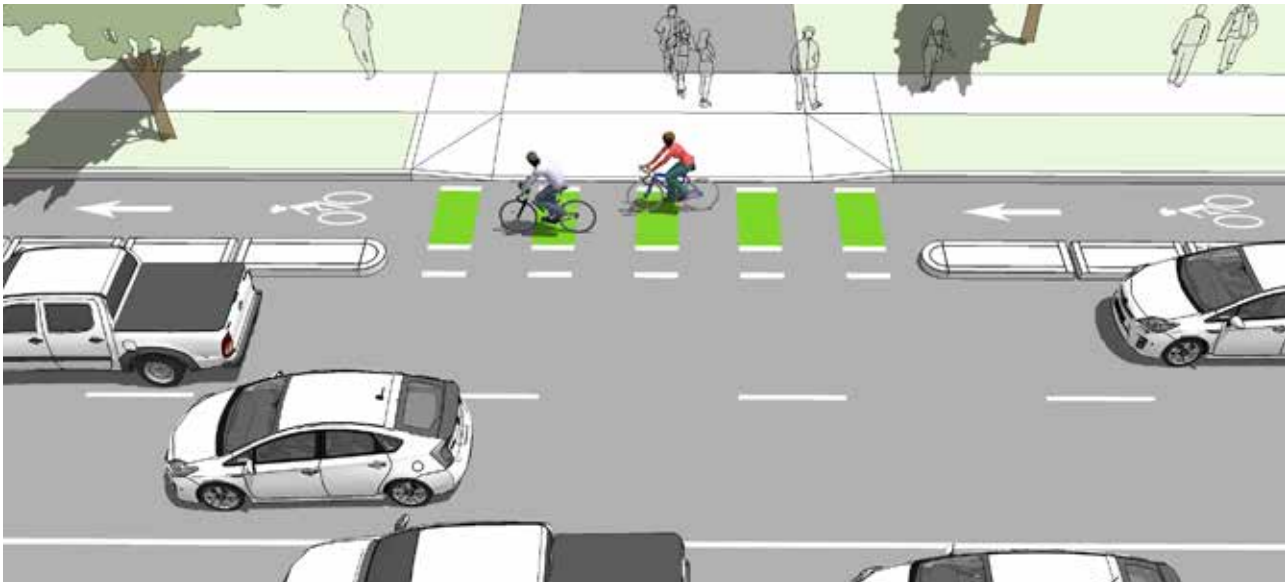
MATERIALS AND MAINTENANCE

Turn boxes may subject to high vehicle wear, especially turning passenger vehicles, buses, and heavy trucks. As a result, bike boxes with green coloring will require more frequent replacement over time. The life of the green coloring will depend on vehicle volumes and turning movements, but Thermoplastic or MMA are generally more durable material than paint.

Driveway & Minor Street Crossings

The added separation provided by separated bikeways creates additional considerations at intersections and driveways when compared to conventional bicycle lanes. Special design guidelines are necessary to preserve sightlines and denote potential conflict areas between modes, especially when motorists turning into or out of driveways may not be expecting bicycle travel opposite to the main flow of traffic.

At driveways and crossings of minor streets, bicyclists should not be expected to stop if the major street traffic does not stop.

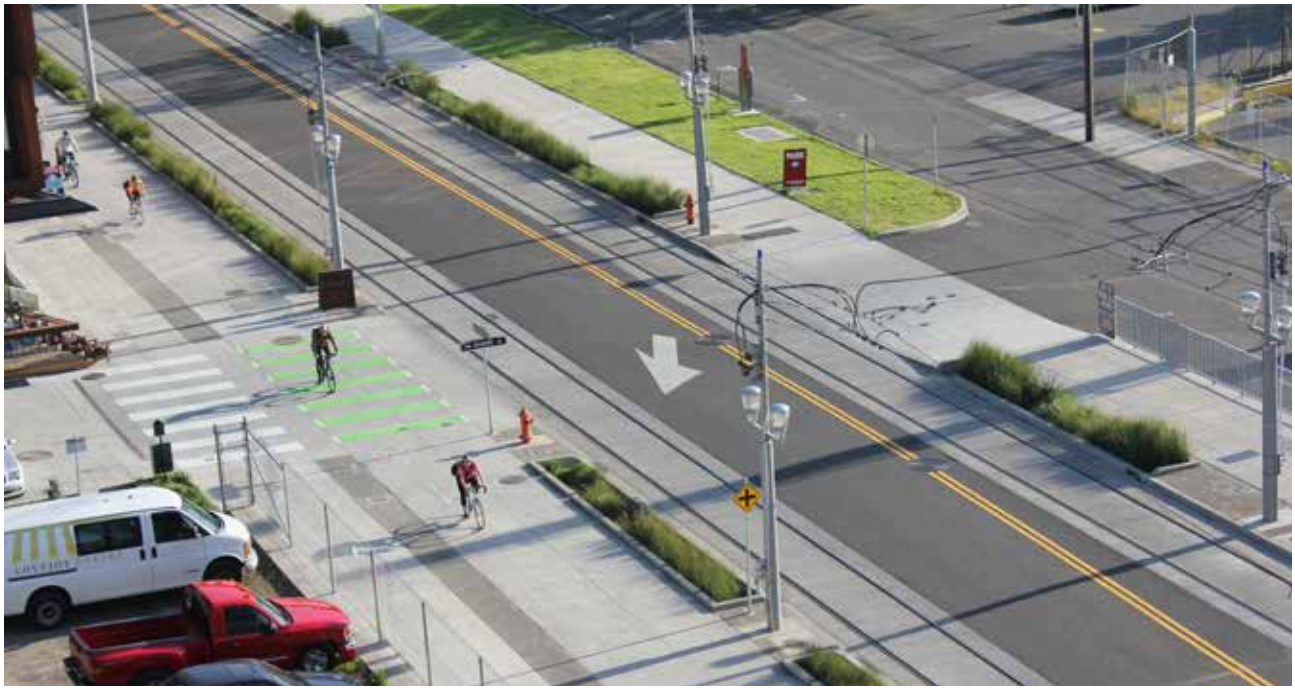


Typical Use

- Along streets with separated bikeway where there are intersections and driveways.
- Higher frequency driveways or crossings may require additional treatment such as conflict markings and signs.

Design Features

- Remove parking to allow for the appropriate clear sight distance before driveways or intersections to improve visibility. The desirable no-parking area is at least 30 feet from each side of the crossing.
- Use colored pavement markings and/or shared line markings through conflict areas at intersections.



Intersection crossing markings can be used at high volume driveway and minor street crossings, as illustrated above.

- If a raised bikeway is used, the height of the lane should be maintained through the crossing, requiring automobiles to cross over.
- Motor vehicle traffic crossing the bikeway should be constrained or channelized to make turns at sharp angles to reduce travel speed prior to the crossing.
- Driveway crossings may be configured as raised crossings to slow turning cars and assert physical priority of traveling bicyclists.
- Motor vehicle stop bar on cross-streets and driveways is setback from the intersection to ensure that drivers slow down and scan for pedestrians and bicyclists before turning.

Further Considerations

- Removing obstructions and providing clear sight distance at crossings increases visibility of bicyclists.
- Treatments designed to constrain and slow turning motor vehicle traffic will slow drivers to bicycle-compatible travel speeds prior to crossing the separated bikeway.

Materials and Maintenance

Green conflict striping and markings, will require higher maintenance where vehicles frequently traverse over them at driveways and minor intersection. Green conflict striping (if used) will also generally require higher maintenance due to vehicle wear.

NETWORK CONNECTIONS AND SUPPORTING FACILITIES

Short-Term Bicycle Parking

People need a safe, convenient place to secure their bicycle when they reach their destination. This may be short-term parking of 2 hours or less, or long-term parking for employees, students, residents, and commuters.

Information on short- and long-term bike parking has been informed by the Association of Pedestrian and Bicycle Professionals (APBP) Bicycle Parking Guide, which is updated frequently and is available online at www.apbp.org.

Application

BIKE RACKS

- Bike racks provide short-term bicycle parking and are meant to accommodate visitors, customers, and others expected to depart within two hours. It should be an approved standard rack, appropriate location and placement.

BIKE CORRALS

- On-street bike corrals (also known as on-street bicycle parking) consist of bicycle racks grouped together in a common area within the street traditionally used for automobile parking.
- Bicycle corrals are reserved exclusively for bicycle parking and provide a relatively inexpensive solution to providing high-volume bicycle parking. Bicycle corrals can be implemented by converting one or two on-street motor vehicle parking spaces into on-street bicycle parking.
- Each motor vehicle parking space can be replaced with approximately 6-10 bicycle parking spaces.

Design Features

BIKE RACKS

- When placed on sidewalks, 2 feet minimum from the curb face to avoid 'dooring.'
- 4 feet between racks to provide maneuvering room.
- Locate close to destinations; 50 feet maximum distance from main building entrance.
- Minimum clear distance of 6 feet should be provided between the bicycle rack and the property line.
- While bike racks could be installed perpendicular or parallel to the curb, it is important to ensure there is sufficient room for pedestrian traffic, even when a bike is locked to the rack.

BIKE CORRALS

- Bicyclists should have an entrance width from the roadway of 5-6 feet.
- Can be used with parallel or angled parking.
- Parking stalls adjacent to curb extensions are good candidates for bicycle corrals since the concrete extension serves as delimitation on one side.

Further Considerations

- Where the placement of racks on sidewalks is not possible (due to narrow sidewalk width, sidewalk obstructions, street trees, etc.), bicycle parking can be provided in the street where on-street vehicle parking is allowed in the form of on-street bicycle corrals.
- Some types of bicycle racks may meet design criteria, but are discouraged except in limited situations. This includes undulating "wave" racks, schoolyard racks, and spiral racks. These discouraged racks are illustrated on the following page.
- Bike racks should be made of thick stainless steel to reduce the chance of thieves cutting through the racks to take bicycles. Square tubing can provide further protection from cutting, as well.
- If a bike rack is installed as surface mount, countersink bolts or expansion bolts should be used to keep the rack in place. Covering the bolts with putty or epoxy can provide additional protection.

REFERENCES

MnDOT Bicycle Facility Design Manual.
APBP Bicycle Parking Guide 2015.

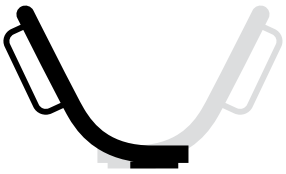
Inverted-U racks provide two points of contact.

Racks with square tubing, good spacing, and a concrete base likewise offer two points of contact.

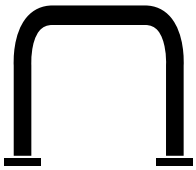
Types of Bike Racks to Use

These racks provide two points of contact with the bicycle, accommodate varying styles of bike, allow for the frame of a bicycle and at least one wheel to be secured by most U-locks, and are intuitive to use.

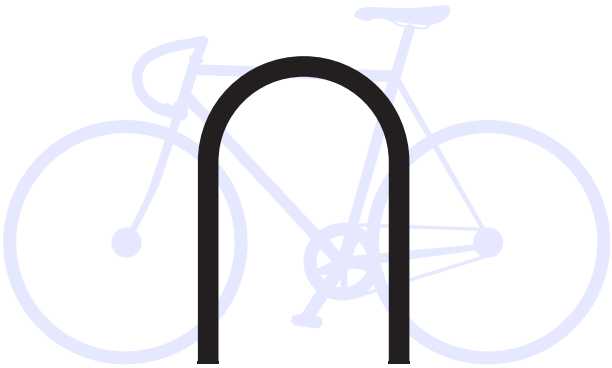
POST & RING



WHEELWELL SECURE



INVERTED-U

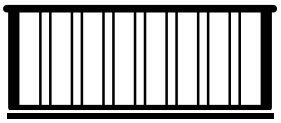


Communities may consider purchasing branded U-racks for installation on sidewalks.

Types of Bike Racks to Avoid

These racks do not provide support at two places on the bike, can damage the wheel, do not provide an opportunity for the user to lock the frame of their bicycle easily, and are not intuitive to use. Because of performance concerns, the APBP Essentials of Bike Parking Report recommends selecting other racks instead of these.

WAVE



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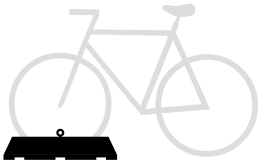


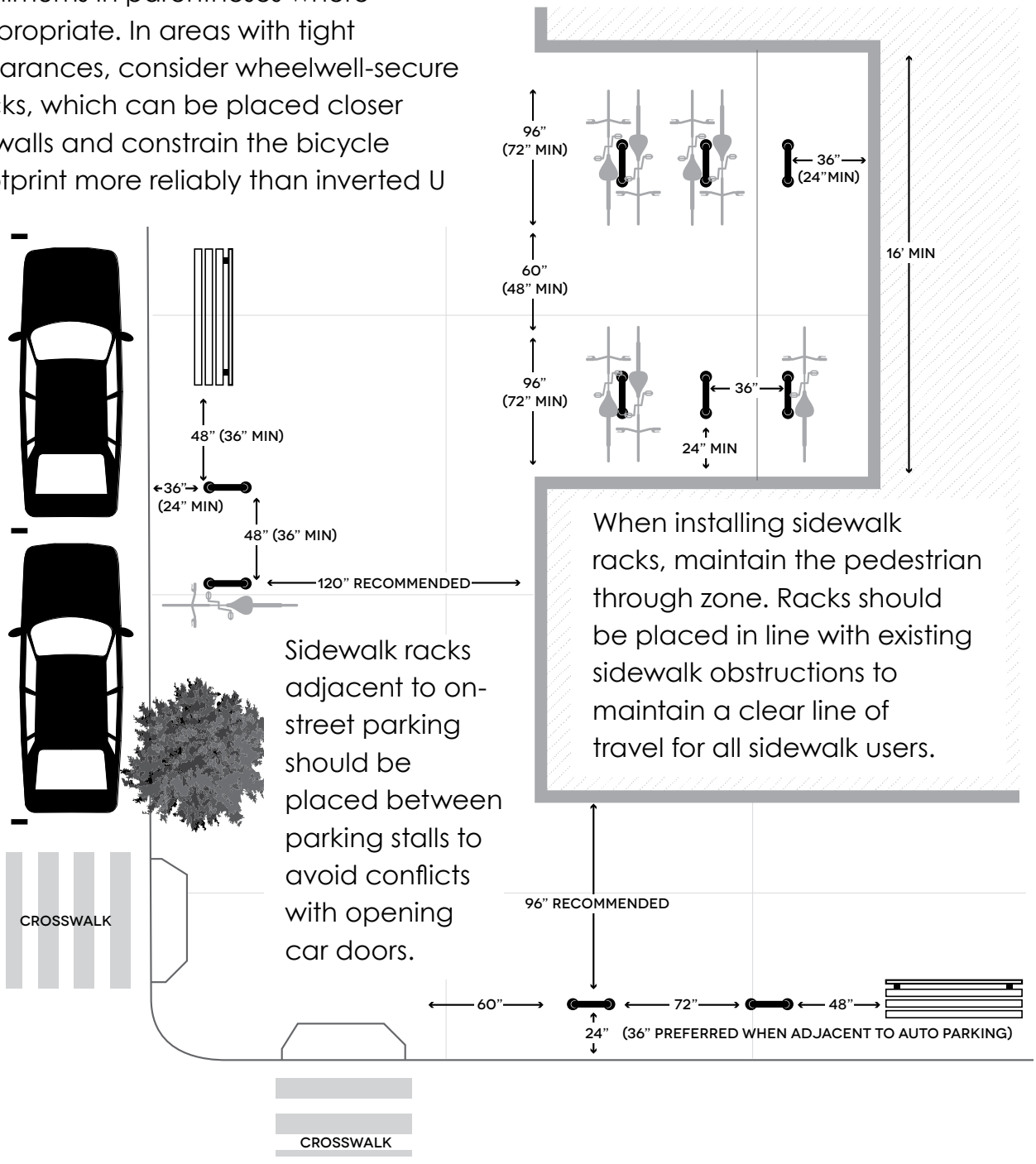
WHEELWELL

COATHANGER

BOLLARD

Space Requirements

The following minimum spacing requirements apply to some common installations of fixtures like inverted U or post and ring racks that park one bicycle roughly centered on each side of the rack. Recommended clearances are given first, with minimums in parentheses where appropriate. In areas with tight clearances, consider wheelwell-secure racks, which can be placed closer to walls and constrain the bicycle footprint more reliably than inverted U and post and ring racks. The footprint of a typical bicycle is approximately 6' x2'. Cargo bikes and bikes with trailers can extend to 10' or longer.



Long-Term Bicycle Parking

Users of long-term parking generally place high value on security and weather protection. Long-term parking is designed to meet the needs of employees, residents, public transit users, and others with similar needs.

Information on short and long term bike parking has been obtained from the APBP Bicycle Parking Guide, which is updated frequently and is available online at www.apbp.org.

Application

- At transit stops, bike lockers or a sheltered secure enclosure may be appropriate long term solutions.
- On public or private property where secure, long-term bike parking is desired.
- Near routine destinations, such as workplaces, universities, hospitals, etc.

Design Features

BIKE LOCKERS

- Minimum dimensions: width (opening) 2.5 feet; height 4 feet; depth 6 feet.
- 4 foot side clearance and 6 foot end clearance. 7 foot minimum distance between facing lockers.

SECURE PARKING AREA

- Closed-circuit television monitoring or on-site staff with secure access for users.
- Double high racks & cargo bike spaces.
- Bike repair station with bench and bike tube and maintenance item vending machine.
- Bike lock "hitching post" – allows people to leave bike locks.

Further Considerations

- As the APBP Bike Parking Guide notes, increasing density of bike racks in a long-term facility without careful attention to user needs can exclude users with less-common types of bicycles which may be essential due to age, ability, or bicycle type.
- To accommodate trailers and long bikes, a portion of the racks should be on the ground and should have an additional 36" of in-line clearance.

REFERENCES

MnDOT Bicycle Facility Design Manual
APBP Bicycle Parking Guide 2015.

HIGH DENSITY BIKE RACKS

Racks may be used that increase bike parking density, like the ones below. While these types of racks provide more spaces, racks that require lifting should not be used exclusively. People with heavier bikes (i.e. cargo bikes) or people with disabilities or people who are simply small in stature may be unable to lift their bikes easily.

STAGGERED WHEELWELL-SECURE

VERTICAL

TWO-TIER

BIKE PARKING ROOMS

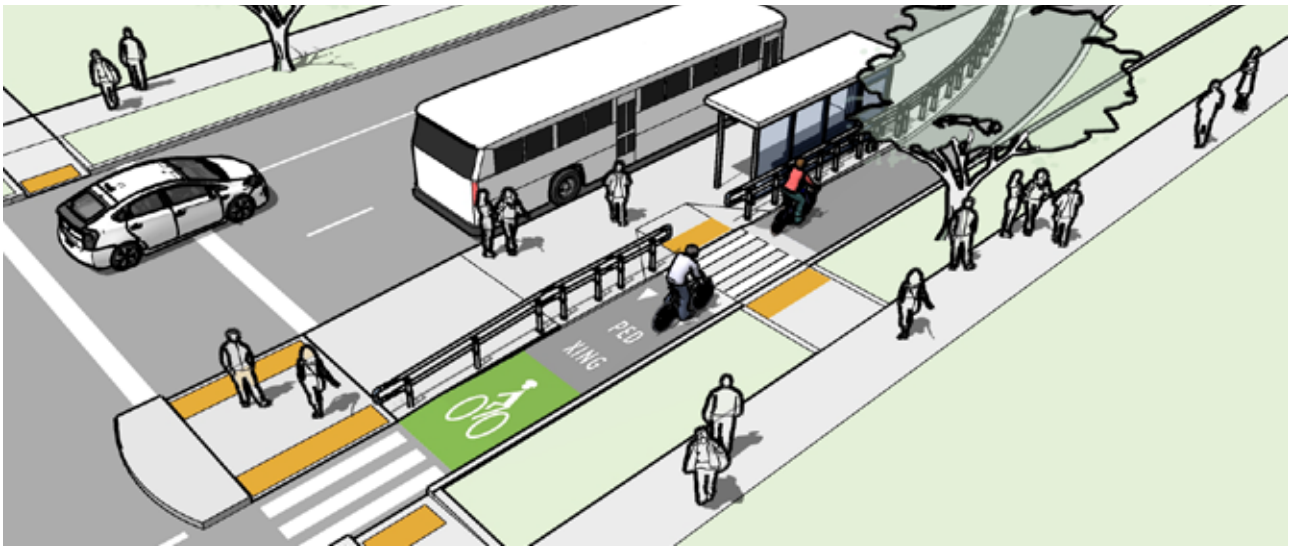
Long term bike parking may be available in dedicated rooms in residential and commercial buildings. Bicycle parking can be accommodated in 15 square feet per space or less.

Bike lockers

Secured parking areas

Transit Stop Design

Bus platforms or waiting areas serve as the critical transition point for pedestrians as transit passengers. As such, bus platforms, shelters, and shelter amenities need to be designed to the benefit of people boarding, alighting, waiting, and passing through. Transit platforms and shelters should be designed to be comfortable and safe, accessible for people with disabilities, sized appropriately based on ridership and demand, use space efficiently, and to minimize delay and conflicts with other modes such as bicycles, and competing sidewalk uses.



Typical Application

- Bus stops can range from simple curbside stops with a pole and seating, to in-roadway platforms with shelters and other shelter amenities depending on demand, adjacent land use, and available right of way.
- Typically, bus stop shelters and amenities occupy an area of the sidewalk, either in the furnishing zone, or a reserved space in the frontage zone. They can also be located on transit islands which accommodates bicycle through traffic, or in medians for center running alignments.
- Shelters can face toward the roadway or away from the roadway. Shelters facing toward the roadway provide better sightlines, but may compete with other sidewalk uses and adjacent property access and circulation.

Design Features

- Bus stops should be designed to minimize potential for conflicts between the bus, and people walking and bicycling through the area.
- Site visibility is a critical safety and security factor. The bus operator needs to be able to see waiting passengers, and waiting passengers need to be able to see approaching buses. The shelter, street trees, and other vertical elements must not obstruct visibility. The stop and shelter should be adequately illuminated at night for safety and security.
- The shelter should maximize use of materials that maximize visibility for waiting passengers, and minimize incentive for vandalism.
- The shelter canopy should be sized to provide sufficient coverage based on stop demand.

Trail and On-Street Transitions

Transitions occur where the trail meets a roadway or railway, where one trail typology meets another, such as when an elevated trail transitions into an at-grade trail or where separated trail segments transition into shared environments. Transitions may also include horizontal shifts to avoid physical obstacles such as utility towers or other structures. Trail access means providing a formalized way for people to arrive and depart from the trail network by a variety of travel modes.

Typical Application

- Regional trail access points can take several different forms ranging from major trailheads, minor trailheads, and neighborhood entryways. These vary in the level of infrastructure and facility amenities.
- These access points are multimodal transition points; they serve as the transition between the on-street network and the off-street network for people walking, biking, riding transit, and driving.
- All trailheads should be open to the public.

Design Features

- Major trailheads feature convenient access to transit, parking for 10 or more vehicles, (including accessible spaces), short- and long-term bicycle parking, restrooms, trash/recycling facilities, wayfinding/interpretive kiosks, benches/picnic tables, and other day use amenities.
- Minor trailheads include similar facilities as major trailheads but a lower provision of vehicle and bike parking and day use amenities, and may be further from major transit and bike connection points.

- Neighborhood entrypoints are the most basic form of local accessways that do not provide many of the amenities of trailheads due to space constraints, neighborhood context, and/or proximity to other trailheads.

TYPOLOGY TRANSITIONS

Design elements used to alert trail users include pavement markings such as optical speed bars, zebra stripe crosswalks with yield/stop markings, and "LOOK" legends and arrows. Other visual indications include bike and pedestrian directional markings, centerlane striping, and the use of colored pavement to visually narrow or indicate a change in environment.

Tactile indications include speed humps, tactile speed bars, and the use of multiple surface types, such as concrete, asphalt, and pavers.

Advisory, regulatory, and/or wayfinding signage are should be considered at transition points. Physical treatments to alert and guide trail users include traffic calming measures such as vertical and horizontal deflection.

Trail illumination is an important design element that must be considered along the trail, but is especially important in transition zones.

MIXING ZONES

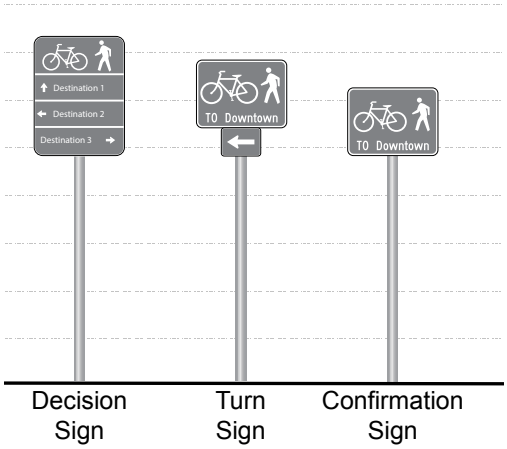
Mixing zones are necessary where physical space constraints do not allow for separated modes, or at locations along the trail where a high level of cross-traffic is expected. Mixing zones need to provide clear indication to all users that a transition is occurring in advance of the change, so that trail users can adjust their speeds and awareness appropriately to proceed carefully into the mixing zone.

Advanced warning can be accomplished with advisory signage, pavement markings, and the use of contrasting surface treatments (e.g. pavers/inlays with contrasting tones/ textures, striping, or a combination of these treatments). These design elements help to guide trail users safely through the mixing zone by alerting users to the change in conditions and thus reducing the speed differential.

Wayfinding

The ability to navigate across an urbanized area is informed by landmarks, natural features, and other visual cues. Signs throughout the city should indicate the direction of travel, the locations and travel time distances to those destinations. A pedestrian wayfinding system is similar to a transit, vehicular, or bike facility wayfinding system, in that it consists of comprehensive signing and/or pavement markings to guide pedestrians to their destination along routes that are safe, comfortable and attractive.

Sign types



Decision sign

Typical Application

Wayfinding signs will increase users' comfort and accessibility to the pedestrian system in denser urbanized areas and connections to other destinations across the larger region.

Signage can serve both wayfinding and safety purposes including:

- Helping to familiarize users with the pedestrian network
- Helping users identify the best routes to destinations within walking distance or connections to other modes.
- Helping to address misperceptions about time and distance.
- Helping overcome a "barrier to entry" for people who are not frequent walkers.

Design Features

- Confirmation signs indicate to pedestrians that they are on the right trail to their destinations. They include destinations and distance/time, but not arrows
- Turn signs indicate where a route turns from one street onto another street.
- Decision signs indicate the junction of two or more pedestrian routes to access key destinations. These include destinations, arrows

and distances. Travel times are optional but recommended.

- A regional wayfinding sign plan would identify sign locations, sign type, destinations, and approximate distance and travel time to destinations, and highlight connections between urban and non-urbanized areas.

Tactile navigation sign

Further Considerations

- Bicycle wayfinding signs also visually cue motorists that they are driving along a bicycle route and should use caution. Signs are typically placed at key locations leading to and along bicycle routes, including the intersection of multiple routes.
- Too many road signs tend to clutter the right-of-way, and it is recommended that these signs be posted at a level most visible to bicyclists rather than per vehicle signage standards.
- Green is the color used for directional guidance and is the most common color of bicycle wayfinding signage in the US, including those in the MNMUTCD.
- Check wayfinding signage along bikeways for signs of vandalism, graffiti, or normal wear and replace signage along the bikeway network as-needed.

PEDESTRIAN-BICYCLE OPERATIONS & MAINTENANCE

Bicycle Access Through Construction Areas

When construction work zones overflow into the right of way, or into an on- or off-street bicycle facility, care must be taken to avoid conflicts with people walking and approaching on bikes. If the work zone obstructs an existing bike facility, every effort should be made to provide a facility of the same, or higher level of access and safety through the area. It is unsafe to force people who are bicycling slowly into a shared lane situation, unless posted speeds are 20 or 25 mph. At higher speeds, the speed differential is a potential deadly combination and is an unacceptable option for how to allocate space along higher speed roadways with construction zones.

Typical Applications

- People on bicycles should not be led into conflicts with work site vehicles, equipment, moving vehicles, open trenches, or temporary construction signage.
- Whenever people area allowed to ride bikes through an exclusive work zone area, measures should be taken to provide a continuous path of travel for bikes.
- Construction warning signage guides people on bikes through construction work zones, and/or along route detours.
- Debris should be swept to maintain a reasonably clean riding surface in the provisional bike facility. Allow temporary use of sidewalk in suburban areas (lower walk/bike volumes) by requiring temporary ramps up to sidewalk and down from sidewalk... ok for short zones. Proper shared use signs on sidewalk are needed as well as "bikes yield to people walking signs."

Design Features

Ⓐ Advanced signage alerts people on bicycles to the changes ahead. Construction warning signage at the site should be located in the furnishing zone of the sidewalk, or in a location that does not obstruct the designated path of travel for people walking and bicycling. Signage mounts and footings should not pose a hazard for bicycle wheels nor a tripping hazard for anyone walking, caning, or traveling in a wheelchair.

- Steel plates used to cover trenches tend to have a 1"-2" vertical raised lip over the roadway surface. Because the plate is not flush, it can cause a person on a bicycle to lose control as they come into contact with it. Require temporary asphalt (cold mix) around steel plates to create a smooth transition. Require steel plate in use signs.
- Use steel plates only as a temporary measure during construction, not for extended periods.
- Reference the MnDOT state level guidance for bicycle and pedestrian access through construction.

In this poor example of a bike accommodation at a construction area, the existing bike lane ends abruptly and forces people to ride in the adjacent vehicle travel lane. The existing bike lane is also covered in gravel and debris, increasing the likelihood of crashes. Options for accommodating bike riding through the construction zone include: strictly limiting the encroachment into the bike lane so it can still be used; requiring daily sweeping; narrowing the travel lanes so the bike lane can continue. If the posted speeds are 20 - 25 mph, another option would be to create a shared lane by providing merge pavement markings and signage, shared lane pavement markings, and signage.

In this example, the existing bike lane was repurposed as a pedestrian travelway, but people riding are forced to merge into the adjacent travel lane. Options for accommodating bike riding through the area could include: widening the pedestrian travelway sufficiently (8-10', depending on the number of expected users) to create a shared use path of travel; tapering to a single travel lane while providing a bike lane; providing a well-routed bike only detour. If the roadway travel lanes are posted 20 or 25 mph, another option would be to add proper merge areas, signing, and temporary retro-reflective sharrows. Setting a construction speed limit might be useful to reduce roadway travel speeds and create a safer situation.

- Mounts and footings should not pose a hazard for bicycle wheels nor a tripping hazard for anyone walking, caning, or traveling in a wheelchair.
- Steel plates used to cover trenches tend to have a 1"-2" vertical raised lip over the roadway surface. Because the plate is not flush, it can cause a person on a bicycle to lose control as they come into contact with it. Require temporary asphalt (cold mix) around steel plates to create a smooth transition. Require steel plate in use signs.
- Use steel plates only as a temporary measure during construction,

  not for extended periods.

Further Considerations

- Contractors should be made aware of the needs of people on bikes, and be properly trained in how to safely route bicyclists through or around work zones.
- Detour paths of travel and routing, detour signage, and path of travel and closure signage should be included on all bikeways where construction activities occur. Signage should also be provided on all other roadways.
- Require both temporary and final repaving to provide a smooth surface without abrupt edges
- Use warning signs where steel plates are in use.
- Although it is common to use steel plates during non-construction hours, these plates can be dangerously slippery, particularly when wet. Applying traction to the surface of the plate can reduce the likelihood of slips.

Parking, Loading, and Garbage Access

Where separated bikeways are adjacent to on-street parking, drop-off locations, freight loading zones, or designated garbage pick-up areas, the design of the separation at those locations should provide an accessible aisle and adequate landing area to allow for travel from the vehicle to the curb ramp.

Colored pavement within a bicycle lane may be used to increase the visibility of the bicycle facility, raise awareness of the potential to encounter bicyclists, and reinforce priority of bicyclists in conflict areas. In 2021, MnDOT received statewide Interim Approval from FHWA for the use of green-colored pavement for bike lanes (IA-14). MnDOT must maintains a list of locations using the green colored pavement.

Typical Application

- Streets with on-street parking and a separated bikeway along the same block face.
- Where ADA-accessible spaces are desired, either due to proximity to nearby building entrances, street grades, or other factors.
- Where loading and garbage pick-up zones are desired along the same side of the street as a separated bikeway due to adjacent commercial users such as retail or hotels, and cannot be relocated to adjacent block faces or alleys.

COLORED PAVEMENT TREATMENT

Within a weaving or conflict area to identify the potential for bicyclist and motorist interactions and assert bicyclist priority.

- Across intersections, driveways and Stop or Yield-controlled cross-streets.
- At bike boxes and two-stage turn boxes
- And curb ramp (6' minimum width) must be provided.

Green colored conflict striping indicates the path of travel of people on bicycles, and alerts people intending to turn across the bike lane to yield when bicyclists are present.

A passenger loading zone allows pedestrians to cross the separated bike lane to access the loading island. These designs should also incorporate truncated domes to alert people walking with vision disabilities of the crossing.

Design Features

- Accessible spaces should be located adjacent to intersections to simplify access to curb ramps.
- Accessible spaces must comply with all ADA requirements.
- To connect between the sidewalk and parking spaces, a crosswalk across the separated bikeway and curb ramp (6' minimum width) must be provided.
- Place a YIELD HERE TO PEDESTRIANS **(MUTCD R1-5)** sign where the separated bikeway crosses the parking access route to clearly establish a right-of-way. Yield line pavement marking may be placed prior to the crosswalk.

A Typical white bike lane striping (solid or dotted 6" stripe) is used to outline the green colored pavement.

B In weaving or turning conflict areas, preferred striping is dashed, to match the bicycle lane line extensions.

- The colored surface should be skid resistant and retro-reflective (MnMUTCD Section 3G.01).
- In exclusive use areas, such as bike boxes, color application should be solid green.

Further Considerations

- Garbage pick-up, freight loading, and drop-off hours should be restricted to hours of the day when less bicycle traffic is expected, to minimize potential interactions.
- The City can provide guidance to both waste management operators and customers on desirable recycling/trash can and bin placement with respect to both walkways and bikeways to improve safety and use of these facilities.

Crash Reduction

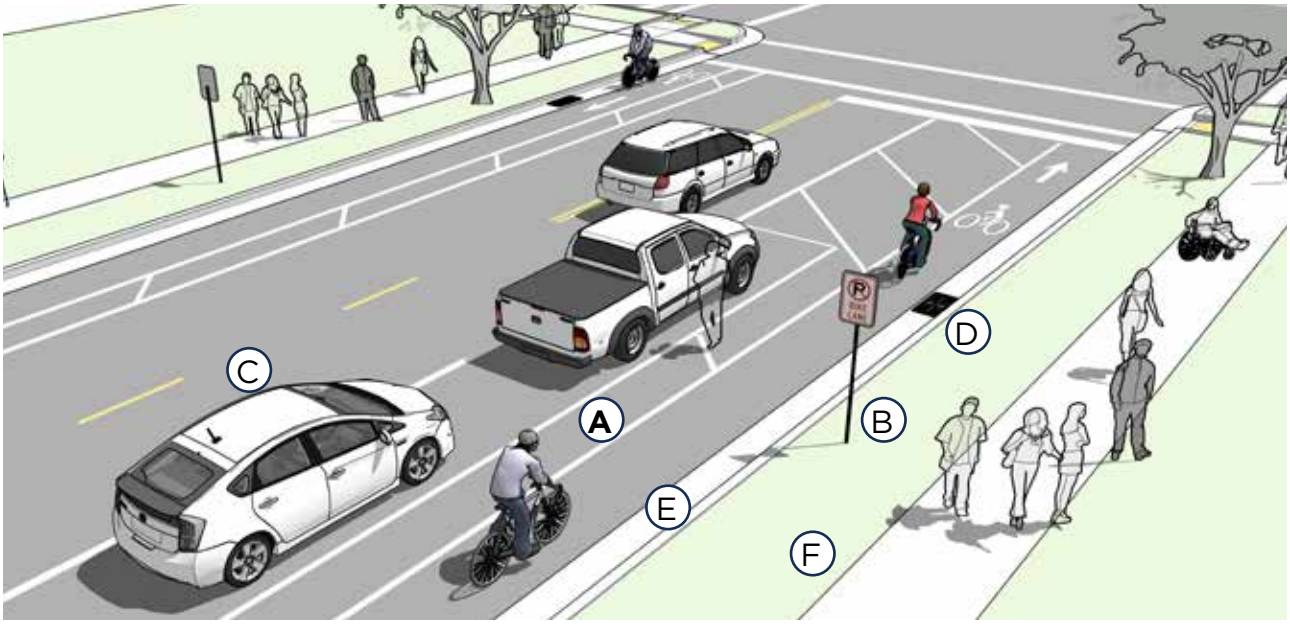
- Removing obstructions and providing clear sight distance at crossings increases visibility of bicyclists.
- Driveway and intersection designs should provide appropriate sight lines, radii, and other features that deliver a turning movement speed that provides the calculated time needed for turning motor vehicle drivers to see and react to bikeway users.

Sidewalk Maintenance

The sidewalk is an essential space for people walking and using wheelchairs and other personal mobility devices, and it is also the location where many other important activities take place. Each of the zones described in 'Sidewalk Zones' needs to be maintained for the overall sidewalk space to function as intended.

Maintaining Sidewalk Zones

- The **Primary Pedestrian Zone** must remain free and clear of obstacles and impediments. This is the primary accessway for people traveling along streets and to and from adjacent properties, and must be maintained to ADA standards.
    - Property owners are responsible for maintaining all sidewalk zones abutting their property, not just the Building Frontage Zone.
    - Maintaining a firm, stable, and slip resistant surfaces is necessary for people walking or rolling to traverse the Primary Pedestrian Zone without risk of tripping, slipping or otherwise uneven footing.
    - Regular sweeping ensures the Primary Pedestrian Zone and other sidewalk zones are kept free of natural debris and litter.
    - Routine maintenance of sidewalk damage due to tree roots, freeze-thaw, etc. is the responsibility of abutting property owners.
- The **Amenity Zone** is where street furnishing are located, where people are often picked up and dropped off, where mail is delivered, and where other loading/unloading happens. It's the space where trees and landscaping are planted, and where street lighting and other utilities are located. The Amenity Zone must be maintained properly to ensure access to this area and all of these curbside uses are possible.
    - Vegetation in the Amenity zone should be regularly maintained by the City so as not to encroach on the pedestrian travel zone. Maintenance should be prioritized by plant species, high demand areas, and/or narrow sidewalk corridors. When they are not maintained on schedule, the space for pedestrian travel becomes constrained, creating bottlenecks, and/or forcing pedestrians into the street.
    - During snow events, the amenity zone may be designated for snow storage, but should not impact the Primary Pedestrian Zone, or Enhancement Zone where there is a bike facility.
- The Building Frontage Zone is the area between the Primary Pedestrian Zone and the abutting property. Along commercial corridors this space may be utilized by businesses for outdoor cafe seating by permit, and in residential areas, this space may be occupied by landscaping or other natural screening.
    - Outdoor seating shall not occupy the Primary Pedestrian Zone or inhibit travel along the sidewalk.
    - Landscaping in the Building Frontage Zone should be maintained in a manner similar to landscaping in the Amenity Zone. Landscaping should be maintained by property owners so as not to encroach on the Primary Pedestrian Zone.
- The Enhancement Zone must be maintained for the following uses: bike facilities, vehicle parking, curb extensions, and bike parking.
    - Street sweeping and snow and ice removal should be conducted per maintenance schedule and following significant weather events to help to ensure intended use of this space. Snow must not be stored in bike lanes.



Bike Facility Maintenance

Regular bicycle facility maintenance includes sweeping, snow plowing, maintaining a smooth roadway, trimming encroaching vegetation, ensuring that the gutter-to-pavement transition remains relatively flush, and installing bicycle friendly grates. Pavement overlays are a good opportunity to improve bicycling facilities. The following recommendations provide a menu of options to consider to enhance a maintenance regimen.

(A) Sweeping

It is important to identify debris management to ensure safe surface conditions in bikeways. Debris that is allowed to accumulate can become a hazard due to loss of control, inner tube blow outs, as well as service dog safety.

The following are recommended items to include in the City's Sweeping Operations Plan.

- Cover both on-road and off-road bikeways under the jurisdiction of the city. Can establish a seasonal sweeping schedule that allows for prioritization of routes. The schedule could prioritize facilities designated as major bikeways, before roadways designated as minor bikeways.
- Sweep bikeways periodically to minimize accumulation on the facility to maintain safe surface conditions.
- Identify winter traction material removal protocols to ensure traction materials are removed from bike ways in a timely manner.

(B) Signage

- Include bikeway regulatory and wayfinding signing as part of the roadway sign maintenance program, regularly checking for vandalism, graffiti, and wear. Schedule replacement/repair as needed.

Ⓒ Roadway Surface

- Smooth pothole-free surfaces are especially critical for people on bikes.
- The finished surface on bikeways does not vary more than 1/4" for new roadway construction.
- Pavement should be maintained so ridge buildup does not occur at the gutter-to-pavement transition or adjacent to railway crossings.
- Ensure pavement inspections occur after trenching activities are completed and if excessive settlement has occurred to require mitigation prior to the expiration of the project's warranty period.
- To the extent possible, pavement markings and green-colored areas should be placed out of the vehicle path of travel to minimize wear. In general, striping, pavement markings, and green colored areas should be well maintained especially areas in the path of vehicle travel, and where high-turning movements occur.

Ⓓ Drainage Grates

- New drainage grates should be bicycle-friendly. Grates should have horizontal slats on them so that bicycle tires and assistive devices do not fall through any vertical slats.
- Create a program to inventory all existing drainage grates, and replace hazardous grates as necessary - temporary modifications such as installing rebar horizontally across the grate should not be an acceptable alternative to replacement.

Ⓔ Gutter-to-Pavement Transition

- Gutter-to-pavement transitions should have no more than a 1/4" vertical transition.
- Pavement transitions should be examined during every roadway project for new construction, maintenance activities, and construction project activities that occur in streets.

Ⓕ Landscaping

- Vegetation on the edge of the roadway should not hang into or impede passage along bikeways.
- After storm events, remove fallen trees or other debris from bikeways as quickly as possible.

Coordination With Emergency Responders

- General roadway maintenance should be coordinated and prioritized on emergency response routes that overlap with major and minor bikeways.
- Provide fire, police, and EMS services with a map of major and minor bikeway routes.

Recommended Bikeway Maintenance Activities

The following table summarizes maintenance activities. The City should ensure that each of these activities is addressed in City requirements, various operations plans, or emergency response plans. The frequency of each activity is at the discretion of the City Engineer. However, the activity should be done in a timely enough manner to ensure bikeways are operated in a safe manner for all users.

Winter Maintenance Best Practices

Many considerations factor into how to provide safe, ridable bikeway surface conditions and sight lines in the winter. These factors are the bikeway type and the presence and type of vertical protection or separation along a bikeway.

Snow Storage and Roadway Design

There are several roadway planning and design considerations that can be taken to avoid the situation where there is no snow storage provisions.

Plan Roadways with Sufficient ROW

On new roadways, or in roadway re-engineering projects that include bike lanes (or may include them in the future), design the street to provide space within the right of way for snow storage space. Ensure that the snow storage space is of adequate width to accommodate typical snowfall accumulations, allows plows to clear the roadway and bike lane of snow, and allows sidewalks to also be kept clear of snow storage.

Best practice for bike lanes or buffered bike lanes is to plow snow onto the amenity zone/snow storage strip as this practice most closely matches that of typical snow plowing operations.

The City standard is to always provide an amenity zone between sidewalk and curb. Calculating the width of the amenity zone is an exercise in

A parking protected bike lane in Salt Lake City, UT after a snow plow operation. Photo Credit: Travis Jensen

right-of-way width available less width allocation to motor vehicle and bike facilities. Additionally, identifying a minimum amenity zone width based on snow storage requirements also needs to be taken into consideration. The width of the snow storage space will depend on equipment capabilities, width of roadway and typical snowfall conditions.

When right of way is restricted to such an extent that only curb-tight sidewalk without snow storage space is available, one of the following techniques needs to be deployed for that segment of the corridor.

Use the Wide Bike Lane Buffer

By providing a wide, painted bike lane buffer, snow plow operations may be able to store snow in the buffer between motor vehicle lane and the bike lane. This requires the roadway plow to plow snow to the right, and the bike lane plow to plow snow to the left. This method may be useful where there is insufficient snow storage area between the bike lane and the sidewalk. Considerations for this method include snow melt. During the day, the stored snow can melt and sheet flow across the bike lane, resulting in a very icy bikeway surface condition. This needs to be countered with a deicing operation.

A small snow plow vehicle clears sidewalks in Vancouver, BC.

Provide Enough Width for Small Snow Plow Vehicles

When typical snow plows are too wide to fit, the City can consider using smaller, more specialized vehicles. These specialized plows are becoming particularly important for bikeways that have confined travelways, such as separated bike lanes and trails.

Many large cities with harsh winter climates, such as Chicago, have a fleet of these specialized vehicles and ATV-mounted snow plows primarily for the purpose of clearing sidewalks. While most separated bikeways in Chicago, IL can be cleared with typical pickup truck mounted snow plows, ATV-mounted snow plows and Bombardier snow plows are used in Chicago, IL, along the few separated bikeways such as Kinzie St. that are too narrow for pickup trucks.

Where bike facility widths permit, utilizing existing maintenance vehicles such as pickup trucks with mounted snow blades can prove to be much more cost-effective and time-efficient than the smaller vehicles which operate at slower speeds and have smaller plow blades.

Design of shared use paths and bicycle facilities should consider how the snow removal vehicles will access the facility.

A recessed thermoplastic bike lane marking in Minneapolis, MN.

Vertical delineators help inform snow plow drivers of obstacles such as cycletracks, raised medians and bulb-outs in Salt Lake City, UT

Recessed Thermoplastic Pavement Markings

Milling the area of pavement 3mm in depth where thermoplastic pavement markings are applied has shown to be effective in reducing damage as a result of snowplows in a 2010 study.[1] Minneapolis, MN, mills the area of pavement where thermoplastic bike lane indicators are placed to help reduce damage as a result of snowplows. While this method increases the cost of installation, it may save in long-term maintenance costs (and help preserve safety conditions along the roadway).

Edge-of-roadway Visual Cues

Pavement markings, striping, sidewalks curbs, and other types of travel delineators installed at ground-level serve as good indicators of the bicycle travel way when they the ground is clear, but after a snow event, these lose their utility, and in some cases can become hazards, making the travelway be difficult to navigate.

For this reason it is important to provide other visual cues to indicate the bicycle travelway for those riding and snow plow vehicles. Possible locations for snow storage include the buffer area of protected bikeways, in the place of parked cars in parking protected bike lanes, and along the furnishing zone of the sidewalk. Piling snow in these locations all help to visually define the path of travel and help snow plows operators identify curblines. This becomes especially critical when the bike facility bends in or out around curb extensions, median islands or other transitions.

[1] *Development of Recessed Pavement Markings that Incorporate Rumble Strips. http://www.easts.info/publications/journal_proceedings/journal2010/100292.pdf*

Winter Maintenance Program

Prioritization and scheduling is a key component of a successful winter bikeway program. For most jurisdictions, keeping all bikeways completely clear during or immediately after a heavy snow event is infeasible. Clearing major city bikeways as soon as possible provides the best access to the greatest number of people possible following a heavy storm event.

The major bikeway network and winter maintenance program need to focus on major local destinations. If roadway clearing and de-icing begins first thing in the morning, primary routes leading to schools, commercial corridors and business districts, and other major destinations should be cleared first.

Snow storage spills out onto a separated bike lane reducing the path of travel along this block in Salt Lake City, Utah.

Coordination between agencies and departments responsible for on-street bikeways and shared use paths is necessary to ensure the major bikeway networks are plowed in an organized, complete, and timely matter.

In Järvenpää, Finland, Class A routes, the main bikeway routes from residential areas to the city center and through the city center, are cleared first. This is followed by Class B routes, bikeways along other major roads, and Class C routes, those along residential streets and through parks.

- Class A routes are plowed within 4 hours of 3 cm of snow accumulation and de-icing treatments are applied before 7am. Plowing is done before 7am when snowing at night.
- Class B routes are plowed within 4 hours of 5 cm of snow accumulation and de-icing treatments are applied as needed. Plowing is done before 7am when snowing at night.
- Class C routes are plowed after class B routes and plowing is done before 10 am.

Sand and road grit is cleared from Class A, B and C bikeways in Järvenpää every year before the 1st of May.

The Wisconsin Department of Transportation also offers guidance on the

prioritization of snow removal from shared use paths (Wisconsin Bicycle Facility Design Handbook, 2009 p. A-4, A-5):

Winter use varies according to local conditions. In some communities (e.g. Eau Claire, Madison), trails are plowed regularly and are used frequently by people walking and bicycling. Heavily-used trails that serve key destinations should be considered first for plowing. Even trails that serve only occasional use should be considered for snow removal if the trail is the only means of making a key connection (e.g., crossing a bridge). Lower priority may be given to isolated trails that serve recreational users who must travel long distances to use them. In these cases, managers may want to allow use by cross country skiers or snowmobile operators as long as all applicable laws are followed.

To ensure that winter use is properly accommodated, agencies must clearly understand who will maintain what trail. For trails along state highways, a municipality will have the responsibility for maintenance. Winter use and snow removal frequency will be determined by the municipality after considering the following factors:

- Expected use by bicyclists and pedestrians;
- Parallel options for bicyclists and pedestrians if the trail is not passable

A good winter maintenance program requires a maintenance plan that prioritizes facilities, establishes a maintenance schedule for frequent clearing, and sets operational standards for winter maintenance relating to facility design, equipment, and materials.

In many cases, adjoining property owners maintain sidewalks and shared-use paths. On priority routes not maintained by the city, the city should work directly with property owners to encourage and/or enforce snow removal.

Additional consideration is required during design and operation to provide winter maintenance on bikeways that are separated.

Major bikeways prioritized for plowing provide direct, predictable, connections for people on bike. These routes may overlap with other designated transit, freight, or emergency service routes and should receive special attention during snow events.

In the situation where the main arterial or collector has curb-tight sidewalks and has not provided a specific snow storage location, the bike lane may be used for snow storage when a parallel off-street or parallel route is available and snow operations can keep that parallel facility ridable. Notification of bike lane closure and re-routing to the parallel facility should also be provided. Temporary signage, news outlets, and routable mapping notifications should ensure knowledge of the maintained route.

As discussed earlier in the use of the buffer of a buffered bike lane being used for snow storage, the melting from this pile will sheet flow across the parking protected bike lane and needs to be worked into the overall winter maintenance operation to ensure adequate traction in icy conditions.