

RENO SPARKS BICYCLE & PEDESTRIAN PLAN

Design Best Practices

October 2011



FEHR & PEERS

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BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

INTRODUCTION

The appropriate design of bicycle and pedestrian facilities is an integral component of encouraging the public to walk and bicycle for utilitarian and recreational purposes. Good design also affects the experience, enjoyment, safety, and comfort for pedestrians and bicyclists.

Bikeway and pedestrian facility planning and design in Reno, Sparks, and Washoe County typically rely on guidelines and design standards established by the following:

- American Association of State Highway and Transportation Officials (AASHTO) *Guide for the Development of Bicycle Facilities* (1999)
- *Manual on Uniform Traffic Control Devices (MUTCD)* includes guidance on bikeway signing and striping.
- The City of Reno, City of Sparks, Washoe County, and Nevada Department of Transportation (NDOT) all have basic standards for bicycle and pedestrian facilities within their respective right-of-ways. The Public Works Design Manual and other related City documents provide design standards for City of Reno roadways.

Reno Sparks Bicycle and Pedestrian Plan Vision:

To support walking and bicycling, the Region will have an integrated system of safe, convenient and comfortable bicycle, pedestrian and other non-motorized facilities that provide access to schools, jobs, shopping, neighborhoods, community facilities, parks and regional trails.

These resources provide a good framework for future implementation, but may not always address specific situations. This document incorporates and expands upon these standards and guidelines to provide a resource for typical design considerations, and to guide design decisions. ***This Design Best Practices document is intended to provide a toolbox of bicycle and pedestrian design options to be used at the discretion of the local jurisdictions. Implementation of these design options is not mandatory.***



**Bicycle Lane on Lincoln Boulevard
Sparks, NV**



**Crosswalk on 2nd Street
Reno, NV**

BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES



Summit Sierra Shopping Mall

The *Reno Sparks Bicycle and Pedestrian Master Plan* notes that different facilities serve different types of cyclists, and that the needs of frequent and casual riders vary. The *AASHTO Guide to the Development of Bicycle Facilities*, states that: “All roads, streets and highways, except those where cyclists are legally prohibited, should be designed and constructed under the assumption that they will be used by bicyclists.” For experienced riders, this means making every street bicycle-friendly, while for casual and intermediate riders, this means including separate bicycle lanes and providing trails where possible. In addition, streets should be designed with pedestrian facilities to provide access to land uses, transit, etc. by all users.

The guidelines in this document are intended as a resource for designers as the RTC endeavors to provide “complete streets”. The guidelines should coordinate with other documents, which generally establish design minimums. This document is meant as a supplement to existing local and national guidelines, and is not intended to replace engineering judgment or become a constraint, particularly as it is difficult to capture the full spectrum of design challenges in a single document.

DESIGN PRINCIPLES

This document is based on the following design principles, which reflect the policies in the Reno Sparks Bicycle and Pedestrian Master Plan:

1. Routinely accommodate bicyclists and pedestrians as part of roadway improvement projects.
2. Provide as much space as is reasonable for on-street bicycle lanes, with a preferred width of 5.5 feet.
3. For on-street facilities, use signs primarily for wayfinding and pavement markings for channelization.
4. Strive for area-wide consistency in signs and markings.
5. Consider all levels of cyclists when making design decisions. Experienced, confident riders are most likely to ride on arterials, while casual, less confident riders are more likely to use paths or low-volume collectors and residential streets.
6. Use lighting, traffic control devices, and striping to enhance frequently used crosswalks and crosswalks on heavily traveled roadways.
7. Provide facilities that take into account the needs of all users, including the transportation disadvantaged.
8. Provide continuous bicycle and pedestrian facilities that directly connect to destinations.
9. Design bicycle and pedestrian facilities to the highest and best standard possible.

BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

BICYCLE LANES

This chapter includes guidelines for bicycle lanes along roadways and at intersections. Generally, bicycle lanes are “a portion of the roadway designated by striping, signing, and pavement markings for the preferential or exclusive use of bicyclists.”¹ Most riders benefit by having a lane that is separate from motor vehicle traffic.

GUIDANCE FOR RETROFITTING STREETS

In mostly built-out cities where there is little construction of new roads, a key challenge for designers is retrofitting existing streets with bicycle lanes. Goal 1 of the *Reno Sparks Bicycle and Pedestrian Master Plan* is to support walking and bicycling and the development of a comprehensive bicycle and pedestrian network that connects to other transportation modes, meets the needs of commuter and recreational users, and creates a viable alternative to the automobile in order to increase the number of people bicycling and walking. Constructing some of these facilities will require a change to the existing roadway configuration. The following steps should be taken to determine the feasibility of bike lanes on existing streets in Reno, Sparks, and Washoe County:

1. Evaluate how well the existing cross section serves bicyclists.
2. Develop an optimum cross section to balance the needs of all users without significantly compromising safety or level of service for vehicular traffic.

The decision-making process to retrofit arterial roadways in Reno, Sparks, and Washoe County includes three steps. The results are driven by specific roadway characteristics.

First, the designer should determine the appropriateness of the roadway as a bicycle route. The following questions should be considered:

1. Is the route part of the Bicycle and Pedestrian Master Plan?
2. Has the route been approved by the local agencies?

Second, the designer should analyze the existing roadway cross section and consider modifications to provide space for bicycle lanes. The figures in this document include minimum and preferred widths for bicycle lanes and vehicle travel lanes. Minimum bicycle lane widths are acceptable under retrofit conditions only when a determination is made that the cost of rebuilding to attain the preferred width far exceeds the benefits of the re-build. The following questions are appropriate:

1. Can any existing vehicle lanes be narrowed?
2. Can any existing vehicle lanes be removed (consider travel lanes, turn lanes, and parking lanes)?
3. Can medians or planting strips (buffers) be narrowed?
4. Can the existing pavement be widened, or can the curbs be moved without compromising local standards for widths of lanes, sidewalks, curbs, etc.?

Vehicle Lanes

Recent research indicates that the use of lanes narrower than 12 feet on urban and suburban arterials does not increase crash frequency (National Cooperative Highway Research Program project 17-26). The researchers recommend that geometric design policies should provide “substantial flexibility” for use of narrower lanes, particularly in retrofit situations where narrow lanes would result in added width for bicycle lanes.

¹ *Regional Transportation Plan*, RTC of Washoe County

BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

Third, the designer should consider the effect of changes to the existing cross section on:

1. Pedestrian needs (buffers, sidewalk and crossing widths, and medians)
2. Roadway capacity, including traffic volume
3. On-street parking demand and turnover
4. Large traffic (trucks and buses)
5. Horizontal alignment (curved roadway sections)
6. The 85th percentile speed

If the analysis finds that bicycle lanes are feasible, the project can move to implementation. If there are constraints, designers should develop alternatives with the goal of improving bicycle safety and access to the highest degree possible.

A common method for retrofitting a street to accommodate bicycle lanes is a road conversion (or road diet). Typically a road conversion is implemented on a four-lane roadway by reducing the vehicle travel lanes from four to three (one travel lane in each direction with a two-way left-turn lane) and adding bicycle lanes. Road conversions are generally considered on roadways that carry up to 20,000 daily vehicles. Bicycle Lane Dimensions

The figures on the following pages illustrate the minimum and preferred widths for bicycle lanes in the following situations:

- Adjacent to Parallel Parking (Figure 1)
- Adjacent to Back In Angled Parking (Figure 2)
- Without Parking (Figure 3)
- Along a Steep Grade (Figure 4)
- With Buffer (Figure 5)
- Contra Flow (Figure 6)
- Cycle Track (Figure 7)

As mentioned above, minimum widths are acceptable under retrofit conditions only when a determination is made that the cost of rebuilding to attain the preferred width exceeds the benefits of the re-build or a change would detrimental in other ways.

Location of Utilities Adjacent to Bicycle Lanes

The Cities of Reno and Sparks, and Washoe County refer to the latest version of AASHTO's *Guide for the Development of Bicycle Facilities* when designing bicycle facilities in their jurisdictions. This Design Best Practices guide provides additional design standards for the area and recommends a minimum bicycle lane width of 4 feet, with a preferred width of 5.5 feet for bicycle lanes adjacent to the curb face. Designers should take care to maintain a 2.5 foot clear longitudinal surface, free from drainage grates and other obstructions in order to give cyclists an adequate width to ride. The gutter pan should not be considered part of the clear surface.

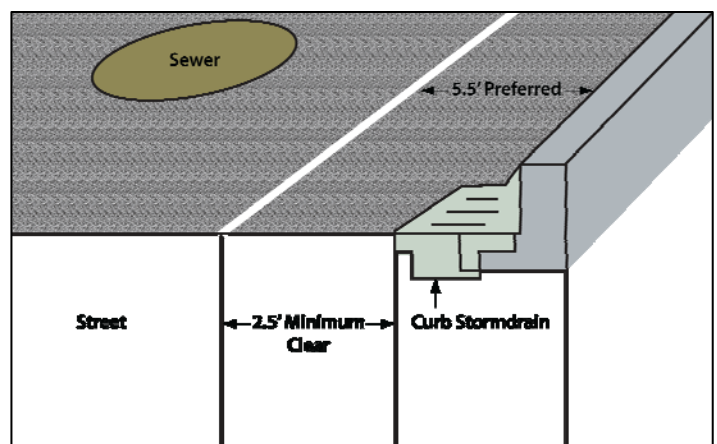
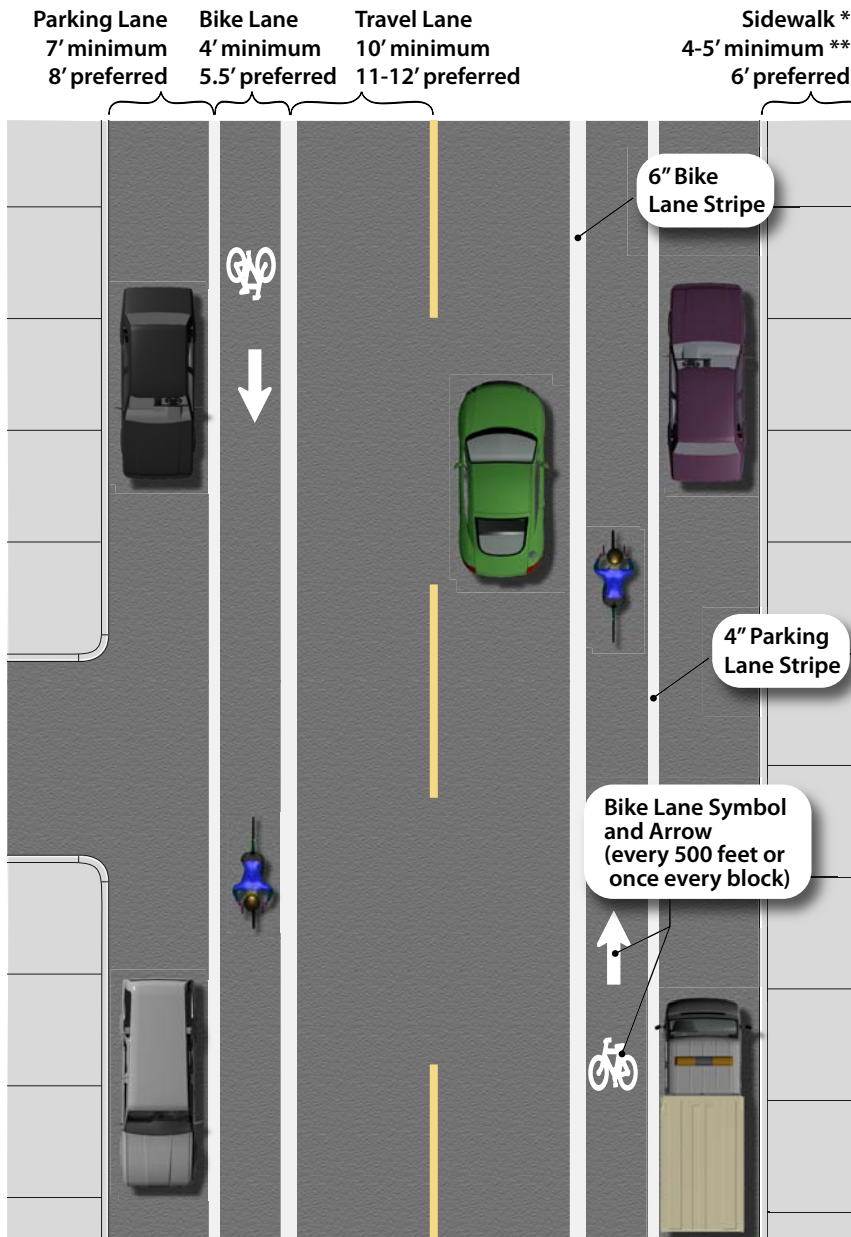


FIGURE 1
BICYCLE LANES ADJACENT TO PARALLEL PARKING



First St and Ralston St



Nevada St and Ralston St

* See Figure 17 Sidewalk Cross Section for sidewalk design guidelines

** 4' minimum on local and residential roadways, 5' minimum on collectors and arterials



Bike Lane signs are optional

Description:

Bike lanes adjacent to angled parking are marked by a stripe on the traffic side of the lane. Back-in parking spaces are preferred because as a driver leaves the parking space they can see and make eye contact with bicyclists in the bike lane. Bike lanes adjacent to angled parking should be avoided and applied only when angled parking is absolutely necessary.

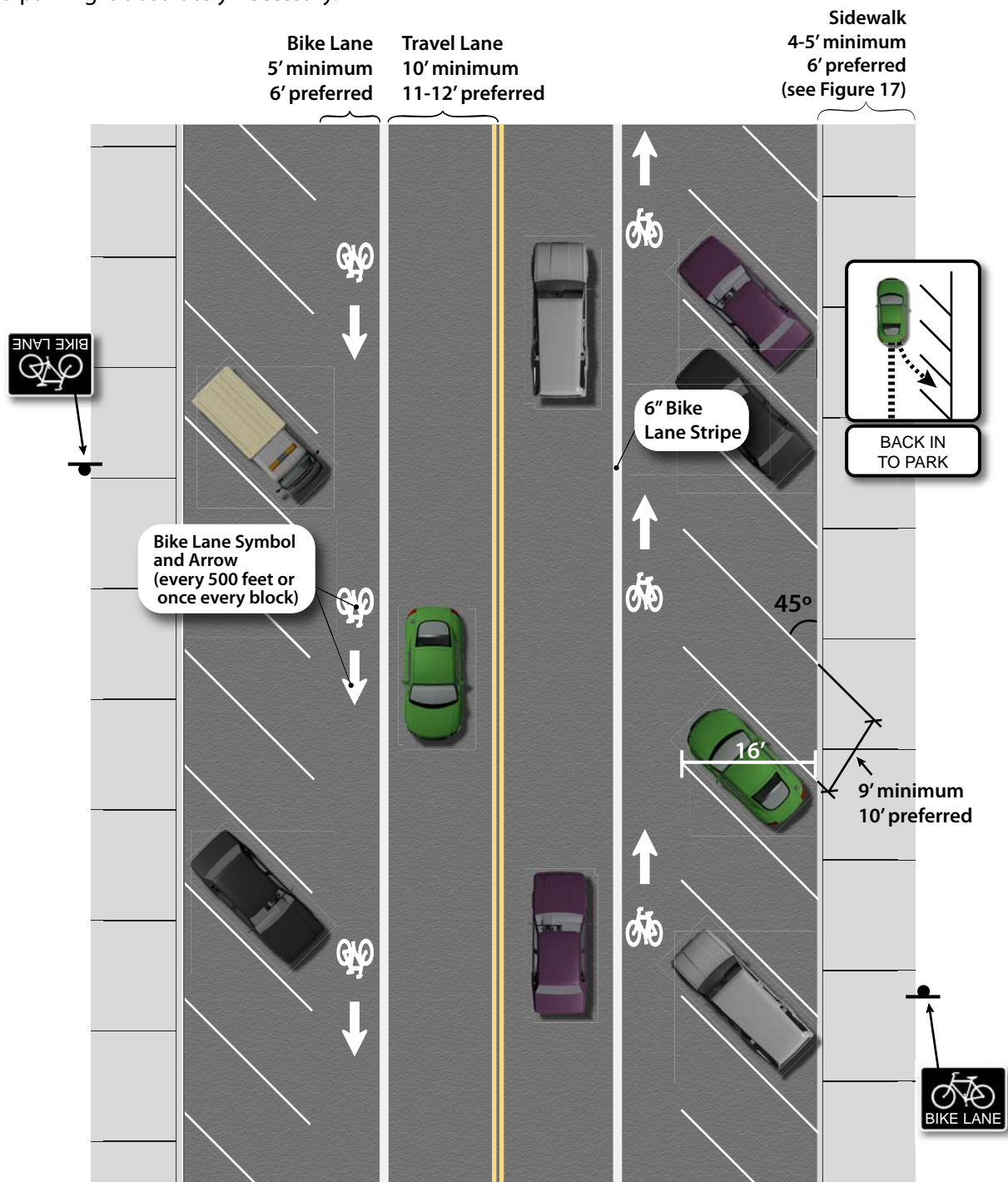
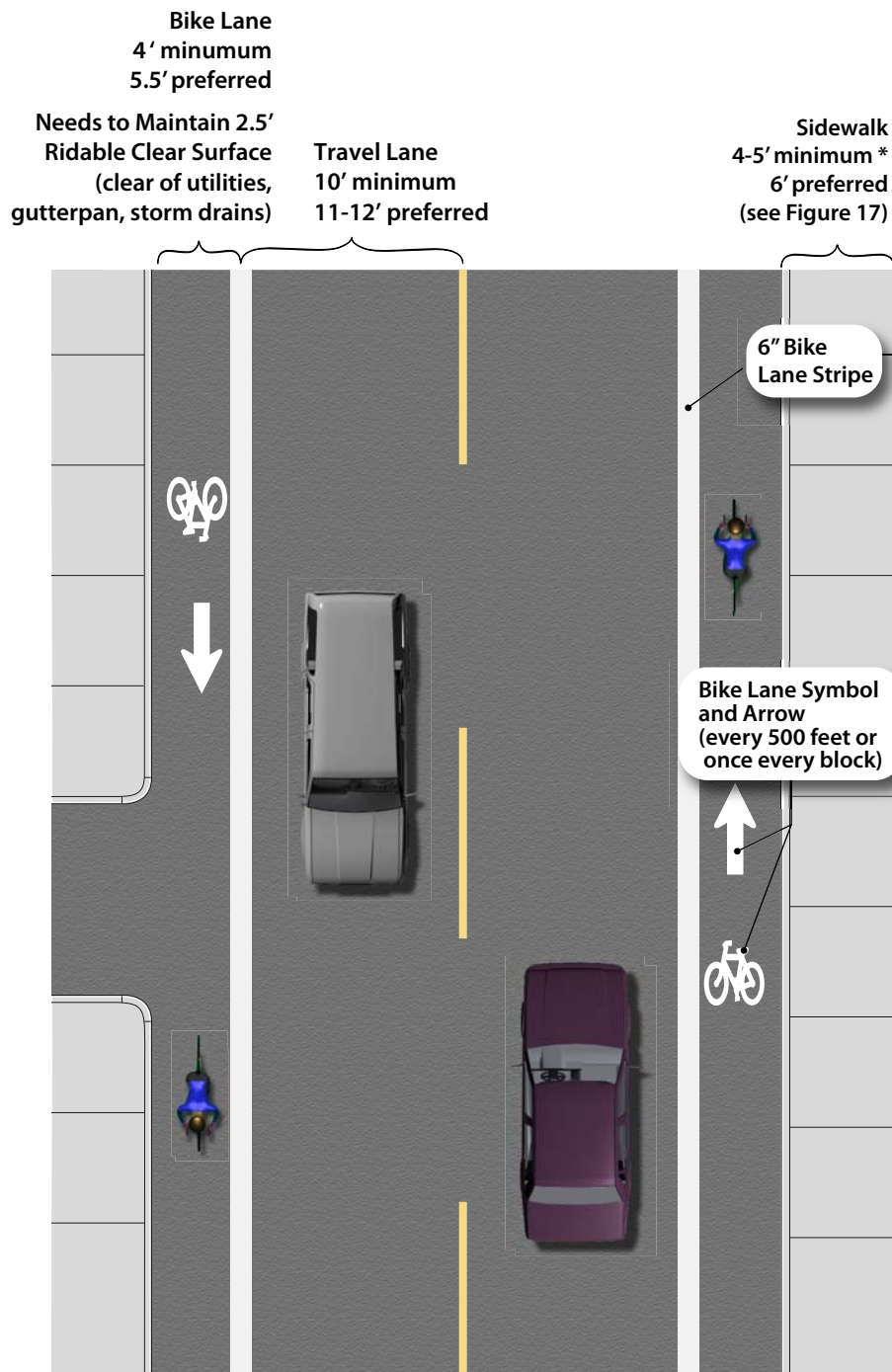
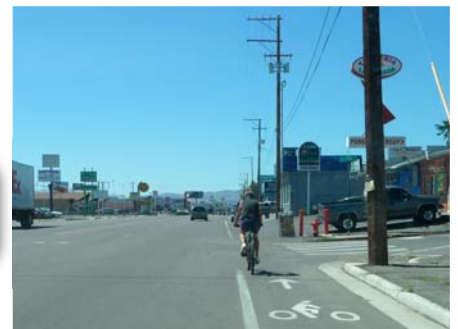


FIGURE 3
BICYCLE LANES WITH NO PARKING



Wedge Pkwy and Whites Creek Ln



Kietzke Ln and Lewis St

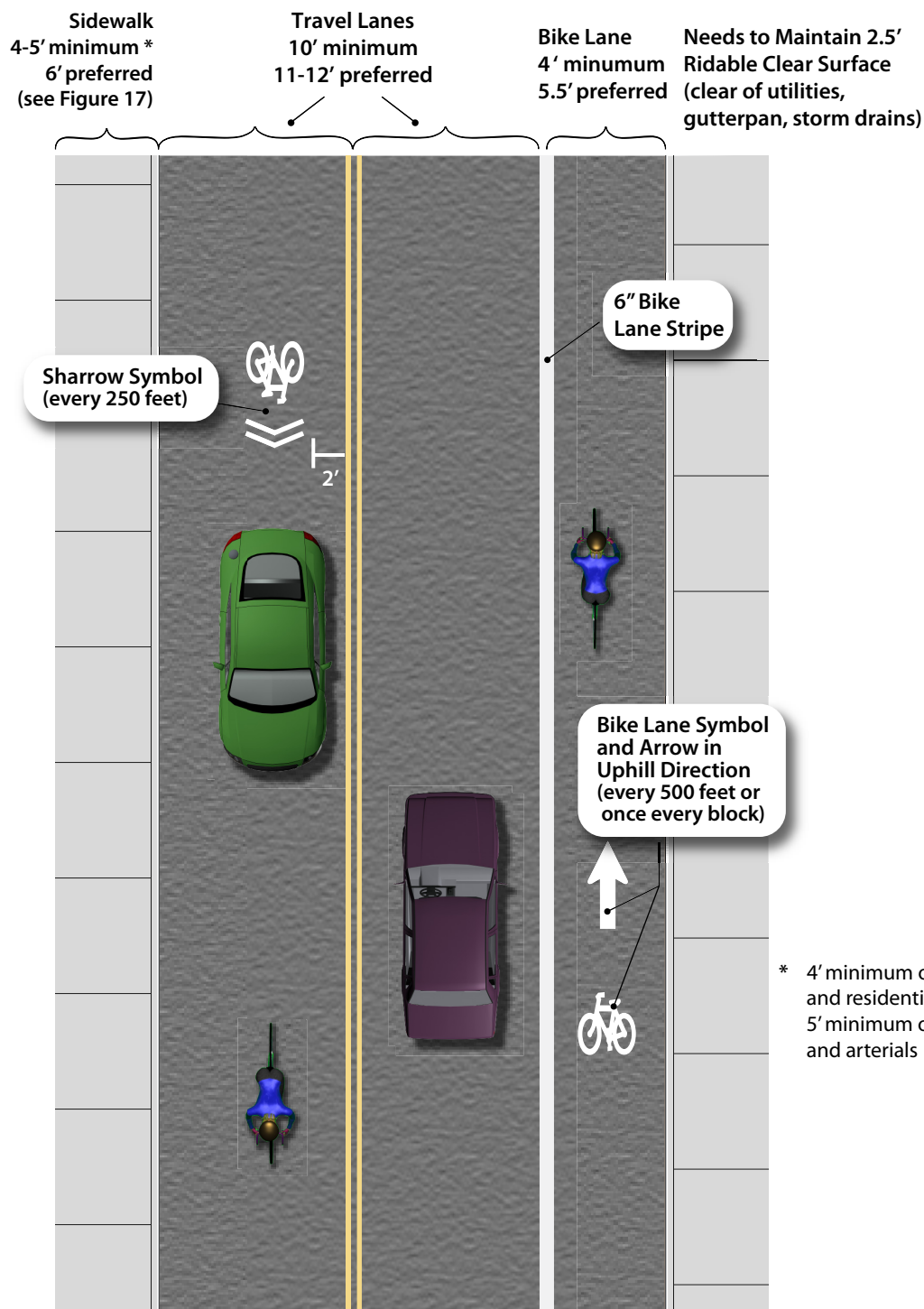
- * 4' minimum on local and residential roadways, 5' minimum on collectors and arterials



No Parking Bike Lane signs are optional

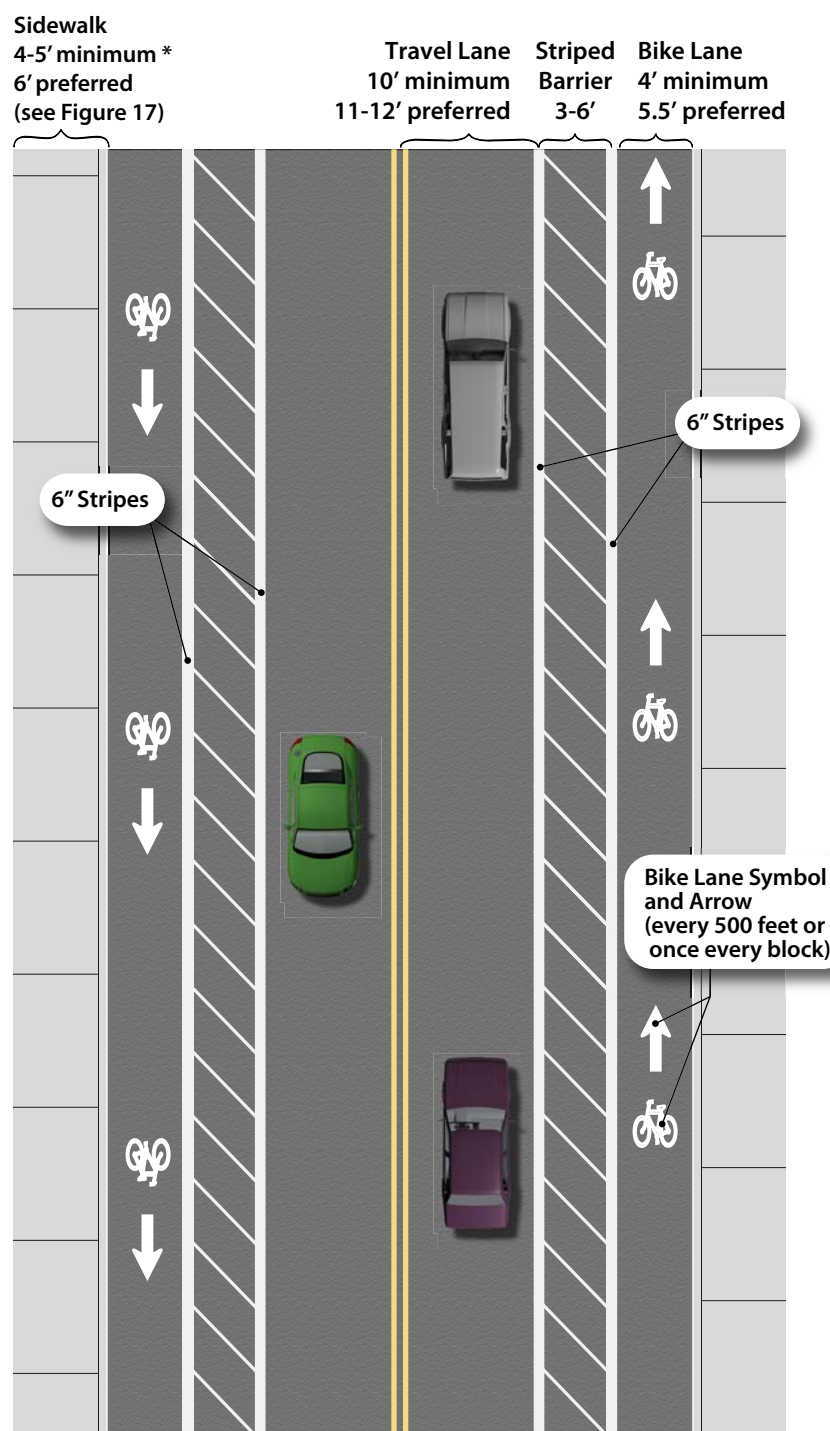
Description:

A bike climbing lane should be used on steep grades where room for a bike lane in each direction is not available. The bike lane should be placed on the uphill side of the road where bicyclists are likely to travel at slower speeds than vehicles. Sharrows should be used on the downhill side where bicyclists can more easily keep with the speed of vehicle traffic.



Description:

A buffered bike lane supplies a space between the vehicle travel lane and the bike lane. The buffer may be painted on or a physical buffer can be applied. Buffer treatments are ideal on streets with minimal cross streets and driveways.



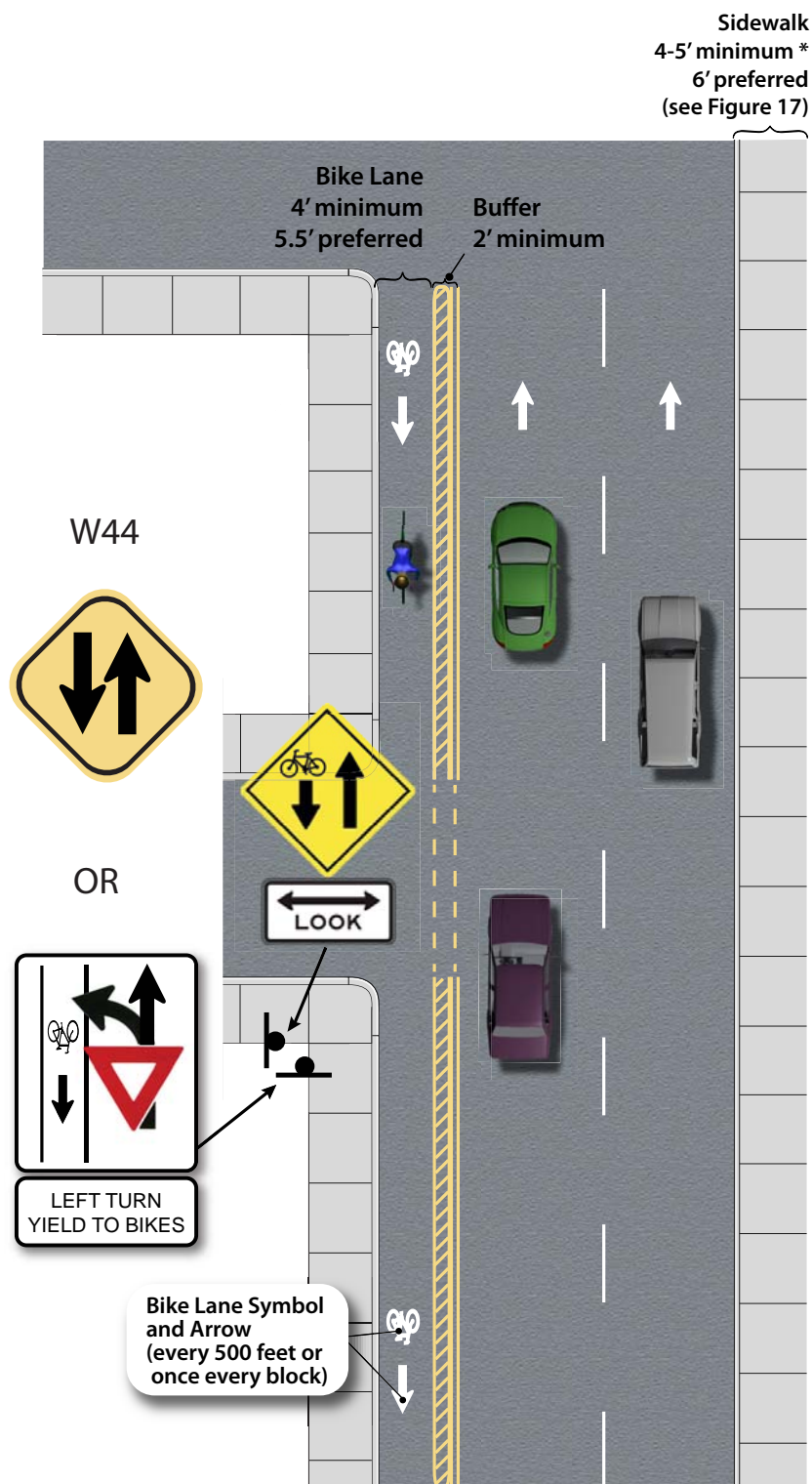
Notes:

- Should be used in locations with relatively few driveways and / or intersections
- Ok on moderate to high speeds roads
- Needs regular street sweeping

* 4' minimum on local and residential roadways, 5' minimum on collectors and arterials

Description:

A contra-flow bike lane is a striped lane that goes against the flow of vehicle traffic on a one-way street. A double-yellow line and a buffer should be used to separate the bike lane from vehicle traffic.



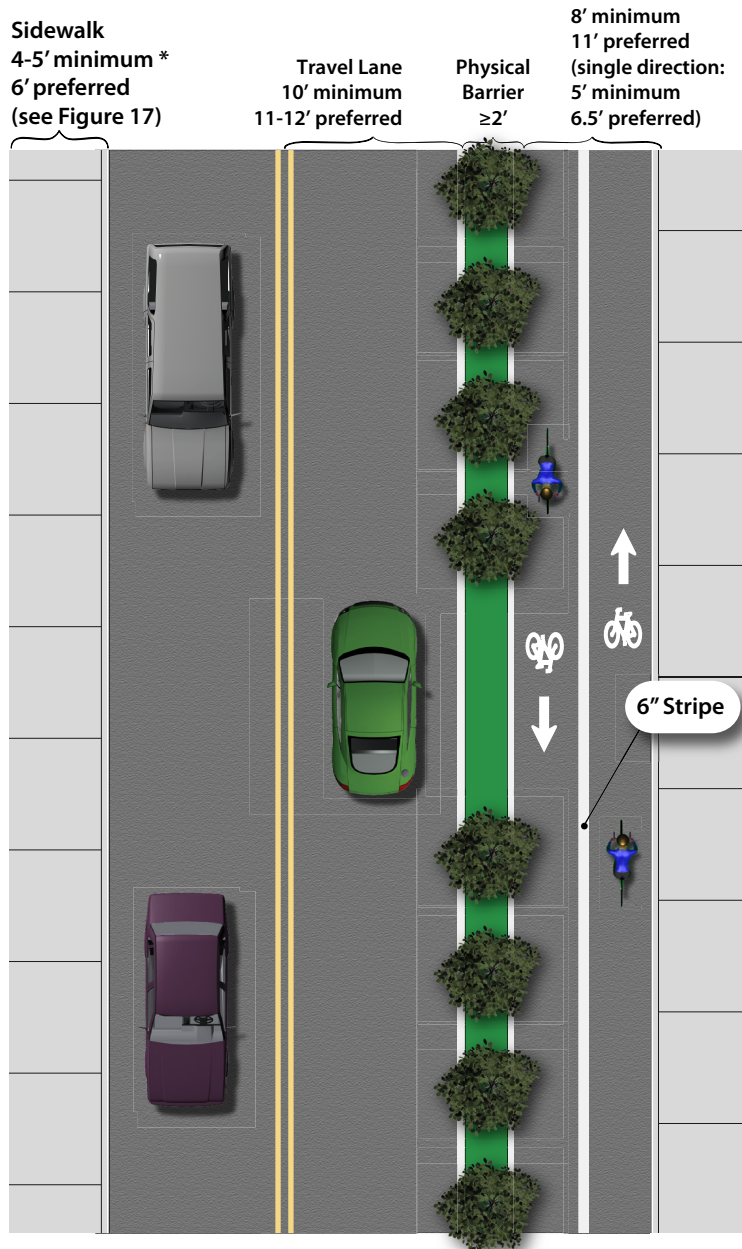
Notes:

- Provides improved safety
- Should be used in locations with infrequent driveways on bike lane side
- Should provide safe connectivity to facility at either end
- Should be used in locations with high bicycle volume
- Not applicable to all one-way streets

* 4' minimum on local and residential roadways, 5' minimum on collectors and arterials

Description:

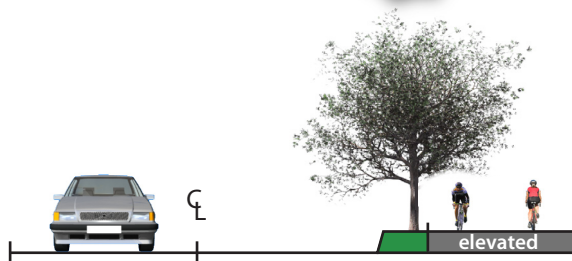
A cycle track is an exclusive bicycle facility located adjacent to a roadway, but separated from vehicle traffic and sidewalks with pavement markings, bollards, or curbs/medians. Cycle tracks can be one-way or two-way facilities and should be elevated from the vehicle travel lane.



Notes:

- Should be used in locations with adequate pedestrian facilities so the bike facility will not be considered a "multi-use path"
- Should be used in locations with few high volume driveways and cross-streets
- Ok on moderate to high speed roads
- Needs regular street sweeping
- Should not interfere with transit stops

* 4' minimum on local and residential roadways, 5' minimum on collectors and arterials





BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

BICYCLE LANE MARKING MAINTENANCE

Longitudinal bicycle lane markings in the region are applied using paint, which should be reapplied at least every 12 months, if possible. Pavement stencils should be reflective and capable of maintaining an appropriate skid resistance under rainy or wet conditions to maximize safety for bicyclists. Thermoplastic can meet these requirements and be modified with crushed glass to increase the coefficient of friction. Pre-formed bicycle lane markings are recommended, rather than a template applied in the field.

Generally, bicycle lane pavement markings should be provided every 500 feet or once every block. It is also recommended that markings be provided at all transition points, particularly when there is a break in the bicycle lane striping (e.g. at intersections).

UTILITY COVERS AND CONSTRUCTION PLATES

Utility covers and construction plates present obstacles to bicyclists due to their slick surface and change in elevation compared to the surrounding pavement. While covers and plates can be replaced with more stable designs, it is ideal to locate them outside the typical path of bicyclists. New construction should avoid placement of manhole covers and other utility plates where bicyclists typically ride (i.e. within the 6 feet adjacent to the curb, or between 7 and 13.5 feet from the curb if parallel parking is permitted) wherever possible. These guidelines require a minimum of 2.5 feet of clear surface, free of obstructions.

Wet utility covers and construction plate materials can be slippery, particularly plain steel plates which are not recommended for temporary or permanent installation on the roadway. Bicycle travel paths should be considered when placing construction plates, and a clear zone provided when possible. Imprinted waffle shaped patterns or right-angle undulations on the surface of steel or concrete covers provide an acceptable skid resistance.

Utility covers placed within a bicyclist's typical path of travel should be marked with "Λ" (vee or chevron lines) so they are more visible for bicyclists, especially on tree shaded streets.

RAISED PAVEMENT MARKERS

Pavement markers, whether raised reflective markers or non-reflective ceramic pavement markers (Bott's dots), present a vertical obstruction to bicyclists. When necessary as a fog line or adjacent to the edge line, reflective markers should be placed to the left of the line outside the shoulder area. Where raised markers cross a bike lanes or extensions of bike lanes through intersections, a gap of 4 feet should be provided as a clear zone for bicyclists. At gore areas or other locations with channelizing lines, if raised reflective markers are used to supplement striping, extra lane width shall be provided in the areas where bicycles travel.

STORM WATER DRAINAGE DESIGN²

This section describes ways to reconcile storm water drainage design, typically curb, gutter, and drainage grates, with bicycle safety, both of which occur on the right edge of the road. An alternative curb and gutter design is presented that provides the same function as standard gutters and grates, but does not pose a threat to bicycle safety. Where grates are used, recommendations are provided to reduce their impact on bicycle safety.

² Ibid

BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

Design Considerations

The primary functions of a drainage grate are to drain storm water quickly from the roadway and provide access to maintenance workers to clean out the inlet. Gutters are sloped to direct water flow into the drainage inlet and keep water from ponding. Grates can become clogged in areas with many deciduous trees, rendering them useless. While the gutter and inlet design must be hydraulically effective, other designs are just as effective in removing water from the roadway.

Design and Placement of Drainage Grates

Drainage grates should always be designed with as little impact to bicyclists as possible. Older grates with wide openings can be harmful to cyclists if the wheel of their bicycle gets stuck in the opening. Newer, bicycle-friendly grates with narrower openings should be used. Attempts to retrofit older, unsafe grates by welding crossbars onto the parallel bars have proven insufficient and should not be considered. Replacing older grates with newer, bicycle-friendly grates is preferred.

Ideally, roadways and bicycle lanes should be designed so bicyclists do not have to traverse drainage grates. However, on roadways with curb and gutter, grates should not be wider than the gutter pan. If the gutter pan needs to be widened to accommodate a large drainage grate, a taper should be provided on the outside edge into the planter strip.

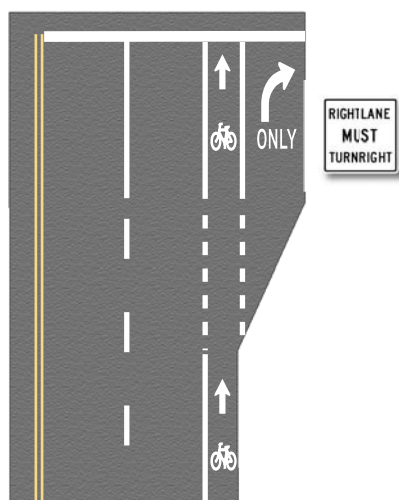
Bicycle lanes should be designed with a minimum clear surface (clear of utilities, gutter pans, and drainage grates) of 2.5 feet. If 2.5 feet of clear surface cannot be maintained, then a curb opening inlet should be considered.

On roadways with shoulders, drainage grates should be placed outside of the bicycle travel path and maintain a minimum width of 4 feet between the shoulder stripe and the left edge of the drainage grate. If 4 feet cannot be provided within the existing shoulder width, the shoulder should be widened to accommodate the grate or a narrower grate should be selected. Optimally a 12 inch maximum gutter pan should be used on new construction projects.

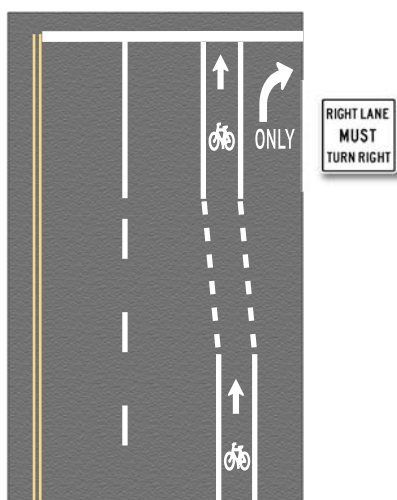
BICYCLE LANES AT INTERSECTIONS

Nationally, the majority of collisions between motorists and bicyclists occur at intersections. There are several bicycle facility treatments that can be used to improve safety and significantly reduce conflicts at intersections. The following figures provide design standards for the following scenarios and treatments:

- Bicycle lanes and right-turn lanes
- Bike boxes
- Colored bicycle lanes
- Bicycle detection at traffic signals



a. Right-turn-only lane



b. Parking lane into right-turn-only lane



c. Drop lane



d. Optional right/straight and right-turn-only



e. Shared bicycle/right-turn pocket



S. Virginia St and Damonte Ranch Rd

Notes:

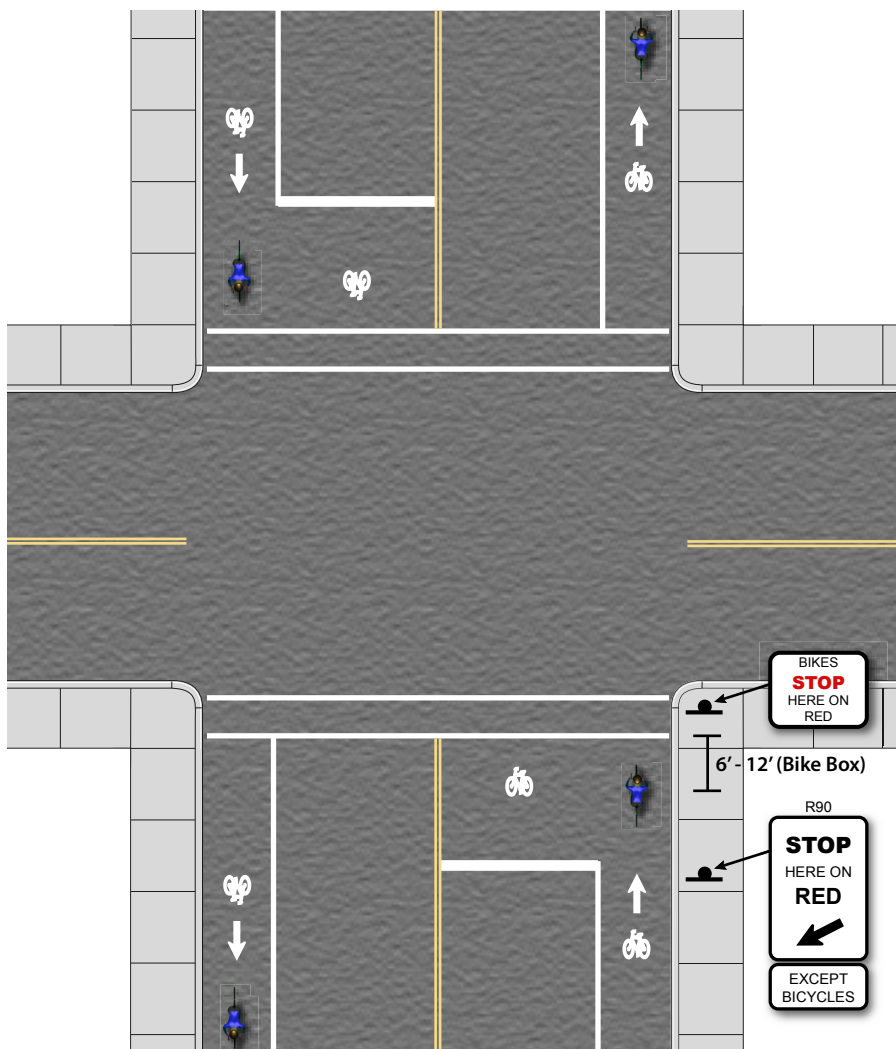
- Treatment c. Drop lane should only be used when no other option is available. This should only be used on roadways with speed limits of 30 mph or less.

Description:

A bike box is a signalized intersection treatment that improves safety for bicyclists at intersections. This bicycle facility provides a bike lane that leads to a “box” positioned behind the crosswalk and in front of the stop bar for vehicles. This facility helps to maintain the visibility of bicyclists by putting them in front of the motorists at an intersection. Bicyclists are given a “head start” when the signal turns green, reducing potential conflicts with vehicles.

Notes:

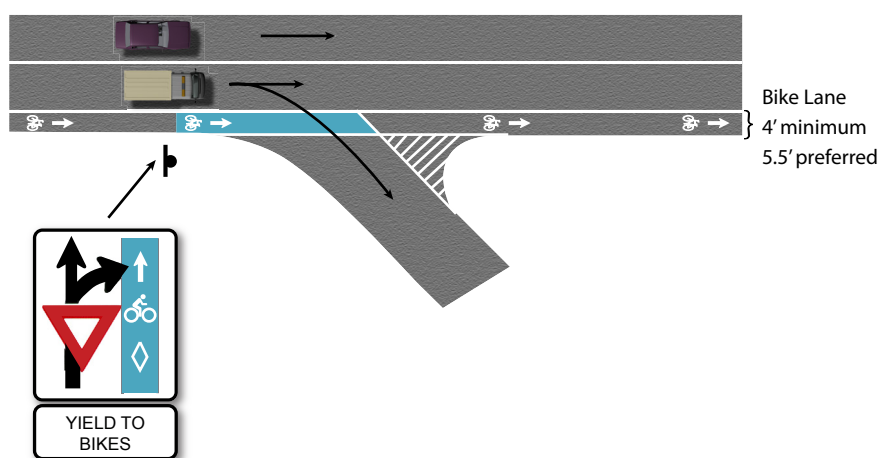
- Should be used at intersections with high bicycle and vehicle volumes
- Should be used at intersections with a high percentage of turning bicyclists and vehicles
- No Right Turn on Red must be enforced
- Can be combined with a bicycle signal (optional)
- For use at intersections with permitted left-turn or split signal phasing



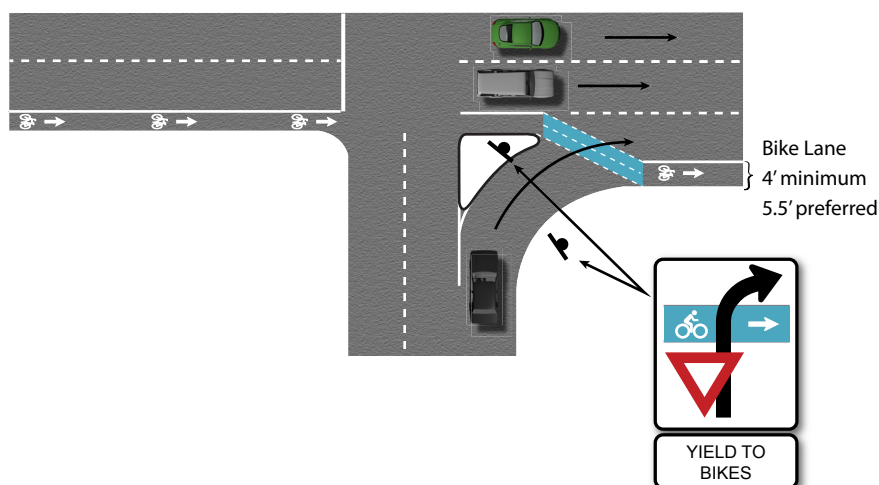
Description:

Colored bike lanes are used as a device to alert drivers of the presence of a bike lane. Typically, a colored bike lane is used in high conflict areas, where motorists merge into or cross the bike lane, or in high speed zones.

Exit Ramp Zone



Entrance Ramp Zone



Notes:

- Should be used where a high volume of vehicles turn across the bike lane (i.e. at freeway ramps or channelized right-turn lanes)
- Should not be used in typical 4-legged intersection situations
- Should be used where motorists merge at an angle and sight distance is impaired
- Should be used in areas with high bicycle volumes
- Should be used where bicyclists have the priority movement
- Can also be used for contra-flow bike lanes

BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

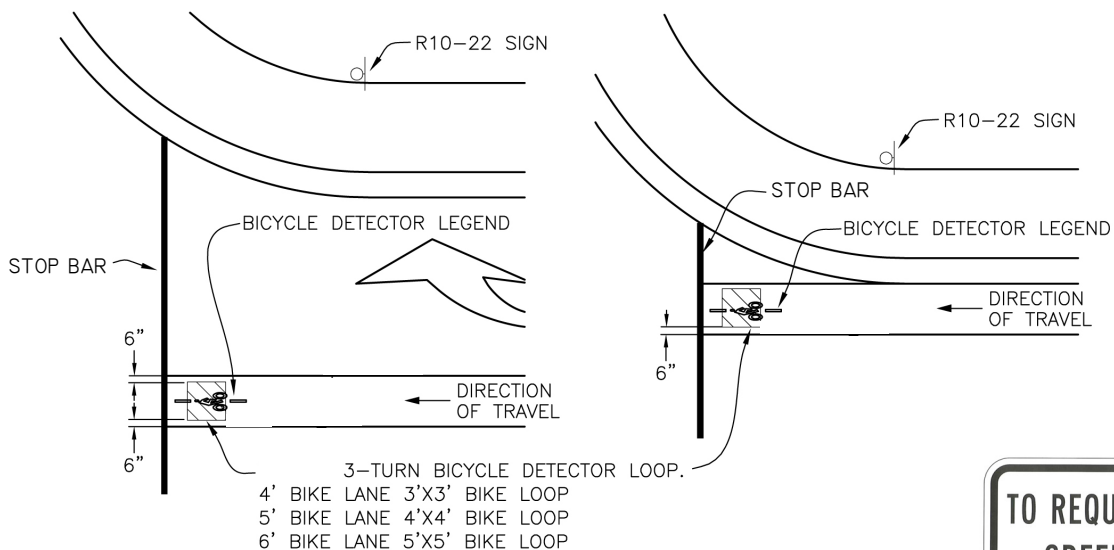
Bicycle Loop Detectors and Push Buttons

As new signals are installed or major updates occur at existing signalized locations, bicycle loop detectors should be installed on the bikeway system for all movements that do not recall to an automatic green light. Bicycle loop detectors should be installed in the bicycle lane approximately 100 feet in advance of the intersection, as well as at the intersection behind the stop bar. The upstream loop should be designed to avoid being triggered by right-turning vehicles. When the first bicycle loop is triggered, the green time of the signal should be extended to allow the cyclist to reach the loop at the stop bar, at which point the signal should allow the cyclist to clear the intersection. The time that a bicycle needs to cross an intersection is longer than the time needed for vehicles, but shorter than the time needed for pedestrians. The *AASHTO Guide for the Development of Bicycle Facilities* includes detailed equations for bicycle signal timing. In general, while the normal yellow interval is usually adequate for bikes, an adjustment to the minimum green should be considered.

Stencils markings should be used to tell bicyclist where to position themselves at the intersection to be detected by the loop. The figure on the following page shows the appropriate location and use of loop detector stencils at intersections.

Push buttons can also be used for bicycle detection when other methods of detection are not feasible, particularly at narrow tunnels or where multi-use paths cross signalized intersections. A bicycle push button is similar to a pedestrian push button, but is installed in a more convenient location for bicyclists. Bicycle push buttons should be labeled with a sign (shown to the right) indicating their use by bicyclists. Larger surfaces are easier for cyclists to use, thus a push pad is preferred to a push button, and a push bar is preferred to a push pad, as it can be actuated without removing one's hands from the handlebars. Push buttons are a popular option because they are less expensive than other options, and they allow for different signal timing for different user needs. Some cyclists do not like push buttons because they are located on the right side of road, making through and left-turn movements difficult.

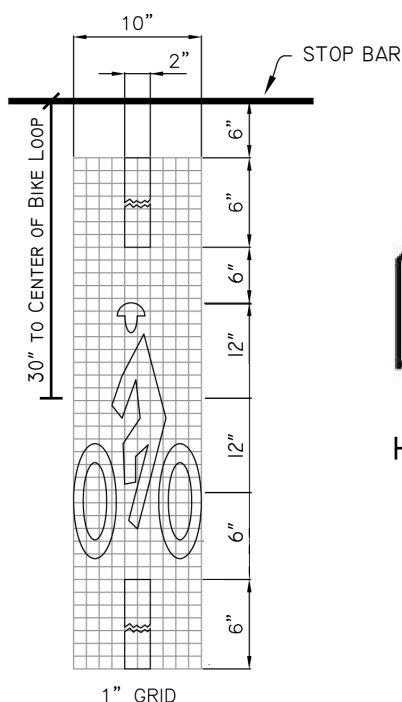




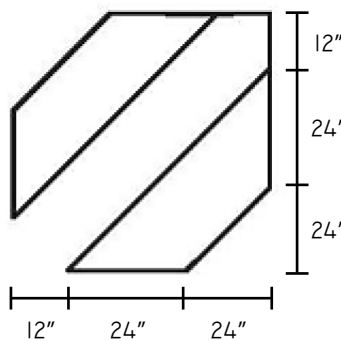
TYPICAL BICYCLE DETECTOR LOOP
AND LEGEND PLACEMENTS
(NO SCALE)



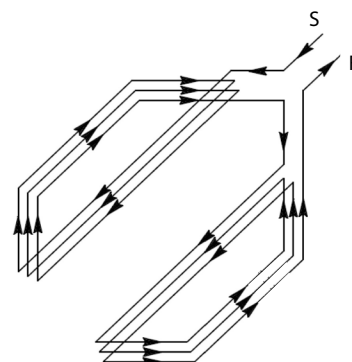
R10-22 SIGN
OPTIONAL



BICYCLE DETECTOR LEGEND
(NO SCALE)



Sawcut Detail



Winding Detail

3-Turn Bicycle Detector Loop Configuration

Notes:

1. Round corners of acute angle sawcuts to prevent damage to conductors.
2. Dimensions shown are for a 5' x 5' loop, adjust accordingly for other size loops.
3. Place legend in center of bike lane.

BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

SHARED ROADWAYS

Shared roadways are intended to provide continuity throughout a bikeway network and are primarily identified with signs. Shared roadways can be used to connect discontinuous segments of a bicycle lane or bicycle path, and are shared facilities with motorists on roadways or with pedestrians on sidewalks (not desirable). Minimum widths for shared roadways are not presented in this document, as the acceptable width is dependent on many factors.

SHARED LANE MARKINGS

The Shared Lane Marking, or “Sharrow” is a new design feature that has been added to the 2009 Edition of the *MUTCD*. Sharrows are pavement markings in the vehicle travel lane that allow bicyclists to use the full lane. Sharrows are helpful connectors between multi-use paths or bike lanes when roadway widths are too narrow to accommodate a bike lane. Sharrows are suitable for streets with posted speeds below 35 mph, preferably with on-street parking. When using Sharrows, pavement markings should be placed every 250 feet.

The following table presents recommended lane widths based on average daily traffic (ADT) and speed thresholds for shared lane markings.

RECOMMENDED GUIDELINES FOR SHARED LANE MARKINGS			
Shared Lane Width	ADT Volumes	Travel Speed	Notes
Arterial – 12 ft Collector – 11 ft Local Street – No minimum	Less than 12,000	Less than 30 mph	Sharrows are recommended on roadways with on-street parking or lane widths narrower than 14 feet.
14 ft	12,000 – 20,000	30 – 35 mph	Sharrows are strongly recommended on roadways with volumes higher than 7,000 vehicles per day, lane widths narrower than 14 feet, or locations with on-street parking
15 ft	Greater than 20,000	Greater than 35 mph	Shared roadways are strongly discouraged under these conditions, special considerations for short stretches connecting bicycle lanes, where sharrows are strongly recommended.

Source: Fehr & Peers, 2011

“SUPER SHARROW”

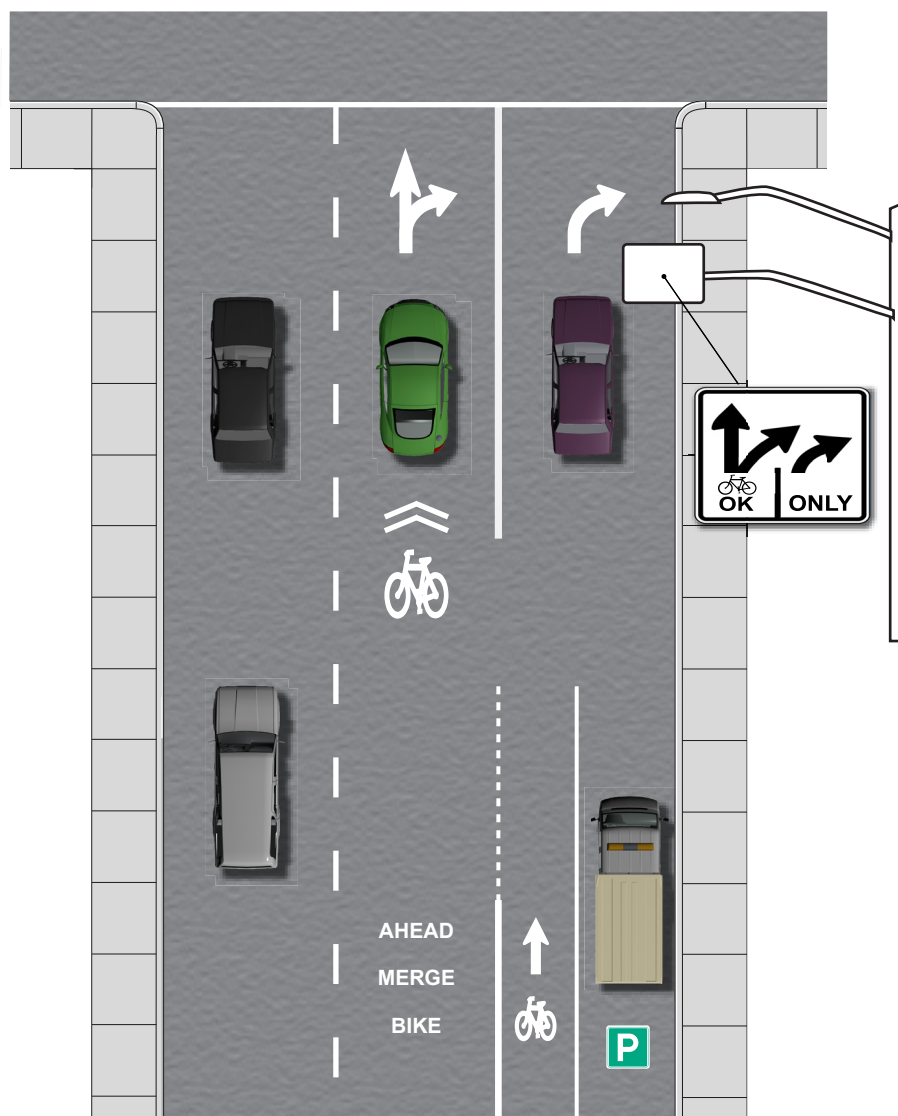
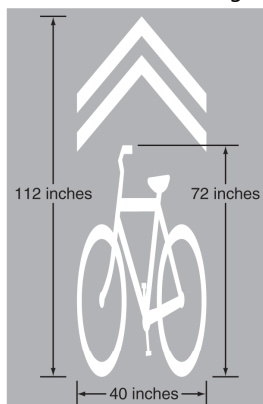
A “Super Sharrow” is essentially the same as a sharrow, but emphasizes the presence of bicyclists with colored pavement in the shared lane. Super sharrows are not approved by the *MUTCD*; however they are being used with experimental status in Long Beach, California and Salt Lake City, Utah. Installation of super sharrows should follow the same design guidelines provided for regular sharrows.



Super Sharrow, Salt Lake City, Utah

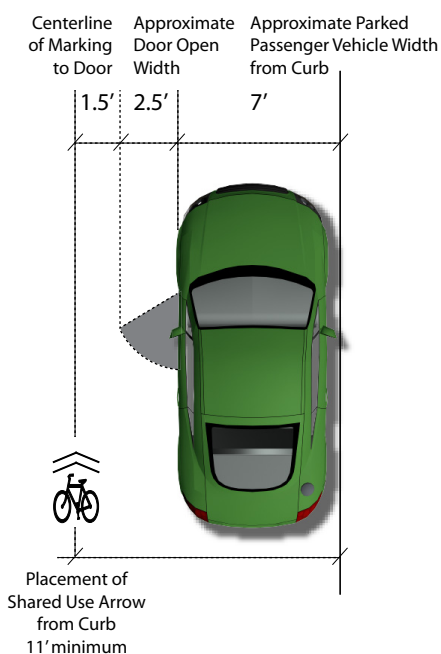
FIGURE 12
SHARED LANE MARKINGS

Shared Lane Marking



Notes:

- Sharrows should be placed after every intersection and at intervals of 250 feet
- Should be used on roadways with a posted speed limit of 35 mph or less
- Used to position bicyclists outside of the parallel parked vehicle "door zone", to reduce the incidence of bicyclists impacting an open car door
- Used to position cyclists in lanes that are too narrow for a bicycle and motor vehicle to travel side-by-side
- Should be placed at least 11 feet from face of curb on streets with on-street parking, and 4 feet from face of curb on streets without on-street parking
- Can be used with "Bicycle May Use Full Lane" sign



BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

BICYCLE BOULEVARDS

The bicycle boulevard is a bicycle treatment intended for low volume streets (less than 1,500 ADT) adjacent to higher volume arterials where bicycles have the priority and a relatively stop-free, low conflict route to their destinations. Traffic calming treatments, such as traffic circles, chokers, and medians are often used on bicycle boulevards as traffic calming measures to restrict vehicle speeds.

There are five general issues to address when implementing a bicycle boulevard:³

1. Create the look and feel of a bicycle boulevard
2. Slow traffic and discourage diversion of traffic to the bike boulevard by removing unwarranted STOP signs. Unwarranted STOP signs cause excessive stopping and delay for cyclists. They also increase noise and air pollution, increase fuel consumption, and non compliance compromises safety for all. They often increase speeds mid-block as well.
3. Address school or pedestrian related safety issues.
4. Help bicyclists cross major streets
5. Reduce motor vehicle speeds
6. Prevent diversion of motor vehicle traffic onto adjacent neighborhood streets.

There are two categories of tools that can help address these issues. The first category is called Basic Tools. These strategies are appropriate for all bicycle boulevards and include:

- Signs
- Unique pavement stencils
- Pavement legends
- Landscaping and street trees

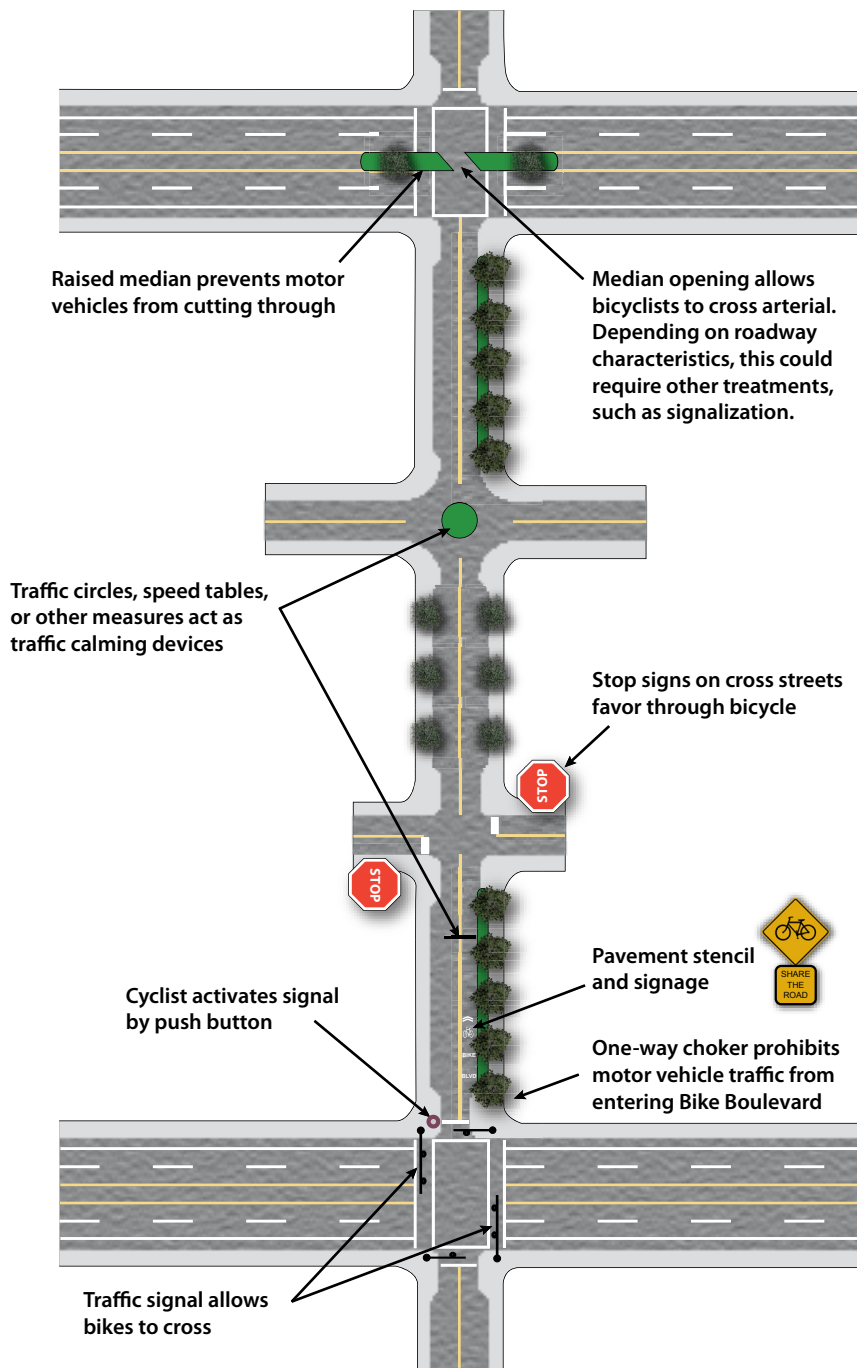
The second category is called Site Specific Tools. These are used to varying degrees on a bicycle boulevard to respond to a specific issue, and they require more analysis and stakeholder involvement:

- Traffic circles
- Bulbouts
- Traffic signals
- High-visibility crosswalks
- Bollards or planters

³ Berkeley Bicycle Boulevard Tools and Design Guidelines

Description:

A bicycle boulevard is a treatment that is typically used on low volume roadways that parallel high volume arterials. Traffic calming measures such as traffic circles, chokers, vehicle diverters, and medians should be used to discourage vehicle traffic.



Notes:

- Vehicle volumes should not exceed 1,500 daily trips
- Should provide connectivity to major destinations
- Needs to provide safe crossing of arterial streets
- Posted speed limit should be 15-20 mph



BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

BICYCLE PATHS

Bicycle paths are facilities that are separated from the roadway by a physical barrier. Separated paths are attractive to casual and intermediate cyclists as they offer a sense of security not provided by bicycle lanes or bicycle routes. Bicycle paths are valuable as both recreational areas and/or desirable transportation corridors.

Some separated paths are designed to accommodate bicyclists and pedestrians and should be classified as shared use paths. Paths that are designed to be used solely by bicyclists should be well marked and have adequate pedestrian facilities nearby to avoid being confused with a shared use path.

The table below provides guidelines on recommended geometrics for bicycle paths.

BICYCLE PATHWAY WIDTHS		
	Minimum Standards	Preferred Standards
Width (Two-Way)	8 feet	11 feet or greater
Width (One-Way)	5 feet	6.5 feet or greater
Vertical Clearance	8 feet	8 feet or greater
Horizontal Clearance	2 feet	3 feet or greater
Maximum Cross Slope	2 %	2 % or less
Shoulder	2 feet	2 feet or greater
Source: Fehr & Peers, 2011		

Separated bicycle paths should be designed with graded shoulders on both sides that are flush with the trail. In some cases, a wider path may be appropriate to accommodate a high volume of users, multiple closely-placed access points, limited sight distance, attractions adjacent to the trail, and busy trail or street intersections. Where feasible, bicycle paths should have an adjacent 4 foot wide, unpaved area to accommodate pedestrians. This pedestrian path should be placed on the side with the best view (e.g. near a river or other vista). Where equestrians are expected, a separate facility should be provided.

Asphaltic concrete or Portland cement concrete should be used for a bicycle path or shared use path. Decomposed granite, which is a better running surface for preventing injuries, is the preferred surface type for side areas and jogging paths.

A yellow centerline stripe may be used to separate opposite directions of travel. A centerline stripe is particularly beneficial to riders who may use unlighted paths after dark. They are also recommended on curves with poor sight distance.

It should be noted that two-way bicycle paths or shared use paths adjacent to roadways (also known as “separated bikeways” or “sidepaths”) with intersecting driveways and roadways have a high collision potential for cyclists because drivers who are exiting driveways or intersecting roadways and looking for oncoming vehicle traffic often do not expect cyclists to approach from the opposite direction.⁴ For these reasons, when the jurisdictions review plans for development adjacent to proposed shared use facilities, driveways and cross-flow

⁴ Wachtel, Alan and Diana Lewiston, *Risk Factors for Bicycle-Motor Vehicle Collisions at Intersections*, Institute of Transportation Engineers Journal, September 1994. pp. 30-35

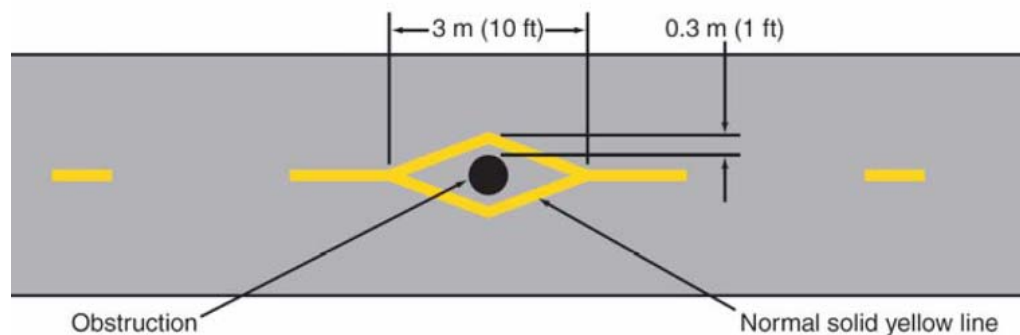
BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

traffic should be minimized. When driveways cross shared use paths, jurisdictions should consider warning signs and pavement markings (such as “BIKE XING” signs or stop bars) for drivers, bicyclists, and pedestrians, as appropriate. These safety issues do not apply to regional shared use paths, which generally have few intersections.

BOLLARDS

Bollards can be used at the access points to shared use paths to prevent unauthorized motor vehicles from entering. Bollards also serve as a warning to bicyclists of approaching intersections or street crossings. Lockable/removable or breakaway designs should be used to allow access to the path by authorized motor vehicles, such as emergency responders. If more than one bollard is used they should be spaced 5 feet apart. Bollards should be highly visible during the day and at night with bright paint and a reflective coating. Striping around the bollard, as shown in the figure below, is recommended for improved visibility. The 2009 *MUTCD* discourage the use of bollards if other options such as signage are practical.

Bollard Placement



BRIDGES

Bridges are recommended wherever paths cross creeks or drainages. Bridges can be pre-fabricated, made from self-weathering steel with wood decks. The preferred width of a bridge is 14 feet. Bridge railings should be a minimum of 42 inches high, with 4 inch maximum openings between railings. Taller railings should be considered for locations with high-speed, steep-angled (25 degrees or greater) approaches.

FENCES

Fencing may be necessary in some locations to prevent path users from trespassing on adjacent lands. In areas adjacent to private residences, privacy may also be a concern. Screen fencing can be made of wood, concrete block, or chain link, and is usually combined with some sort of vine-type plant to provide a more aesthetically pleasing environment. When installing fence, it is important to maintain at least two feet of horizontal clearance for cyclists.

BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

AT-GRADE TRAIL CROSSINGS

The following guidance is taken from the AASHTO *Guide to the Development of Bicycle Facilities*, the City of Seattle's Bicycle Master Plan, and the City of San Francisco's Supplemental Bicycle Design Guidelines.

Many variables should be considered when designing shared use path crossings, including:

- Number of roadway lanes to be crossed
- Divided or undivided roadways
- Number of approach legs
- Vehicle speeds and volumes
- Traffic control at the crossing location

Each intersection is unique and requires engineering judgment to determine the appropriate intersection treatment. The safe and convenient passage of all modes through the intersection is the primary design objective.

Regardless of whether a pathway crosses a roadway at an existing intersection, or at a new mid-block location, the principles that apply to general pedestrian safety at crossings (controlled and uncontrolled) are transferable to pathway intersection design.

When trails cross roadways at existing intersections, the trail should generally be assigned the same traffic control as the parallel roadway (i.e., if the adjacent roadway has a green signal, the trail should also have a green/walk signal, or if the parallel roadway is assigned the right-of-way with a stop or yield sign for the intersecting street, the path should also be given priority). At signalized intersections, if the parallel roadway has signals that are set to recall to green every cycle, the pedestrian signal heads for the trail should also be set to recall to the walk phase. Countdown pedestrian signals should be installed at all signalized trail crossings as signal heads are replaced. As required by the MUTCD, the walk signal for any trail shall not conflict with a protected left- or right-turn interval.

Consideration should be given to providing a leading pedestrian interval at trail crossings (i.e., 3 seconds of green/walk signal time are given to trail users before any potentially conflicting motor vehicle movements are given a green signal). This allows pedestrians and bicyclists to have a head start into the roadway and become more visible to turning traffic.

Where the signals for the parallel roadway are actuated, the trail crossing will also need to be actuated. For trail crossings, the minimum WALK interval may be 9-12 seconds to accommodate increased flow. A "USE PED SIGNAL" sign should be used at trail crossings with signalized intersections. Pedestrian push buttons should be located within easy reach of both pedestrians and bicyclists, who should not have to dismount to reach the push button.

The figure on the following page illustrates the preferred approach for a trail at a controlled intersection. An advance loop detector within 100 feet of the intersection should be considered so bicyclists can approach the intersection slowly but without having to stop.

BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

Trail Crossings at Unsignalized Intersections

Trail crossings at stop controlled intersections should provided bicycle/pedestrian stop signs at each trail approach.

Consideration should be given to converting all-way stop controlled intersections to side-street stop controlled intersections, and giving the shared use path and parallel roadway the free movement. An engineering study would need to be conducted before removing or adding any stop signs.

At intersections with stop signs controlling the side-street approach, the trail should be assigned the same right-of-way as the parallel street. Stop signs should not be placed on trail approaches to the intersecting roadway if the parallel street does not have stop signs.

If two intersecting streets have the same roadway classification, and stop signs face the intersecting street that is parallel to the trail, consideration should be given to reversing the stop sign placement, and giving the free movement to the trail and parallel street. An engineering study would need to be conducted before reversing the stop sign placement.

The decision of whether to use a traffic signal at a mid-block trail crossing should be primarily based on the latest version of the *MUTCD* Pedestrian Signal warrants.

At mid-block crossings, all trail users (including bicyclists) should be included in calculating the “pedestrian volume” for the warrant procedure. When a trail crossing meets the warrants, there may be other reasons why a signal is not necessary at the crossing. Where a decision has been made not to install a traffic signal at a mid-block trail crossing, stop signs should be used to assign the right-of-way to the trail or the roadway. These signs are intended to remind cyclists and pedestrians to stop and look before crossing because although these locations are marked crosswalks, trail users should exercise caution before crossing. To minimize driver confusion, these stop signs should be installed such that they are not visible by drivers on the intersecting street. If the signs are visible to drivers, it may lead them to interpret that they have the right-of-way and do not need to stop for trail users. The assignment of priority at a shared use path/roadway intersection should be assigned with consideration of the following:

- The relative importance of the trail and the roadway.
- The relative volumes of trail and roadway traffic.
- The relative speeds of trail and roadway users.

BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

BICYCLE PARKING

This section provides guidance on the provision and placement of safe, secure, and convenient bicycle parking facilities.

As the bicycle network in Reno, Sparks, and Washoe County grows, so will the population that chooses to ride a bike. The availability of secure and convenient parking is critical to the majority of bicyclists. The availability of short-term and long-term bicycle parking at key destinations such as parks, schools, community centers, and transit stations is a vital component of a complete bicycle network.

Parking should be highly visible, easily accessible, user friendly. Parking facilities should be located in well-lit areas and covered where possible.

Three types of parking facilities are discussed in this document:

- Bicycle Racks
- Bicycle Lockers
- Multimodal Center and Bicycles Stations

BICYCLE RACKS

Bicycle racks are low-cost devices that provide a short-term location to secure a bicycle. Ideally, bicycle racks should be designed to allow a bicyclist to lock the frame and wheels of their bicycle to the rack. The bicycle rack should be secured to ground in a highly visible location, preferably within 50 feet of a main entrance to a building or facility. Whenever possible, bicycle racks should be visible from the doorways and/or windows of buildings, and not in an out-of-the-way location, such as an alley. Adequate pedestrian clearance needs to be provided, and the design must consider the rack plus the bicycle. . Bicycle racks are short-term parking solutions, commonly used for short trips when cyclists are planning to leave their bicycles for just a few hours.



Covered bicycle racks provide protection from rain and other elements.

BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

Bicycle Rack Materials

Stainless Steel

Although typically the most expensive material, stainless steel is an attractive option that does not require coating, and is virtually maintenance free.

Vinyl Coating

Vinyl coating can be somewhat more expensive than other options, but is one of the best in terms of aesthetics and durability. This low-maintenance option will not scratch bicycles the way harder coatings will.

Powder Coating

Powder coatings are very durable and aesthetically pleasing. This option is available in a variety of colors and generally priced comparably with galvanized coatings.

Galvanized Coatings

Galvanized coatings are very durable, however this option is considered less attractive than other options.

Paint

Although economical, paint is not as durable as other options.

Stock

Whenever possible, racks should be constructed from square metal stock, since round stock may be vulnerable to pipe cutters.

Bicycle Rack Installation

Bicycle racks can be installed using two primary methods:

- **Surface Mounting** – Locations with an existing concrete slab are ideal for surface mount installation. If an asphalt substrate is all that is available, concrete footings should be poured. Anti-tampering bolts should be used to prevent theft.
- **Cast-in-Place** – This is the most secure option for bicycle rack installation, but may not be feasible in locations with existing concrete or asphalt slabs. Cast-in-place installation is not available for all types of bicycle racks.

For security, bicycle racks should always be installed in concrete. If a sufficient concrete area is not available asphalt can be used, but is not preferred. Bicycle racks should never be installed in soil.

Careful consideration should be taken when determining the location of bicycle racks. Commonly, bicycle racks are placed too close to a wall or fence, or oriented in the wrong direction, rendering them unusable.

Bicycle racks can be placed in the sidewalk, in sidewalk “lots”, or in an on-street parallel parking space. Bicycle racks should always be a minimum of 32 inches from a fence or wall. Where multiple racks are used, each rack should be a minimum of 36 inches from the next. Ideally, bicycle racks should be placed in “lots” off of the sidewalk (as shown on Figure 14); however, if they are placed in the sidewalk, a minimum clear space of 7 feet is required (to provide enough space between the pedestrian path and the bicycle). Bicycle rack locations on right-of-way may require permitting or license agreements with local agencies or owner of right-of-way.

The figures below provide guidelines on proper bicycle rack installation in a sidewalk or parallel on-street parking space.

FIGURE 14
BICYCLE RACKS ON SIDEWALKS

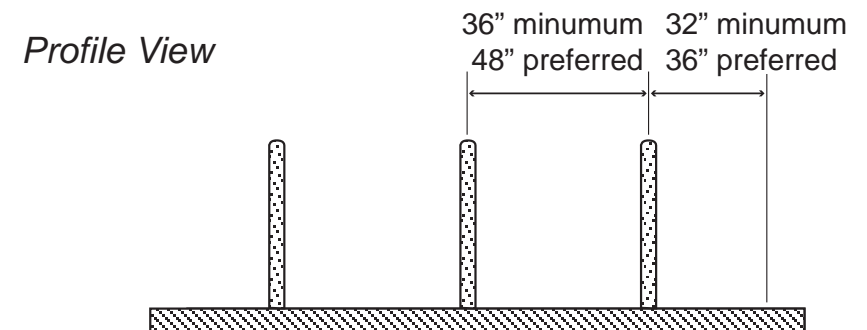
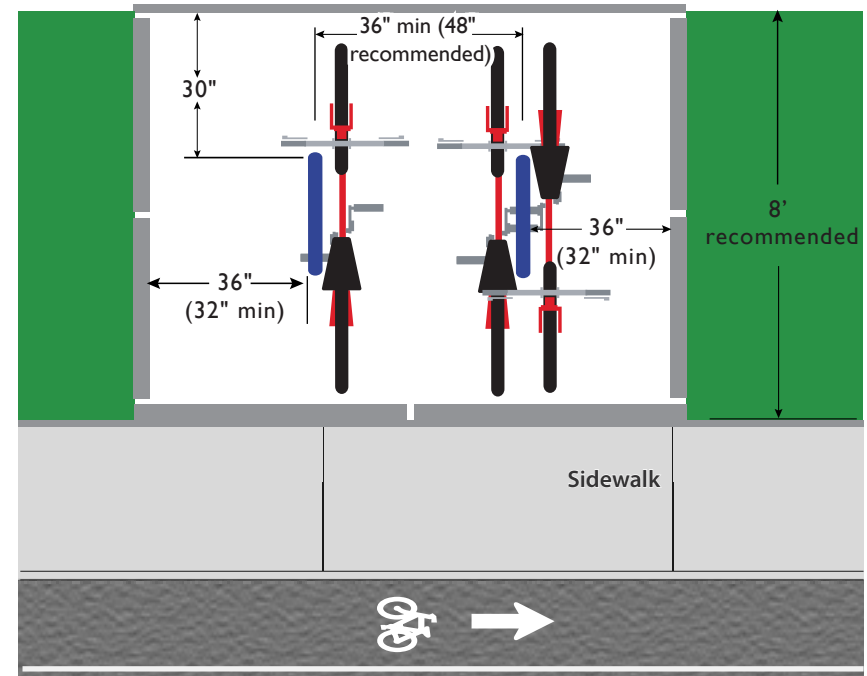
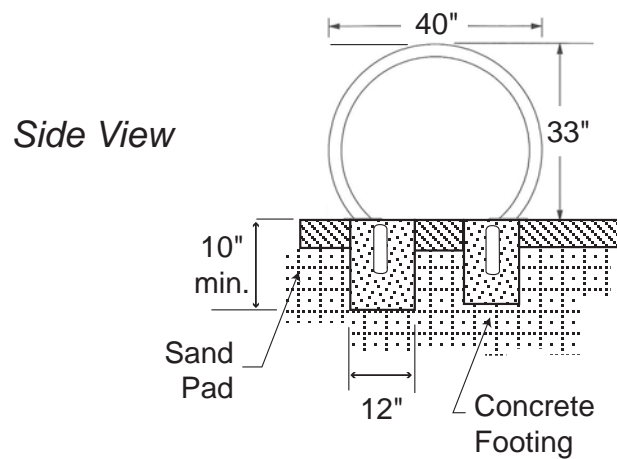
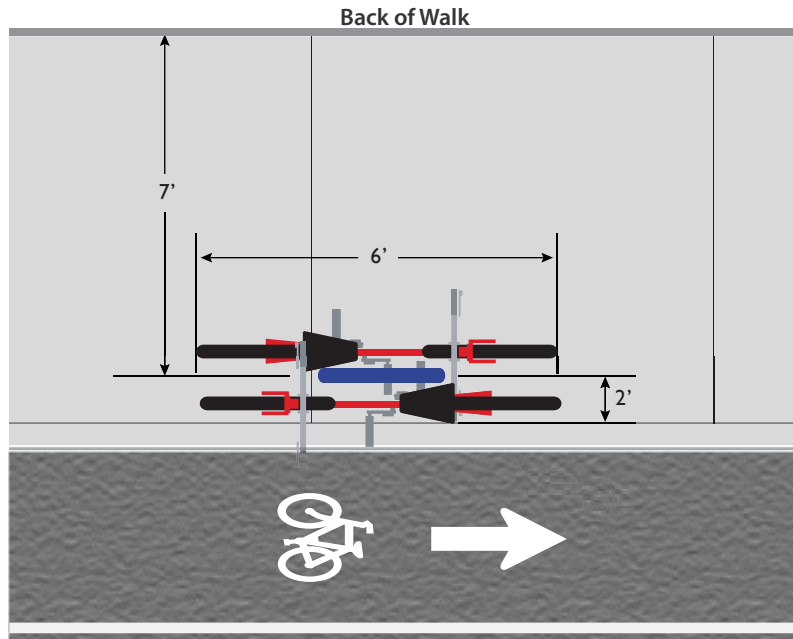
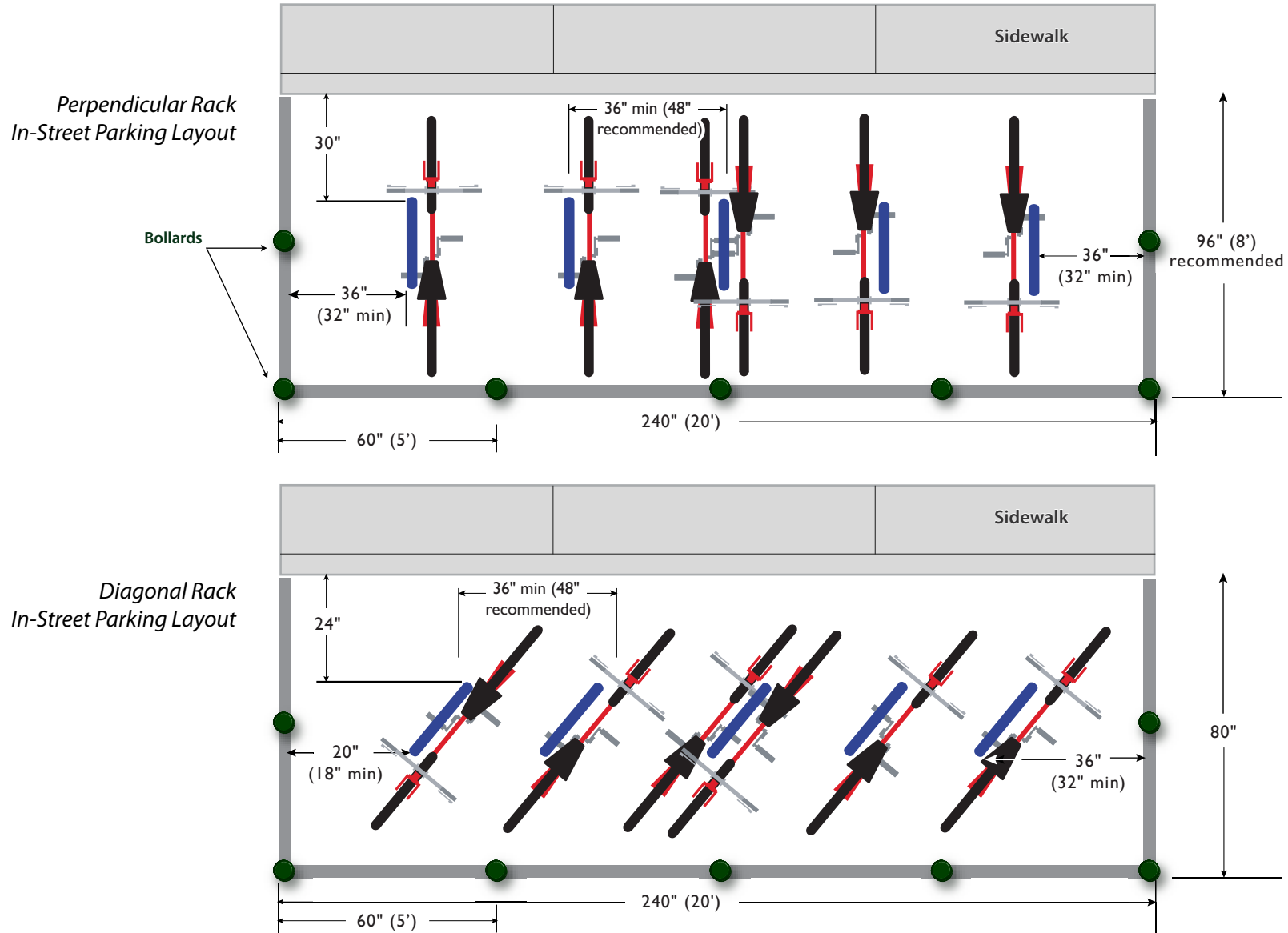


FIGURE 15
BICYCLE RACKS IN PARALLEL ON-STREET PARKING SPACE



BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

Bicycle Locker Materials

Stainless Steel

Stainless steel is the best material because it is the most durable, it reflects sunlight well, and it requires the least amount of maintenance.

Powder Coated Steel

Powder coated steel is a durable option that is available in a broad range of colors (although dark colors should be avoided due to heat absorption in the summer).

Composite Materials

Composite materials such as resin-based materials, chip-board, and particle board should be avoided. These materials photo-oxidize and break down quickly. Composite materials are also the least secure option.

BICYCLE LOCKERS

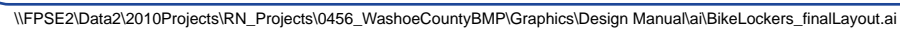
Bicycle lockers are covered storage units that can be locked individually, providing secure parking for one bicycle. Bicycle locker users can also store helmets and other riding gear safely. Bicycle cages are a similar option, and provide a secure area with limited-access doors that may or may not be attended. Bicycle lockers and cages are designed to provide bicyclists with a high level of security so they feel comfortable leaving their bicycles for long periods of time. They are appropriate for employees of large buildings or at transit stations.

Electronic Bicycle Lockers

Electronic bicycle lockers provide secure, individualized parking that can be accessed with an electronic card. Unlike standard key lockers which provide one key for one renter, a single e-locker can be rented by multiple cyclists each week by using smart card technology.

Bicycle Locker Placement

The figure below provides guidance for installation of bicycle lockers. A minimum clear space of 6 feet shall be provided adjacent to locker openings to allow easy access to the lockers.



BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

MULTIMODAL CENTERS AND BICYCLE STATIONS

Unstaffed bicycle stations are shared access storage areas in which registered cyclists lock their own bicycles. Cyclists gain access to these facilities by registering for a key or key code. Security can be bolstered with surveillance cameras, human monitoring, visual transparency (such as wrought iron fencing), and by locating them in areas with abundant pedestrian activity. (Note: cameras are only recommended in conjunction with human monitoring and action; otherwise, they do not deter vandalism or theft.)

Staffed bicycle parking facilities, also known as valet bicycle parking, offer a high level of security. In addition, some valet parking facilities provide repair and retail services to generate revenue to offset staffing costs, and to provide additional services for users. Bicycles parked in staffed facilities are typically not locked if they are checked in and out by the staff person. Staffing costs make such facilities more expensive to operate than other types of bicycle parking, so hours of operation can be limited. Cyclists who need to retrieve a parked bicycle after hours must make prior arrangements with the staff operator. Arrangements may include securing the user's bike to an outdoor rack or locker at the time the staffed facility closes, thereby allowing the cyclist to retrieve their bicycle after hours.

Other services or amenities sometimes offered at attended bicycle parking facilities include: bicycle repairs, bicycle and electric car sharing, bicycle rental, bicycle maintenance classes, restrooms, locker rooms and showers, tool and repair stands for customer use, bike tours, and cafés.

Staffed bicycle parking facilities that are subsidized typically offer free parking. Typically, these facilities struggle to mature into self-sustainable operations.

Determining the best type of bicycle parking to augment lower-security bicycle racks requires consideration of a number of factors:

1. Cyclists' usage patterns and potential demand. Considerations include:
 - How many spaces are needed
 - Duration and frequency of parking
2. Available space or facilities:
 - Is there enough space to install bicycle lockers or would a bicycle shed or bicycle station, which provide the same amount of parking in a smaller footprint, suffice?
 - Is there an existing structure that could be used to house the shared bicycle parking?
3. Resources for parking administration:
 - Who will manage the bicycle parking on a day-to-day basis?
 - Who will respond to customer issues?
4. Available funding for capital/operating costs:
 - Outside capital funding to construct bicycle parking facilities is much easier to come by than securing ongoing operations funding.

BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

SIDEWALKS

It is important to create sidewalks that support the activities and pedestrian levels along a street. This section provides guidelines for designing sidewalk widths, buffer zones, and areas for walking, sitting, and lingering.

SIDEWALK ZONES

The sidewalk zone is the portion of the street right-of-way between the curb and building front. The sidewalk zone generally consists of four distinct areas that serve different organizational purposes – curb, throughway zone, furnishing zone, and frontage zone – although all four zones are not always necessary. (See Figure 17.)

Sidewalks should be wide enough to support the expected pedestrian demand. The minimum width for sidewalks is 4 feet on residential and local roadways, and 5 feet on collectors and arterials. 5 feet is desirable for two people to walk side by side comfortably. Sidewalks in areas with high pedestrian volumes, such as downtown areas and TODs, should have widths of 6 feet or more.

Curbs

The curb or curb zone of a sidewalk should have a minimum width of 6 inches in areas with low pedestrian activity. Other areas, such as downtowns, should have at least an extra foot to prevent conflicts with car doors and pedestrians.

Throughway Zone

The throughway zone of a sidewalk is the primary travel area for pedestrians, and should be clear of any obstructions such as benches, utility poles, bike racks, etc. The minimum width of this zone is 4 feet on residential and local roadways and 5 feet on collectors and arterials. Areas with higher pedestrian volumes, such as downtown areas, should have throughway zone widths of 6 feet or more. Areas where the throughway zone is less than 5 feet must have a passing space every 200 feet. The passing space must be either a minimum of 60 inches by 60 inches, or at an intersection of two walking surfaces providing a T-shaped space where the base and arms of the T-shaped space extend a minimum of 48 inches beyond the intersection.⁵

The Americans with Disabilities Act (ADA) provides standards when designing facilities to accommodate people with disabilities. It is recommended that the throughway zone of the sidewalk remain clear of any obstructions, such as sign posts, newspaper racks, etc.; however, if an object is placed in the throughway zone, the ADA Accessibility Guidelines provide minimum clear width requirements. If the object in the throughway zone has a running width of 24 inches or less, the clear width adjacent to the objects must be at least 32 inches. Multiple obstructions must be at least 48 inches apart. If the throughway zone obstruction is longer than 24 inches, the clear width adjacent to the object must be at least 36 inches.

Furnishing Zone/Buffer

The furnishing zone acts as a buffer between the curb and the throughway zone. Sidewalk amenities such as street trees and benches should be located within the furnishing zone to avoid interference with pedestrians in the throughway zone. If planting strips are included, the minimum required width of the furnishing zone is 5 feet. Sidewalks adjacent to higher speed roadways should have wider furnishing zones.

⁵ "2010 ADA Standards for Accessible Design." September 2010.
<<http://www.ada.gov/regs2010/2010ADAStandards/2010ADAstandards.htm#c4>>

BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

Frontage Zone

The frontage zone is the area between the throughway zone and an adjacent building or fence. The primary purpose of this zone is to create a buffer between pedestrians walking in the throughway zone and people coming in and out of buildings. The frontage zone provides opportunities for shops to place signs, planters, or chairs in front of their building without encroaching into the throughway zone. The minimum recommended width of the frontage zone is 1 foot, although 3 or more feet is preferred to accommodate opening doors. The frontage zone is only needed in areas with adjacent buildings or fencing.

GRADE AND CROSS SLOPES

The sidewalk cross slope and running slope (grade) are important measurements when designing to standards of the Americans with Disabilities Act (ADA). The maximum cross slope of a sidewalk shall be 2% (1:48). The running slope, or grade, shall match that of the adjacent roadway, and not exceed 8.33% (1:12) in man-made conditions (e.g. wheelchair accessible ramps).

SURFACE TREATMENTS

Special surface treatments such as stamped concrete or pavers can be used to distinguish the sidewalk and/or crosswalk from the roadway at roadway crossing locations or driveways. These treatments enhance the overall character of the pedestrian environment. The rougher roadway surface may also slow vehicles and enhance driver awareness to the potential presence of pedestrians.

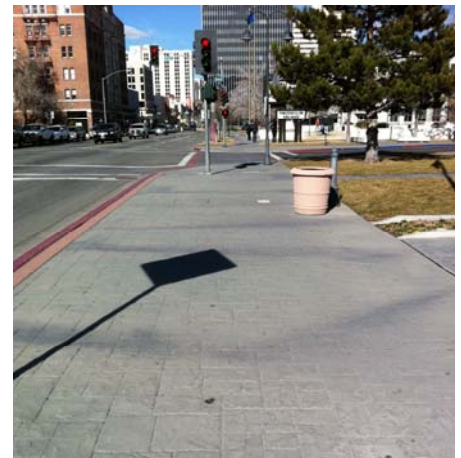
Examples of special surface treatments include:

- Bricks or pavers
- Stamped or colored concrete
- Stamped asphalt or concrete painted to resemble bricks
- Pavement stencils

When designing special surface treatments consideration should be given to visually and physically impaired pedestrians. Surfaces should be adapted to accommodate wheelchair users. Additionally, a stripe of contrasting color is recommended on either side of a crosswalk, even when special paving treatments are used, to enhance the contrast between the crosswalk and the roadway.

DRIVEWAY DESIGN

Driveways present high conflict areas for pedestrians and vehicles, and should be designed to minimize conflicts as much as possible. Driveways that intersect sidewalks should be designed with the shortest possible crossing distance for pedestrians, while still meeting vehicle design standards. It is recommended that the surface treatment at driveways where the pedestrian crossing is located match the pedestrian walking surface, rather than the roadway, to heighten driver awareness of the presence of pedestrians.



**Stamped Concrete Sidewalk
Downtown Reno**

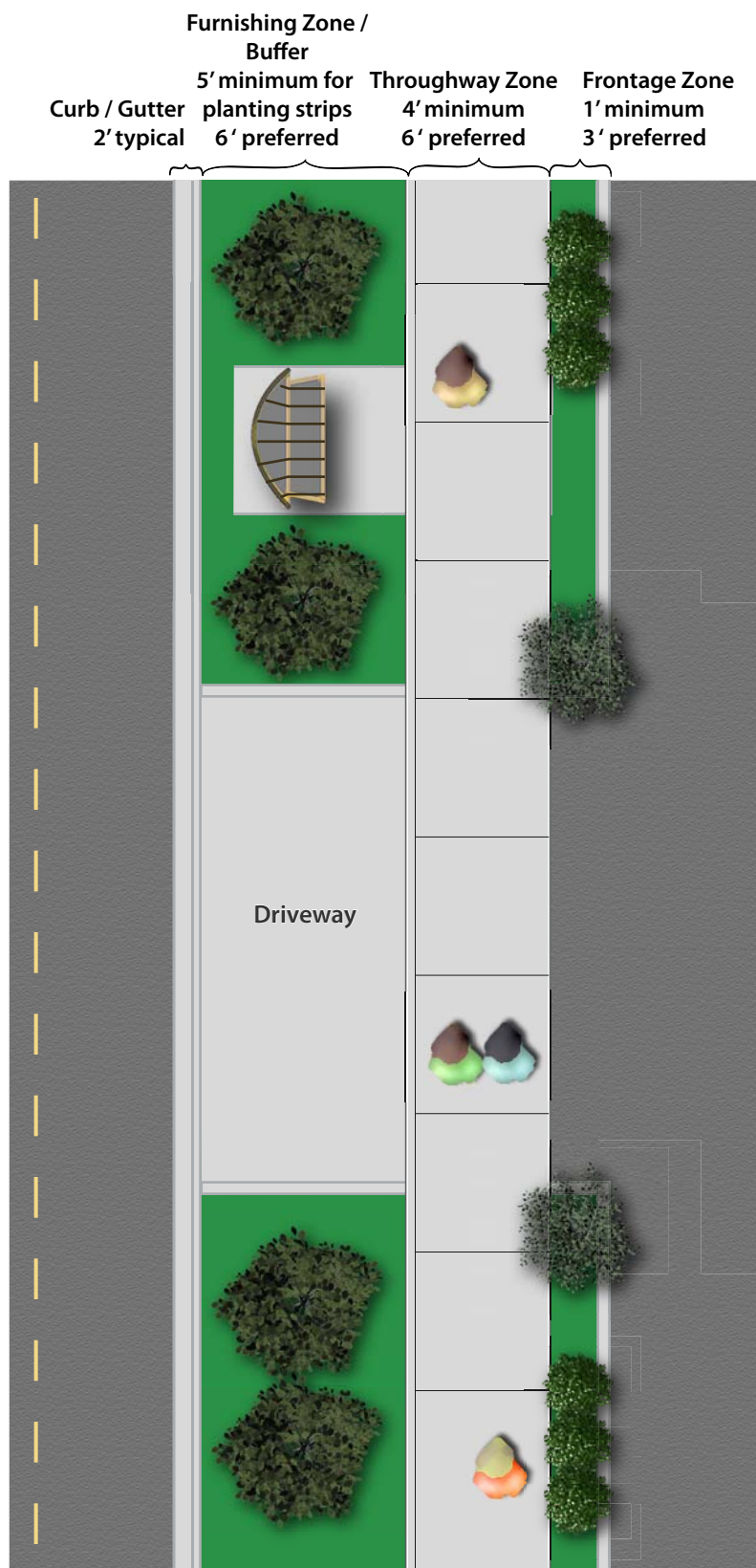


**Stamped Concrete Crosswalk
Downtown Reno**

BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

Preferred driveway design (shown on Figure 17) includes a separated sidewalk that can maintain a cross slope of 2% or less. Driveways with steeper cross slopes, installed directly in the pedestrian pathway, can be difficult for physically impaired individuals to navigate.

FIGURE 17
SIDEWALK CROSS SECTION



Notes:

- Maximum sidewalk cross slope = 2%
- Maximum sidewalk/curb ramp running slope (grade) = 8.33% (does not include running slope of natural terrain)
- Furnishing Zone/Buffer not required
- Frontage Zone only recommended for sidewalks adjacent to buildings
- Wider curb/gutter width recommended for downtown areas with on-street parking to avoid conflicts with car doors and pedestrians
- Crosswalk material should continue across driveways



Preferred Driveway Design

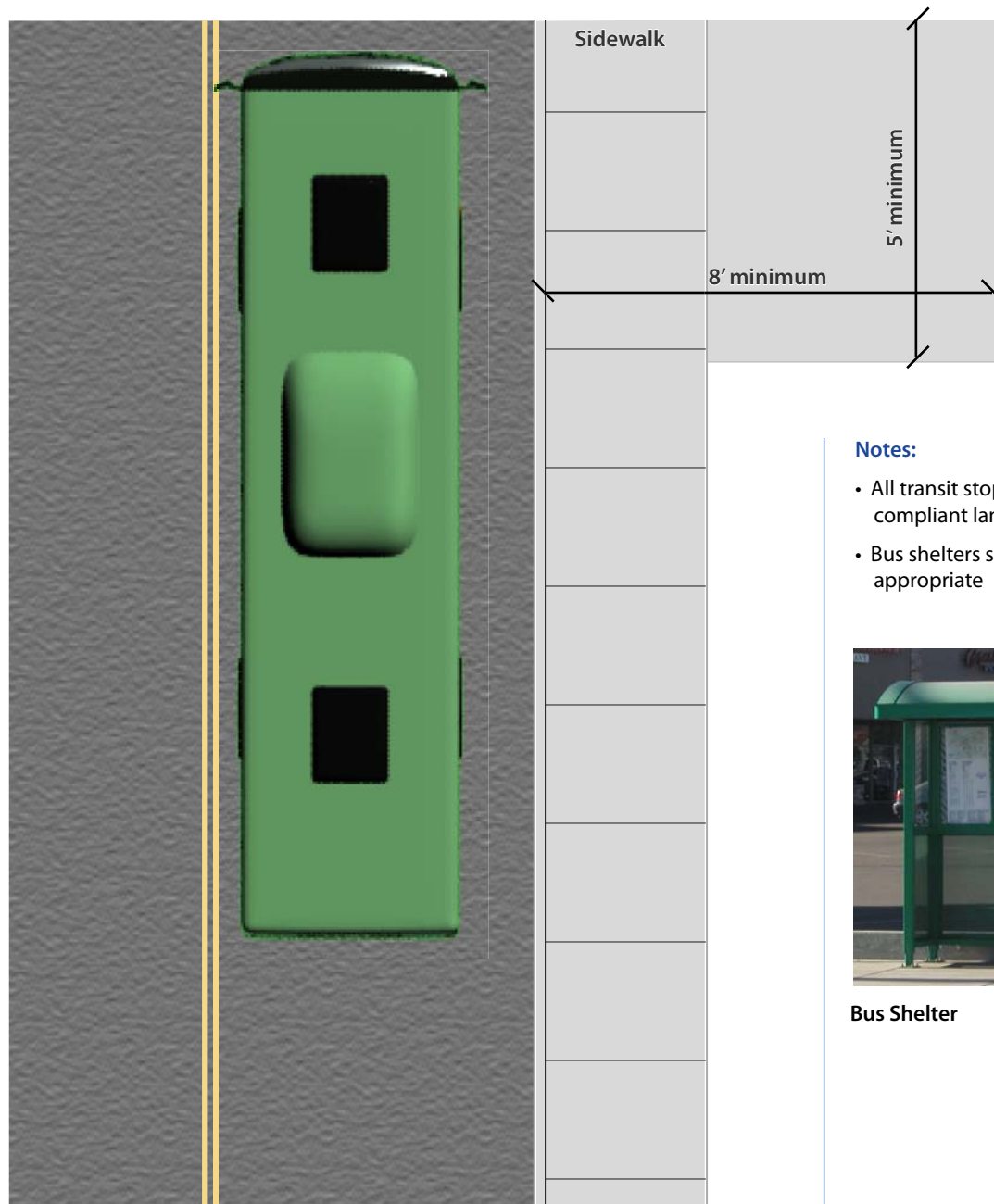
BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

TRANSIT STOP DESIGN

Transit stops should be installed on paved surfaces adjacent to a sidewalk. The ADA Accessibility Guidelines require that a 5 foot wide (measured parallel to the vehicle roadway) by 8 foot long (measured perpendicular to the vehicle roadway) landing be provided for wheelchair accessibility. It is preferred that a shelter be provided where determined appropriate by the transit operator and where sufficient space is available. If a shelter is provided, the landing area may be provided within or outside the shelter. The maximum slope of the landing perpendicular to the roadway shall be 2%. Transit stops should be located along pedestrian accessible routes, preferably with adequate connections to popular destinations.

Figure 18 shows the standard transit stop design.

FIGURE 18
TRANSIT STOP DESIGN



Notes:

- All transit stops need to include ADA compliant landing (8' x 5' minimum)
- Bus shelters should be provided where appropriate



Bus Shelter

BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

CROSSING TREATMENTS

MID-BLOCK/UNCONTROLLED CROSSINGS

Uncontrolled intersection crossing locations include approaches without a stop sign or signal to regulate vehicles. Mid-block crossings are locations where there is a demand for pedestrian crossings in between intersections. Without a formal signal to control traffic, uncontrolled locations and mid-block crossings require unique treatments to ensure pedestrians are visible within the roadway.

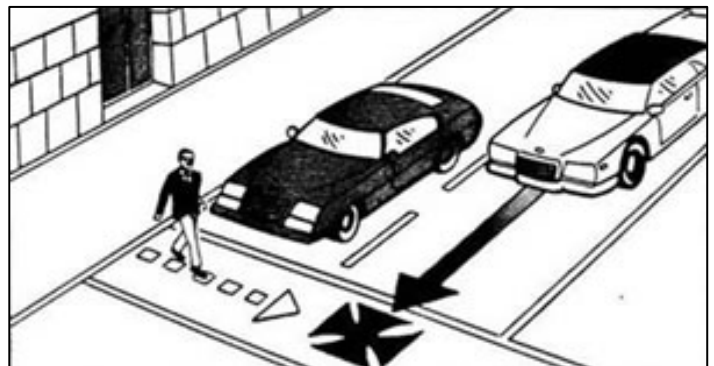
Pedestrians tend to walk in the path that provides the shortest distance. If intersection crossings are too far apart, mid-block crossings may be necessary to accommodate these paths, or 'desire lines'. Marking a crosswalk helps identify the most appropriate place for pedestrians to cross the street. Clearly roadways with lower speeds and traffic volumes, and narrower cross sections are better suited for marked crosswalks than multi-lane, high volume roadways. Mid-block crosswalks are not recommended on roadways with six or more lanes and/or a speed limit of 40 mph or more.

When designing a crosswalk at an uncontrolled location, the following should be considered:

1. Does sufficient demand exist to justify the installation of a crosswalk?
 - Is the location near a school, park, or hospital?
 - Do more than 20 pedestrians cross at the location per hour or 60 in four hours?
 - If the answer is "yes" to either of the questions above, move to the next question. If "no" then a marked-crosswalk is not appropriate.
2. Is there a marked crossing less than 300 feet away?
 - If the answer is "yes" to the question above, then a marked-crosswalk is not appropriate and pedestrians should be directed to the existing crosswalk.
3. Does the crossing location have sufficient sight distance (as measured by stopping sight distance calculations)? Or, can the sight distance be improved prior to crosswalk installation?
 - If the answer is yes, the location is a good candidate for a marked crosswalk.

Mid-block crossing locations must provide adequate sight distance, so pedestrians can be clearly viewed by motorists, and vice versa. Additionally, it is important to consider the "multiple threat" collision situation when designing a crosswalk. Multiple threat collisions are common when pedestrians have to cross more than one lane of traffic in each direction, as shown in the figure to the right.

Streets should be designed to minimize conflicts between vehicles and pedestrians. Basic crossing



Source: FHWA

Multiple Threat Risk on a Multi-Lane Street

BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

treatments such as high visibility striping and advanced yield lines shall be used as a minimum at uncontrolled crossing locations. Enhanced crossing treatments, including flashing beacons or in-street pedestrian signs, should be used in locations with higher vehicle and pedestrian volumes and higher vehicle speeds. The following table provides guidance on crossing treatments.

CROSSING TREATMENT RECOMMENDATIONS BY ROADWAY TYPE AND SPEED												
Number of Vehicle Travel Lanes	Vehicle ADT ≤ 5,000			Vehicle ADT > 5,000 to 12,000			Vehicle ADT > 12,000 to 20,000			Vehicle ADT > 20,000		
	Speed Limit ¹											
	≤ 30 mph	35 mph	40 mph	≤ 30 mph	35 mph	40 mph	≤ 30 mph	35 mph	40 mph	≤ 30 mph	35 mph	40 mph
2 lanes	1	1	2	1	1	2	1	1	3	1	2	3
3 lanes	1	1	2	1	2	2	2	2	3	2	3	3
4 or more lanes	1	2	2	2	2	3	2	2	3	3	3	3
4 or more lanes (with raised median)	1	2	3	2	2	3	3	3	3	3	3	3
Notes: ¹ Unsignalized locations with a speed limit greater than 40 mph should include more than a striped crosswalk alone.												
Crossing Types:												
1 = Crossings should include a minimum of High Visibility Crosswalk Striping, and consider additional treatments such as a Pedestrian Refuge Island and/or Advanced Yield Lines.												
2 = Crossings should include an enhanced treatment such as a Raised Crosswalk, In-Street Pedestrian Crossing Signs, Overhead Flashing Beacons, or Rectangular Rapid Flashing Beacon.												
3 = Controlled crossing treatments such as a HAWK Signal, Pedestrian Signal, or Two-Stage Crossing should be considered. A signal warrant analysis should be performed prior to installation of a traffic signal.												

Basic Crossing Treatments

Basic crossing treatments that can be used to improve visibility and safety for pedestrians at uncontrolled locations include pedestrian refuge islands, high visibility crosswalk striping, and advanced yield lines.

Pedestrian Refuge/Median Island

Pedestrian refuge islands, or median islands, are raised islands in the center of a roadway that separate opposing lanes of traffic. A cutout or wheelchair accessible ramps in the median provide a refuge area to allow pedestrians to cross the roadway in two stages. This treatment increases pedestrian comfort by ensuring a reasonable distance to cross at one time.

Pedestrian refuge islands should be considered in locations with two or more lanes of traffic in each direction, or when crossing distances exceed 60 feet. The minimum width for a median island is 5 feet, although 6 feet is recommended in order to accommodate bicycles. Areas with high pedestrian volumes, high vehicles volumes, and/or multiple lanes of traffic should have wider median islands.

BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

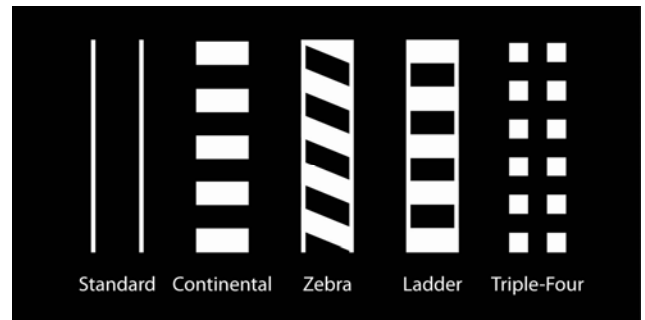
At intersection locations, pedestrian refuge islands should always include a “thumbnail” (shown in the figure below) on the intersection side to avoid collisions between vehicles and pedestrians.



Pedestrian Refuge with “Thumbnail”

High Visibility Striping

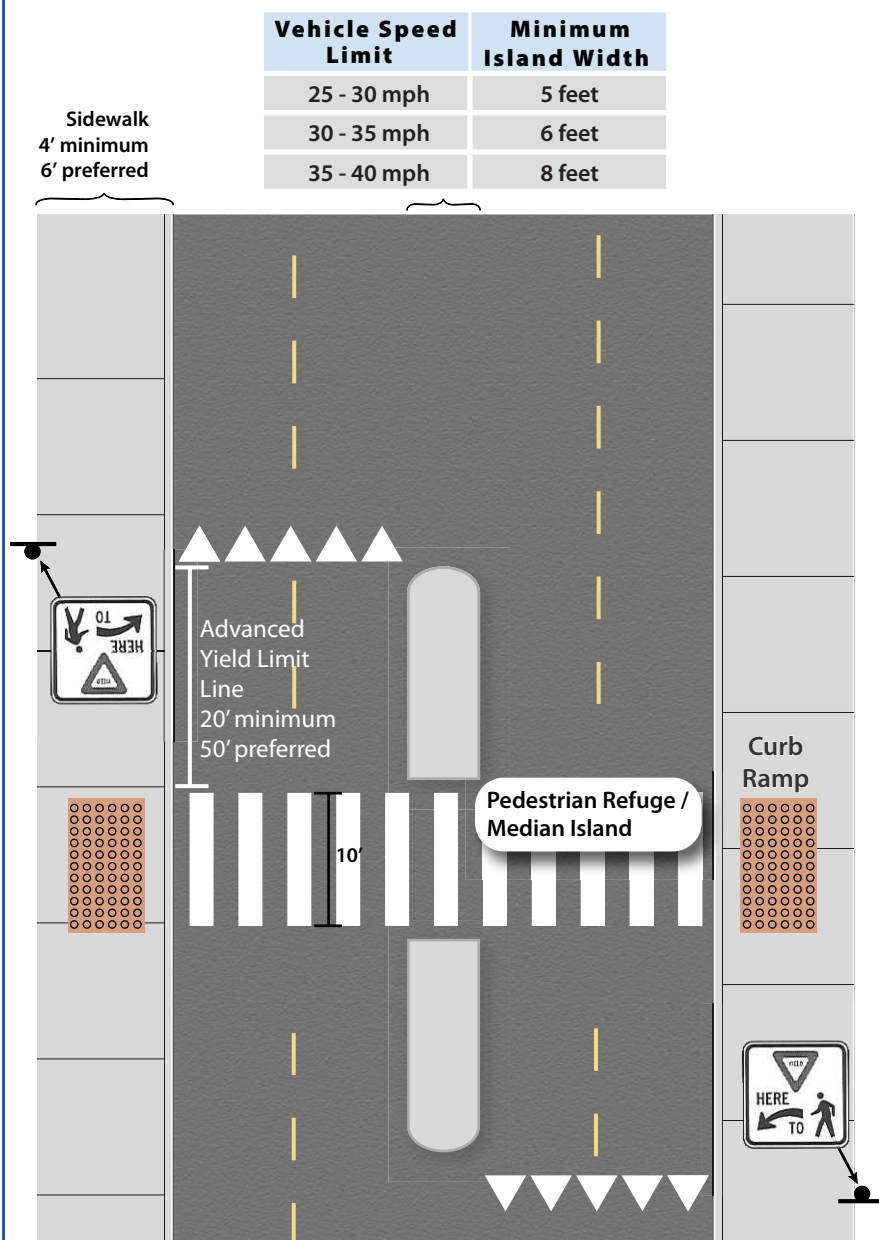
At a minimum, all mid-block/uncontrolled crossing locations should include high visibility crosswalk striping. There are several options for high visibility markings, including Standard, Continental, Zebra, Ladder, and Triple-Four patterns. The Reno Sparks region typically uses the Continental striping pattern to mark crosswalks. For consistency, Continental striping should continue to be the standard for the area.



Advanced Yield Line

Advanced yield lines are a treatment used at uncontrolled crosswalks to discourage vehicles from encroaching into the crosswalk, by creating a buffer between the location where vehicles are supposed to stop and the crosswalk. Advanced yield lines should be used in conjunction with high visibility striping to bring extra attention to motorists to reduce their speed for crossing pedestrians. Placement of advanced yield lines should be 20 to 50 feet before a marked crosswalk.

Advanced yield lines are useful on multi-lane streets to reduce the “multiple threat” collision potential. By requiring vehicles to stop well before the crosswalk, pedestrians are more visible to oncoming traffic.



Notes:

- Continental crosswalk striping preferred
- Pedestrian refuge/median island is not necessary on roadways with 3 lanes or less (i.e. 1 through lane in each direction and a two-way left-turn lane)
- Mid-block/uncontrolled crossings not recommended on streets with more than 20,000 vehicles per day or speeds of 40 mph or greater



Curb Ramp

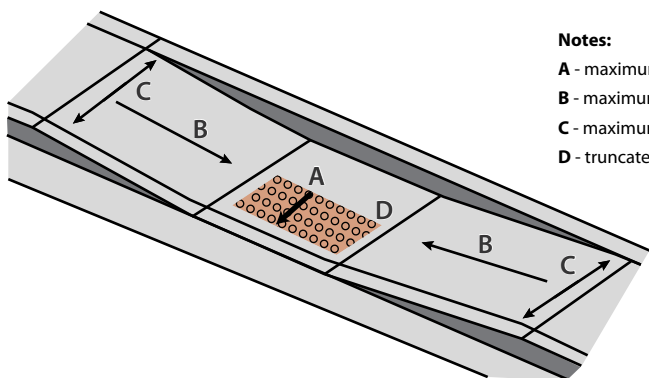


Note: Stripes should be 12" - 24" wide and separated by gaps of 12" - 60"

Continental Crosswalk

Notes:

- A - maximum 2%
- B - maximum 8.33%
- C - maximum 2%
- D - truncated domes in contrasting color



BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

Enhanced Crossing Treatments

Enhanced crossing treatments such as raised crosswalks, in-street pedestrian crossing signs, overhead flashing beacons, and rectangular rapid flashing beacons should be used at locations that require heightened awareness of pedestrian presence. These locations include multi-lane streets (with three or more lanes), streets with daily traffic volumes (ADT) greater than 12,000, and streets with a posted speed limit between 30-40 miles per hour.

Raised Crosswalk

Raised crosswalks, also known as speed tables, provide an elevated surface above the travel lane that raises awareness of crossing pedestrians. The raised roadway surface acts similarly to a speed bump requiring drivers to slow down as they travel through the crosswalk.

In-Street Pedestrian Crossing Sign

In-street pedestrian crossing signs are regulatory signs placed on the roadway centerline, either in front of or behind the crosswalk. These signs are approved by the MUTCD, and serve to remind drivers that pedestrians have the right-of-way in a crosswalk. Careful placement of these signs is necessary to avoid maintenance issues, as the signs can easily be knocked over by vehicles. Raised, in-pavement markers can be placed around the sign for protection. In-street pedestrian crossing signs are useful at mid-block locations or intersections with significant pedestrian activity (e.g. near transit stations or schools).

Overhead Flashing Beacon

Overhead flashing beacons enhance driver visibility of pedestrians at uncontrolled crossing locations with overhead or post-mounted, flashing, amber lights. This treatment is useful at locations with limited sight distance.

Rectangular Rapid Flashing Beacon (RRFB)

The rectangular rapid flashing beacon (RRFB) is also known as the stutter flash. This treatment enhances the overhead flashing beacon by replacing the slow flashing incandescent lamps with rapid flashing LED lamps. The RRFB can be activated by a push-button or with remote pedestrian detection. Design variations include versions with LED lights placed within the pedestrian crossing sign.

Two-Stage Crossing

An enhancement to the pedestrian refuge island is the two-stage crossing, which can be signalized or unsignalized. The two-stage crossing provides a "channel" in the median for the pedestrian to turn right and walk toward the vehicles they are about to cross. This allows drivers and pedestrians to make eye contact. The crosswalks on either side of the median should be separated by at least 10 feet.

Raised Crosswalk



Notes:

- Used to enhance visibility of pedestrians
- Reduces vehicle speeds through crosswalk

In-Street Crossing Sign



Notes:

- Signs may be placed directly on roadway centerline
- Careful placement of signs is necessary to avoid maintenance issues
- Should be used at locations with significant pedestrian activity (i.e. near transit stations or schools)

Overhead Flashing Beacons



Notes:

- Used to enhance visibility of pedestrians
- Includes flashing amber lights either overhead or on a post-mounted sign
- Recommended on multi-lane streets (3 or more lanes), 2-lane streets with more than 12,000 vehicles per day, street with speeds of 30 mph or greater
- Should be pedestrian activated

Rectangular Rapid Flasing Beacon (RRFB)



Notes:

- Also known as a "Stutter Flash"
- Includes rapid flashing LED lights
- Pedestrian activated
- Solar powered
- Shown to have 80-90% compliance rate
- Approved for experimental use by the MUTCD

Two-Stage Crossing

- See "Controlled Crossing" figure for details

BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

CONTROLLED CROSSINGS

Pedestrian Signal

Pedestrian signals are usually provided at mid-block crossing locations with significant pedestrian activity. Vehicles navigate the intersection the same way they would a regular intersection, but rather than regulating vehicle traffic at all approaches, an all pedestrian phase is provided. Pedestrian signals provide the strictest right-of-way control at a pedestrian crossing. Warrants for placement are defined within the 2009 MUTCD.

HAWK Signal

The high-intensity activated crosswalk signal, also known as the HAWK signal, should be used at locations with high vehicle speeds and significant pedestrian activity. The HAWK signal combines a beacon flasher with a traffic control signal to generate a higher driver yield rate. The signal is pedestrian activated and has six steps (shown on Figure 21):

1. A blank signal allow drivers to proceed as usual through the crosswalk.
2. When a pedestrian activates the signal, a flashing yellow light warns drivers that a pedestrian is present.
3. The flashing yellow light becomes a solid yellow light and warns drivers to yield (the same they would at a regular traffic signal)
4. The light turns to red and drivers are required to stop. The pedestrian is given a WALK signal to proceed through the crosswalk.
5. During the “flashing don’t walk” phase for pedestrians, drivers see a “wig wag” red signal (alternating, flashing red signal) that operates as a stop sign. When the crosswalk is clear of pedestrians, drivers may proceed.
6. Following the “wig wag” red phase the signal returns to a blank phase and drivers may proceed as usual through the crosswalk.

The HAWK signal is included in the 2009 Federal MUTCD.

Signalized Intersection

Similar to the pedestrian signal, a signalized intersection provides pedestrians with a protected crossing phase. At a signalized intersection the pedestrian phase operates with the parallel vehicle movement. Pedestrians should be cautious of right-turning vehicles when crossing an intersection.

Two-Stage Crossing

An enhancement to the pedestrian refuge island is the two-stage crossing, which can be signalized or unsignalized. The two-stage crossing provides a “channel” in the median for the pedestrian to turn right and walk toward the vehicles they are about to cross. This allows drivers and pedestrians to make eye contact. The crosswalks on either side of the median should be separated by at least 10 feet. Pedestrian push buttons should be provided in the median at signalized intersections.

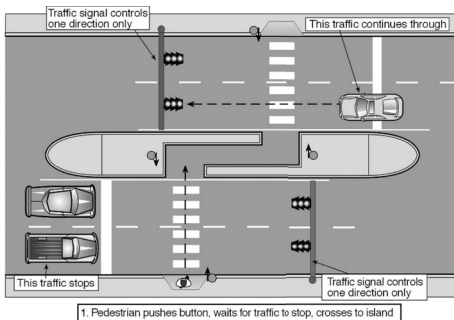
Pedestrian Signal



Notes:

- Provides strictest right-of-way control at a pedestrian crossing
- Requires MUTCD signal warrant analysis

Two-Stage Crossing



Notes:

- Can be signalized or unsignalized
- Provides shorter crossing distances for pedestrians
- Pedestrians walk toward oncoming vehicles in median, making them more visible to drivers

Signalized Intersection

- See "Intersection Design" figure

HAWK Signal (High Intensity Activated Crosswalk)



Operation:

- 1 – Drivers may travel freely
- 2 – Pedestrian activates flashing yellow light to warn drivers to begin to yield
- 3 – Steady yellow light warns drivers to yield at crosswalk
- 4 – Steady red light requires drivers to stop, pedestrians can cross the street
- 5 – Red "Wig Wag" light acts as a stop sign, drivers may continue through crosswalk when it is clear of pedestrians
- 6 – Returns to blank signal, drivers may travel freely

Notes:

- Approved in 2009 MUTCD
- Developed by the City of Tucson (they have >60 installed)
- Studies have shown a 28% reduction in vehicle collisions and a 58% reduction in pedestrian / vehicle collisions
- For use at mid-block crosswalks on collector or arterial streets (can be used at an intersection with special design considerations)

BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

INTERSECTION DESIGN

Pedestrian treatments at intersection locations are used to:

- Improve the visibility of pedestrians to motorists and vice-versa
- Communicate to motorists and pedestrians who has the right-of-way
- Accommodate vulnerable populations such as the disabled, children, and seniors
- Reduce conflicts between pedestrians and vehicles
- Reduce vehicular speeds at locations with potential pedestrian conflicts

CURB RAMPS

Curb ramps, whether at intersection corners or mid-block locations, should always be designed to standards of the ADA Accessibility Guidelines.

Curb ramps provide safe access to the sidewalk for mobility impaired pedestrians, such as wheelchair users or those with canes. Curb ramps provide a gradual transition from the crosswalk or roadway to the sidewalk. Curb ramp cross slopes should not exceed 2%, while the running slope should be less than 8.33%.

Appropriate curb ramp design depends on the geometrics of the intersection. Directional curb ramps are preferred over diagonal ramps, as they provide direct access to each crosswalk at an intersection corner. Detectable warnings, which consist of raised truncated domes, are required by the ADA Accessibility Guidelines with any new curb ramp or reconstruction.



Diagonal Curb Ramp
Liberty Street/Hill Street

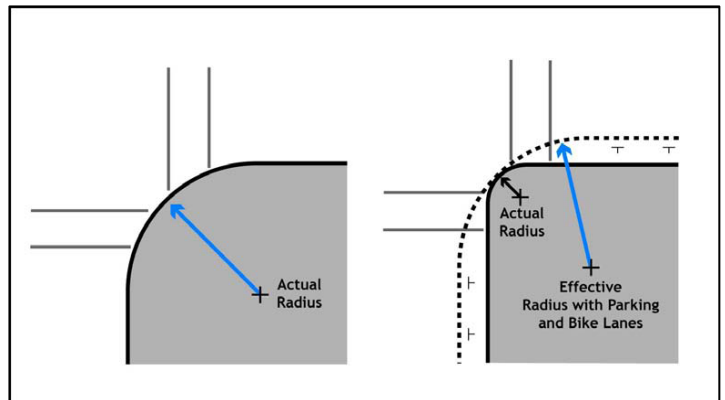
BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

CROSSING DISTANCE

Intersections should be designed to minimize pedestrian crossing distances. Shorter crossing distances ultimately reduce the exposure time of pedestrians within the roadway, and are easier to navigate. Consequently, compact intersections are more comfortable for pedestrians, and improve visibility between motorists and pedestrians.

CORNER RADII

When designing the corner radii at an intersection, the smallest appropriate radius should be used at each corner, acknowledging that each location has a unique set of factors that determines what is appropriate. A large corner radius (generally 30 feet or greater) allows vehicles to turn at high speeds. If the radius is reduced, it forces approaching vehicles to slow down, thus reducing the frequency and severity of pedestrian collisions at the intersection. As shown in the graphic, on-street parking and bicycle lanes can impact the effective corner radius. In this case, curb extensions can be used to maintain the actual corner radius designed.



While corner radii may be as small as 1.5 feet, locations with any amount of turning traffic cannot accommodate a radius this tight. At locations with on-street parking, a 10 feet radius is recommended. Locations with no on-street parking should have a maximum corner radius of 20 feet. Locations with heavy truck or transit traffic may also require a wider turning radius.

CURB RADII	
Roadway Type	Recommended Curb Radius
Residential	15 ft
Local/Collector	20-30 ft
Arterial	30 ft
Industrial	Up to 50 ft
Source: Fehr & Peers, 2011	

CURB EXTENSIONS

Also known as bulb-outs, curb extensions increase driver awareness of pedestrians and help slow vehicle traffic. Curb extensions provide a larger space for pedestrians at an intersection corner and prevent cars from parking near the crosswalk. Curb extensions are beneficial near schools, transit centers, and other areas with pedestrian activity.

BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

Curb extensions should be considered at intersections with three or more lanes, or at uncontrolled crossings with poor visibility. Generally, curb extensions should extend a minimum of 6 feet into the street adjacent to parallel parking, 12 feet adjacent to diagonal parking, and no further than the edge of the vehicle travel lane or bicycle lane in any situation. Designers should consider bicycle lanes when designing curb extensions and avoid situations that force cyclists to “take the lane” at intersections where it is not appropriate. Installing curb extensions may require removal of some on-street parking if it is not already restricted near the intersection. Landscaping within bulb-outs is an additional feature that can enhance the character and comfort of the pedestrian area. Bulb-outs may also create space for pedestrian amenities or bicycle parking.

PEDESTRIAN FRIENDLY SIGNAL TREATMENTS

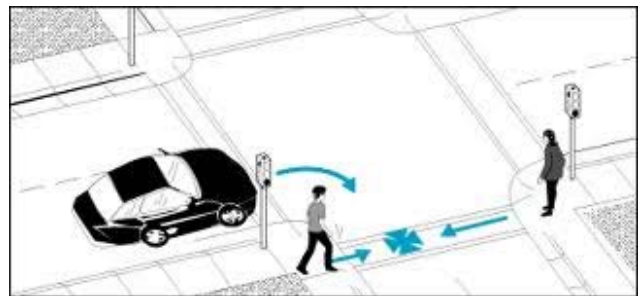
There are several innovative treatments that enhance the visibility and convenience of pedestrian crossings at signalized locations. These treatments can be applied in a variety of contexts depending on the pedestrian demand and vehicle movement within the streetscape.

Countdown Signals

Countdown pedestrian signals display the number of seconds remaining for the pedestrian crossing interval. Research has shown that countdown signals improve pedestrian compliance by reducing the tendency for pedestrians to “dash” across an intersection. This treatment is particularly helpful when crossing multi-lane arterials.

Leading Pedestrian Interval

The leading pedestrian interval is a signal timing tool that can be used at locations with heavy right-turn vehicle volumes and frequent pedestrian crossings. The leading pedestrian interval gives pedestrians a head start by displaying the walk signal approximately 2-4 seconds before vehicles are given a green light. Crossing with a head start allows pedestrians to be more visible to motorists approaching an intersection. Larger intersections may require a “No Right-Turn on Red” restriction if a leading pedestrian interval is used.



Pedestrian Push Buttons

When pedestrian push buttons are used, they should be well-marked, visible, and accessible to all users from a flat surface with a clear reach of no more than 24 inches, consistent with ADA standards. Pedestrian push buttons should be located within 5 feet of the crosswalk and not further than 10 feet from the curb.

Signals with pedestrian activations for more than 75% of the peak hour signal cycles should be timed to accommodate pedestrian crossings during every peak hour cycle.

At intersection locations with low side-street volumes that are not on a direct path to a generator, signals should be partially actuated, i.e. side street pedestrian signals should give a WALK sign on every cycle, but the main street signals should be activated by the pedestrian push button.

BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

Pedestrian push buttons should be designed based on the following criteria:

- Intersection corners with more than one pedestrian push button should have the buttons mounted on separate poles. The closest push button to a crosswalk should call the pedestrian signal for that crosswalk.
- An arrow indicator should be used show which crosswalk the button will affect.
- The push button should be visible to a pedestrian facing the crosswalk, unless space constraints dictate another button placement.
- The push button must be accessible from the level landing (with a maximum cross slope of 2%) at the top of the curb ramp, or from the dropped landing of a parallel curb ramp with a clear side reach of no more than 24 inches. Buttons must be not higher than 48 inches above the level landing.
- Where audible pedestrian signals are installed, audible push buttons should also be used. Newer audible signals have the sound coming from the push button and automatically adjust to background noise. This combination addresses neighborhood concerns about the noise associated with audible signals.
- Tactile symbols should be installed for visually impaired persons.
- Crossing locations with pedestrian refuge islands or medians and crossing distances greater than 60 feet should include a pedestrian push button in the median.

Pedestrian Scramble

The pedestrian scramble allows pedestrians to walk in all directions at an intersection while all vehicle approaches have a red light. This gives pedestrians an opportunity to cross through the intersection orthogonally or diagonally, providing a direct and efficient walking route.



Pedestrian Scramble
Victorian Avenue/Victorian Plaza Circle

BICYCLE & PEDESTRIAN FACILITY DESIGN BEST PRACTICES

Audible Signal

Pedestrian phases are typically difficult to recognize by the visually impaired. Audible signals can be used to communicate to pedestrians in a non-visual way, through a verbal message, bell, buzzer, or vibrating surface. The pedestrian is notified when the WALK signal is on.

Where audible signals are installed, it is recommended that they be placed on a separate pole close to the crosswalk line. If more than one signal is used at an intersection corner, the signals should be placed a minimum of 10 feet apart decipher which direction is communicating.

Curb Ramps



Notes:

- Directional curb ramps are preferred
- A corner curb ramp must serve both crosswalks
- Needs to meet ADA design standards

Curb Extensions



Notes:

- For use on streets with on-street parking
- Should not impede bicycle or vehicle traffic
- Shortens crossing distances for pedestrians and increases visibility

Pedestrian Scramble



Notes:

- Should be used at intersections with significant pedestrian crossing volumes
- Provides an "all pedestrian" phase

Countdown Signal



Corner Radii

Notes:

- Smaller corner radii reduce vehicle speeds, increasing safety for pedestrians and are recommended wherever possible
- Corner radius should be designed based on the largest vehicle that uses the street on a weekly basis

Push Buttons



Notes:

- Minimum 2" diameter required
- Tactile buttons are beneficial for the visually impaired
- Maximum button height = 48"
- Pedestrian push buttons should be on separate poles for multiple crossing directions at one location

Audible Signal

Notes:

- Can include verbal messages or vibrating surfaces
- Recommended to be placed on a separate pole and close to the crosswalk line
- Two audible signals at the same corner should be placed 10 feet apart to decipher which direction is communicating