7 BIKEWAYS ON MAJOR AND RURAL ROADS

Optimally, as stated in Chapter 3, all arterials should have bike lanes. However, options are needed for arterials that cannot be retrofitted to accommodate bike lanes. The standard Class 3 Bike Route designation defined in the HDM requires no special markings or treatments other than signage. It is a generic category which applies to roadways ranging from busy arterials with narrow lanes to quiet low-volume residential streets. To aid bicyclists, city staff and motorists in anticipating what type of roadway conditions to expect on a Class 3 Bike Route, this manual presents many options for accommodating bicycles on roadways without bike lanes. Those that apply to arterials, collectors and highways are presented after the bike lane discussion in this chapter. Those that apply to local roads are presented in Chapter 8. It is encouraged that cities use one or more of these categories in their planning documents and bikeway maps. See also Chapter 8 *Local Roads*.

IN THIS CHAPTER:

Bike Lane-Parking Permitted

Local and National Practices

Many cities in Santa Clara County have adopted additional bikeway categories. Palo Alto has developed a bikeway called a Bicycle Boulevard. This is a residential street where unnecessary STOP signs have been removed to improve travel time for bicyclists, and traffic calming measures have been implemented to reduce its attractiveness to automobiles. The cities of Cupertino and Berkeley, California; and Portland, Oregon have followed Palo Alto's example and are developing a network of bicycle boulevards. Napa County has developed Class 3A and Class 3C to describe rural roads with four-foot minimum and two-foot minimum shoulders, respectively. Berkeley has included on its adopted bike network a category called Class 2.5, for arterials where bike lanes are preferred but widening would be prohibitively expensive. The cities of San Francisco, California; Portland, Oregon; and Charlotte, North Carolina have adopted roadways with wide outside lanes as a specific facility for bicyclists. The cities of Denver, San Francisco, and Oakland are using the Sharrow stencil on busy roadways with narrow outside lanes to identify them as roadways where the full travel lane needs to be shared by both motorists and bicyclists.

Wide Curb Lane

Wide Shoulder

Road with "Sharrow"

NOTE

Separate bike paths paralleling the roadway do not substitute for bike lanes on the arterial.

7.1 BIKE LANES

Urban arterials and collectors carrying 2000 or more vehicles per day per lane (vpdpl) (e.g. 4000 vpd for a two-lane roadway) should have bike lanes (See also Section 7.4 for discussion on the use of shoulders in lieu of bike lanes e.g. on County Expressways and state highways). Optimally, the width of bike lanes should increase as motor vehicle travel speed increases as discussed below.

Bike Lanes on Steep Grades

Bicycle lanes are generally not recommended on downhill grades greater than 5% unless a minimum of 8 feet can be provided because the grade enables descending bicyclists to attain higher speeds and fast bicyclists require more space.

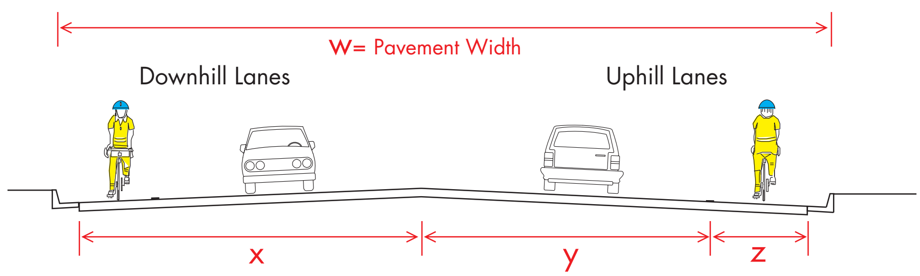
TECH TIP

RETROFIT OPTIONS

To retrofit existing roadways to have 5 ft minimum bike lanes, consider the following options:

- *Reduce lane widths to 11 or 10 feet;*
- *Four-lane undivided roads can be redesigned as three lanes with bike lanes; see PTG Fig 2.31*
- *Remove parking on one side of the street*

On steep grades (5% or greater) where pavement widening potential is limited and extra lane width or a bike lane can only be provided on one side of the road, the bike lane or extra width should be provided in the uphill direction. Downhill bicyclists typically can travel nearer to or at the prevailing speed of traffic and can take the lane while uphill cyclists may be travelling as slow as 5mph and motorists will want to pass them. See Figure 7-1 for guidance for various roadway widths.



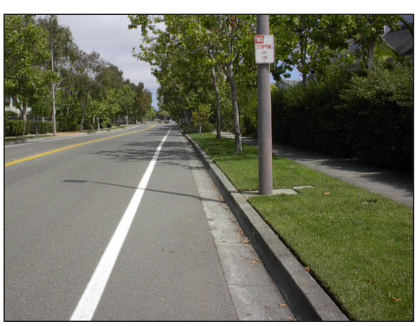
W	X	Y	Z
28	12	12	4
30	14	12	4
32	15	12	5
34	16	12	6
36	18	12	6

Not to scale

Figure 7-1:
Bike Lanes on Roadways Where Grade is ≥ 5%

7.1.1 Bike Lane Widths on Arterials/Collectors

The following provides guidance for three ranges of posted speeds. Note that the gutter pan is unusable for cyclists, therefore wide gutters (> 1.0 foot) are discouraged so that more usable roadway width can be provided. See Chapter 3.2- for additional discussion on gutter pan widths and drainage options.

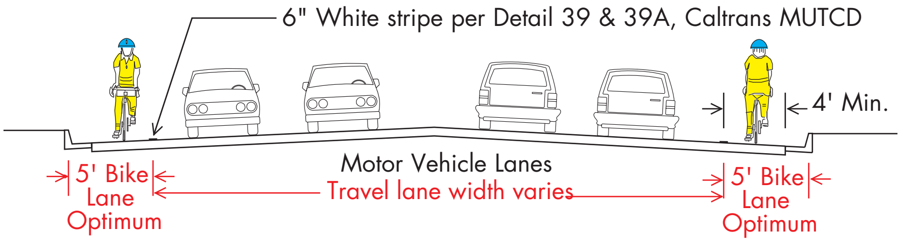


Bike lane-parking prohibited.

With Posted Speeds Less Than or Equal to 30 mph

The optimum width for a bike lane on an arterial/collector with no on-street parking with speeds of 30 mph or less is five feet. The optimal minimum width to the longitudinal joint with the gutter pan is four feet;

(Caltrans HDM states that a minimum width of 3 feet shall be provided.) If there is on-street parallel parking, an additional eight feet should be provided. (See Section 7.1.2 for striping options of the parking lane).

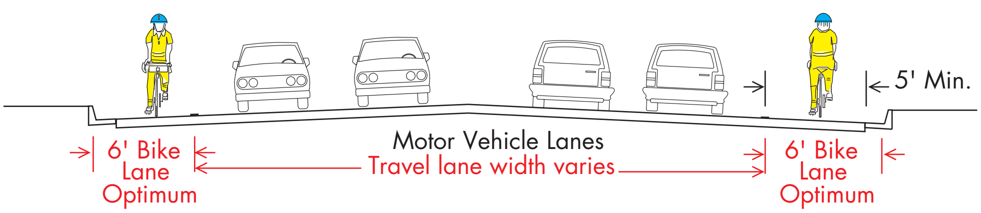


Not to scale

Figure 7-2a:
Bike Lane Width - 30 mph or less Posted Speed

With Posted Speeds between 35 and 40 mph

The optimal width for a bike lane on an arterial/collector with no on-street parking with posted speeds of 35 mph to 40 mph, is six feet. The optimal minimum width to the longitudinal joint with the gutter pan is five feet. If there is on-street parallel parking, an additional eight feet should be provided.

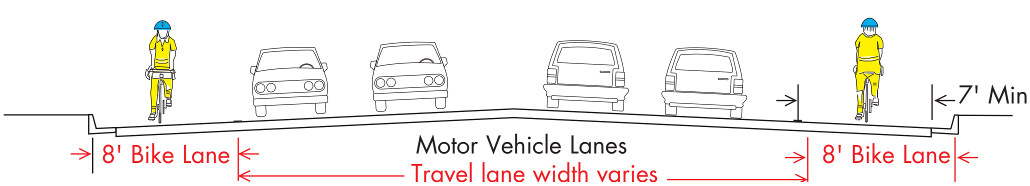


Not to scale

Figure 7-2b:
Bike Lane Width - 35-40 mph Posted Speed

With Posted Speeds of 45 mph or more

The optimum width for a bike lane on an arterial/collector with no on-street parking with posted speeds of 45 mph or more is eight feet. The optimal minimum width to the longitudinal joint with the gutter pan is seven feet. If there is on-street parallel parking, an additional eight feet should be provided.



Not to scale

Figure 7-2c.:
Bike Lane Width - 45 mph or more Posted Speed

NOTE

On-street parallel parking presents the possibility of drivers illegally opening doors into the path of oncoming bicyclists. Wider bike lanes or a buffer zone would allow bicyclists to ride outside of this "door zone."

LOCAL PRACTICE

Some communities are placing buffer zones next to their bike lanes; one philosophy is to place them between the parked cars and the bike lane as a countermeasure to "dooring" (when motorists open car doors without looking and hit oncoming cyclists). This is a prevalent type of collision in urban areas. Other communities are placing buffer zones between the bike lane and the travel lane, to help cyclists feel more "protected" from adjacent traffic.

Buffered Bike Lane in Downtown San Jose.

R81 (CA)

FRONT

R5-1b

BACK OF R81

R81/R26 SIGN

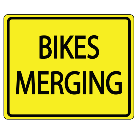
FRONT

R5-1b

BACK

MUTCD R4-4
ADVANCE OF
RIGHT-TURN LANE

VTA SR-4



VTA SW-4

VTA SW-5

7.1.2 Pavement Markings and Signage in Bike Lanes

Signs:

MUTCD-CA

Bike Lane (MUTCD R81 (CA))-The Bike Lane sign shall be placed at the beginning of each designated bike lane, after every arterial street intersection and at maximum half-mile intervals. No Parking signs may be integrated with the Bike Lane sign where parking is prohibited.

Wrong–Way signing (MUTCD R5-1b)-"Wrong-Way" signs may be posted on the back of the R81(CA) bike lane signs to educate bicyclists that bike lanes are intended for one-way travel. The Cities of Cupertino and Santa Clara currently do so.

Begin Right-Turn Lane Yield to Bikes (MUTCD R4-4)-This sign is used to reinforce to motorists entering a right-turn lane that the through bicyclist has the right-of-way.

VTA Best Practice

Bike Lane (through) at Forced Right-Turn Lane (VTA SW-5)-This sign is used at intersections with a bike lane and a trap right-turn lane where cars must turn right but bicyclists may proceed straight. See also Figure 5-14.

Right-turning Vehicles Enter Bike Lane When Clear (VTA SR-4)-This sign is used at locations where right-turning motorists are not complying with CVC Section 21717 to enter the bike lane prior to making their turn. This prevents turning motorists from cutting off a through bicyclist and helps ensure that the bicyclist will pass the motorist on the left. A variation of this sign is currently used in Lafayette, California.

Markings:

Caltrans Standard

Bike lanes are marked with a 6-inch white stripe per MUTCD-CA Detail 39. The MUTCD-CA contains three options for the bike lane pavement marking: the words BIKE LANE, the BIKE symbol and the BIKE RIDER symbol. The word legend may be used in conjunction with a symbol as shown in Figure 7-3. The practice of using symbols in lieu of words is favored by many cities including San Jose. See California Standard Plans A24C and A24D for specifications for the bike lane markings.

VTA Best Practice

Include a straight directional arrow, to reinforce the one-way travel flow of the bike lane. The arrow is placed after the bike lane pavement markings.

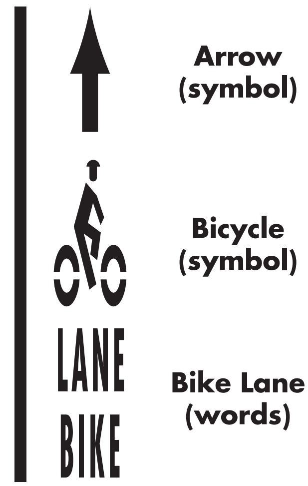
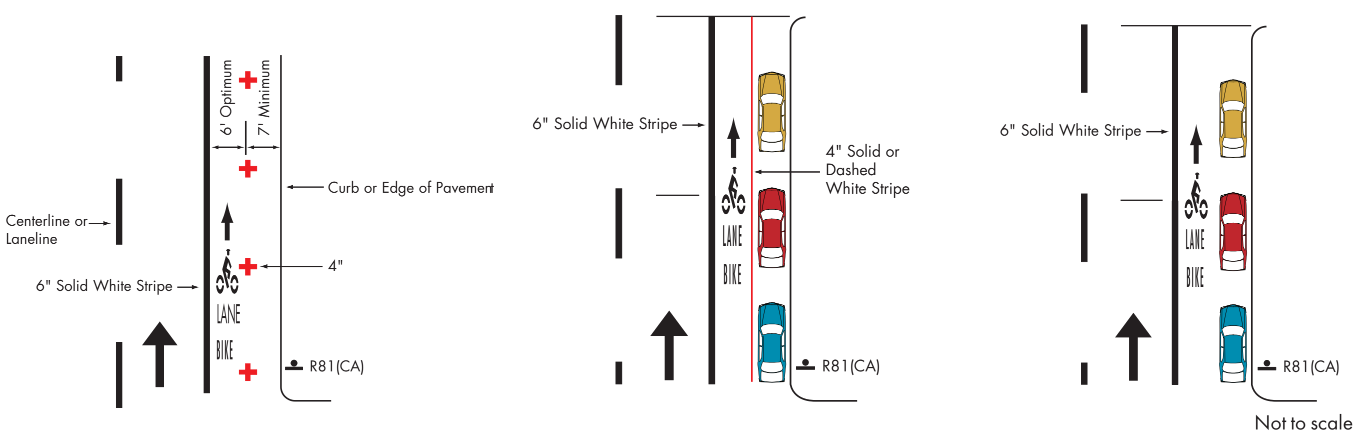


Figure 7-3:
Optimal Bike Lane Pavement Marking Set

Caltrans Option –Bike Lane Striping with Parking Lane

When the bike lane is next to a parking lane, optimally add 8 feet to the widths presented above.

There are three ways to delineate the parking spaces from the bike lane as shown below in Figure 7-4:

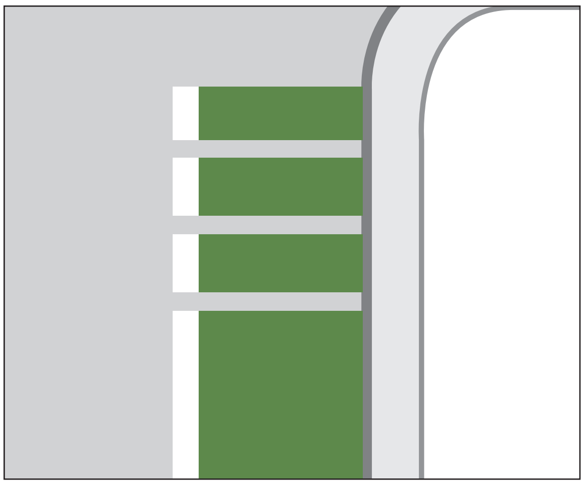


A. With metered parking, parking crosses are recommended: these are 24 inches by 24 inches and the center of the cross is placed 7 feet from the curb face;

B. Solid stripe or dashed stripe, where individual parking spaces are not marked;

C. No stripe-where turnover is low but parking occupancy is high, then no stripe or marking may be necessary.

Figure 7-4:
Bike Lane Striping Options with On-street Parking



TECH TIP

Preformed thermoplastic such as ViziGrip by Flint Trading has a minimum skid resistance value of 60 BPN when tested according to ASTM E 303.

It must be supplied at a minimum thickness of 90 mils (2.29 mm) or 125 mils (3.15 mm).

When used as a word or symbol, to be most bike-friendly, this should also be its maximum thickness.

Caltrans Option – Green Color

The MUTCD states that if color is used to regulate, warn or guide traffic, the colored pavement is considered to be a traffic control device. FHWA has issued an interim approval (IA-14) for the use of green color markings in bike lanes to any jurisdiction that submits a written request. Caltrans has received permission from FHWA on behalf of all local California agencies. Local agencies desiring to use green color must inform Caltrans headquarters of the location of the application.

If used, this marking:

- must be accompanied by the longitudinal white stripe;
- must conform to the day time and night time chromacity coordinates set forth in IA-14.

The color may take up the entire length of the bike lane or portions of the bike lane. It may be dashed to match the bike lane dash pattern where so dashed. It also may be used as a rectangular background behind the white pavement marking as described above.

VTA Best Practice

If colored pavement is used, then at intersection approach where Bike Lane is dashed, the green pavement should be similarly dashed.

Discussion

Section 3.3 discusses the common pavement marking materials, their relative slip-resistance and the need for all pavement markings to be slip-resistant especially when wet. In implementing green bike lanes, maintaining appropriate traction for cyclists is essential since the colored material covers the entire bike lane and is not merely an occasional word or symbol.

The most slip-resistant marking appears to be colored asphalt or slurry seal, but this may not meet FHWA's color specifications. Paint with added sand has improved slip-resistance but paint typically lasts only two years, thus it is a maintenance issue. The most cost-effective material appears to be preformed thermo plastic.

7.1.3 Bike Lanes Approaching Intersections

Caltrans Standard

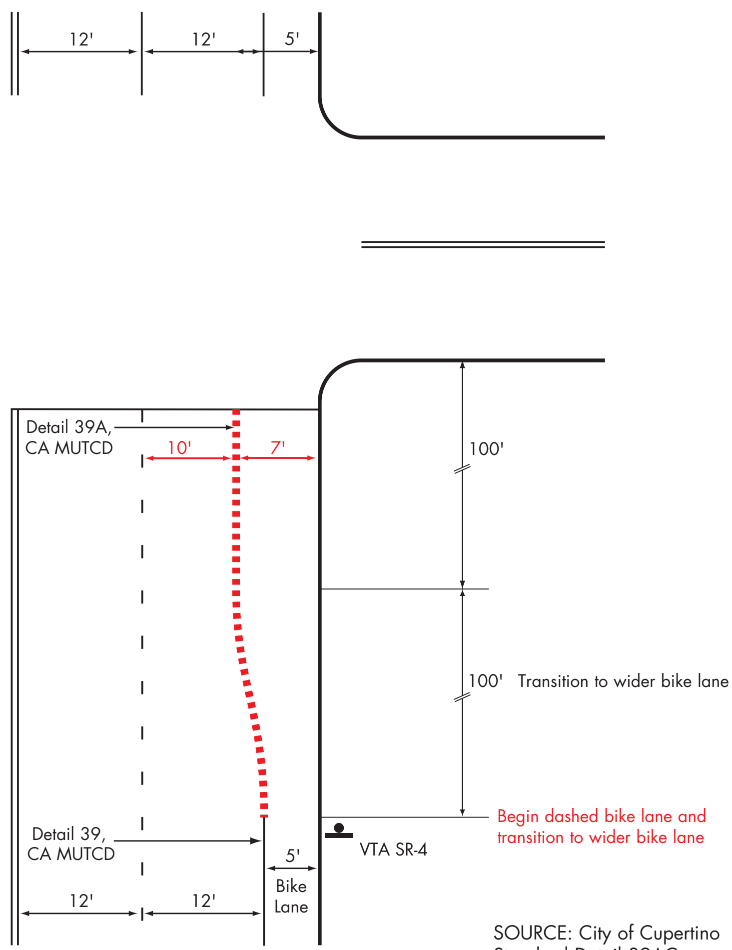
Bike lanes approaching intersections should dash the solid bike lane line for the last 100 to 200 feet in advance of the intersection. This encourages the right-turn vehicle to enter the bike lane prior to the turn per CVC 21717.

See Chapter 5.1.1 for guidance on providing a bike lane at right-turn only lanes

See Chapter 5 for guidance on bike lanes through freeway interchanges.

VTA Best Practice

See Figure 7-5 for option to encourage motorists to enter bike lane prior to their turn.



SOURCE: City of Cupertino
Standard Detail 39AC.

Not To Scale

Figure 7-5:
Bike Lane Striping Option at Intersection Approach

LOCAL PRACTICE

As depicted in Figure 7-5, an option used in Cupertino at intersections without right-turn lanes is to dash and widen the bike lane for the last 200 feet by narrowing the travel lane. The City found that by narrowing the through lane and widening the bike lane, motorists were more likely to enter the bike lane to make their right-turn.

VTA SR-4

7.1.4 Bike Lanes at Bulbouts

When designing a bulbout on a street with bike lanes, the following design elements should be considered so that bicyclists are not adversely impacted:

1) the width of the curb extension (see Section 3.6);
2) the width of the bike lane adjacent to the bulb-out; and
3) the width of the gutter pan adjacent to the bulb-out.

Caltrans Standard

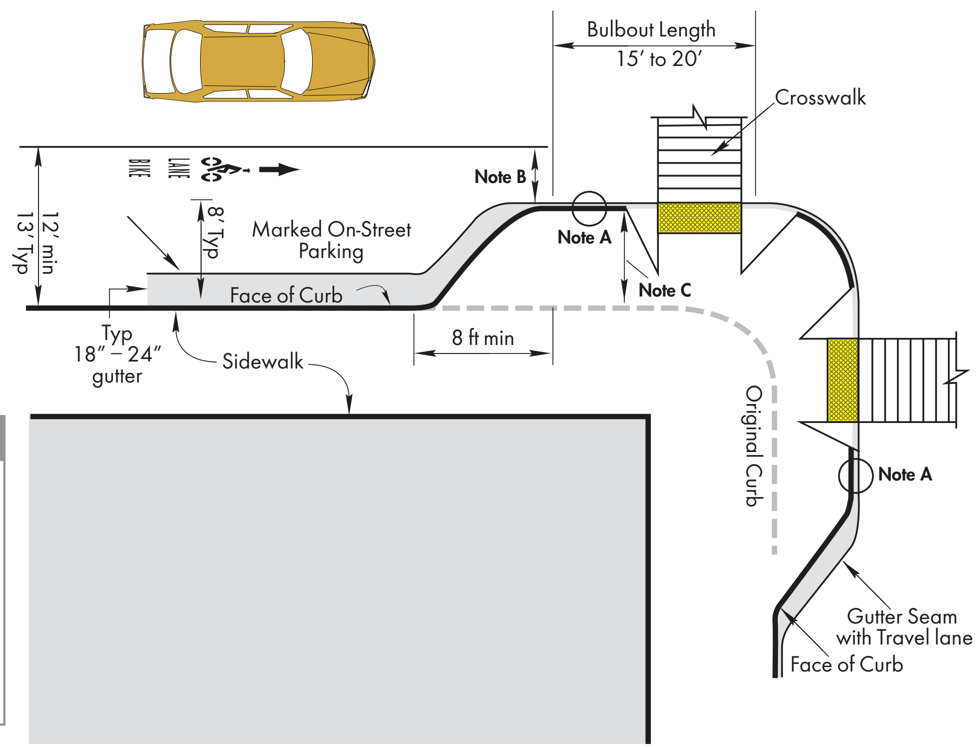
Width of Bike Lane

"Available width for bicyclists should not be reduced along the curb face of the bulbout." (HDM §303.4)

"On highways with concrete curb and gutter, a minimum width of 3 feet measured from the bike lane stripe to the joint between the shoulder pavement and the gutter shall be provided." (HDM §301.2)

VTA Best Practice Bulbout with Bike Lane

The width of gutter pan and bike lane adjacent to a bulbout is depicted in Figure 7-6.



Notes

A. Gutter pan width adjacent to the bulbout is 6 in. maximum, or eliminate the gutter pan entirely. See also Section 3.6.

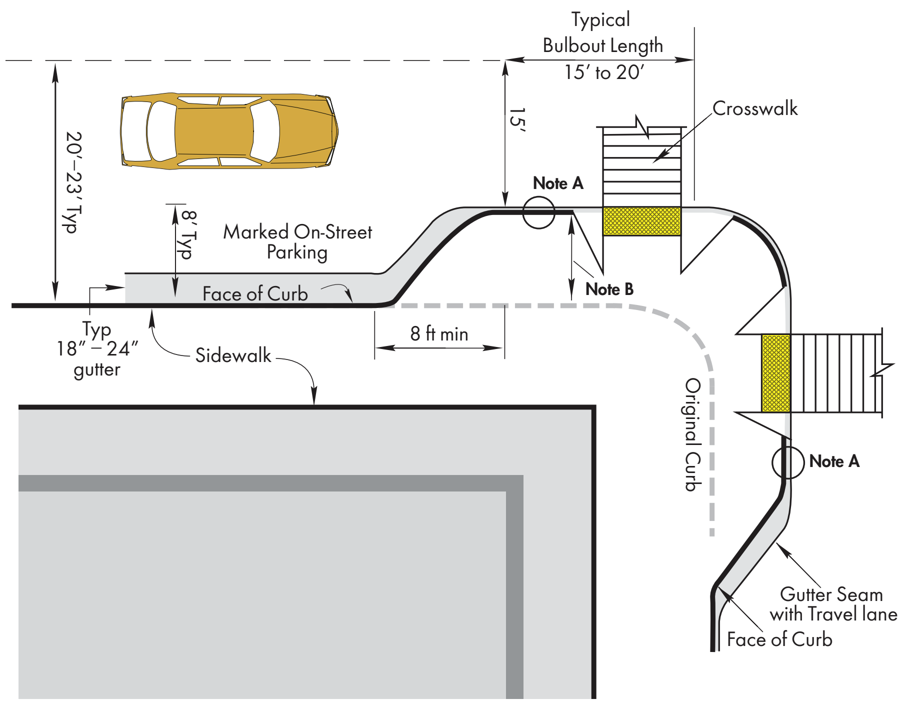
B. Maintain minimum bike lane width of 4 feet, optimally 5 feet, adjacent to the bulbout. Narrow travel lanes at intersection approach if necessary.

C. 6 ft optimum; see Section 3.6

Figure 7-6: Bulbout with Bike Lane

VTA Best Practice Bulbout with No Bike Lane

Where there is no bike lane, the gutter pan width affects bicyclists even more profoundly. At these locations, the gutter pan should be as narrow as possible or eliminated entirely as shown in Figure 7-7.



Notes

A. Gutter pan width adjacent to the bulb-out is 6 in. maximum, or eliminate the gutter pan entirely. See also Section 3.6.

B. 6 ft optimum; see Section 3.6

C. Retain lane width of 15 ft. min. from curb face to lane line, so bicyclists and motor vehicles can pass the bulbout side by side.

Figure 7-7:
Bulbout without Bike Lane

7.1.5 Bike Lanes Approaching Signalized Intersections

Bike lanes approaching signalized intersections should drop the solid bike lane line and provide a dashed line for the last 200 feet leading to the intersection. Dashing is preferable to dropping the bike lane stripe because it alerts bicyclists and right-turning motorist of the weave. Also, if there are loop detectors in the bike lane, the dashed bike lane stripe encourages bicyclists to wait in the proper location to be detected. Type Q loop detectors, adjusted to detect bicycles, should be placed near the limit line in the bike lanes and Type D should be used in motor vehicle travel lanes including the left-turn lanes (See Figure 7-8). The pavement marking as depicted in Standard Plans A24C shall be used to inform bicyclists where to wait to trigger the signal (Figure 7-9). More discussion is presented in Chapter 6.2. Alternative detection technology is acceptable as long as it reliably detects bicycles (see Chapter 6.2.3).

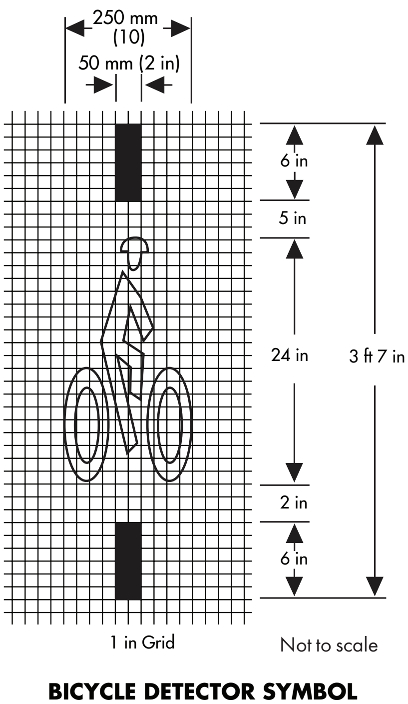


Figure 7-9:
Loop Detector Pavement Marking (Calrans Standard Plans A24C)

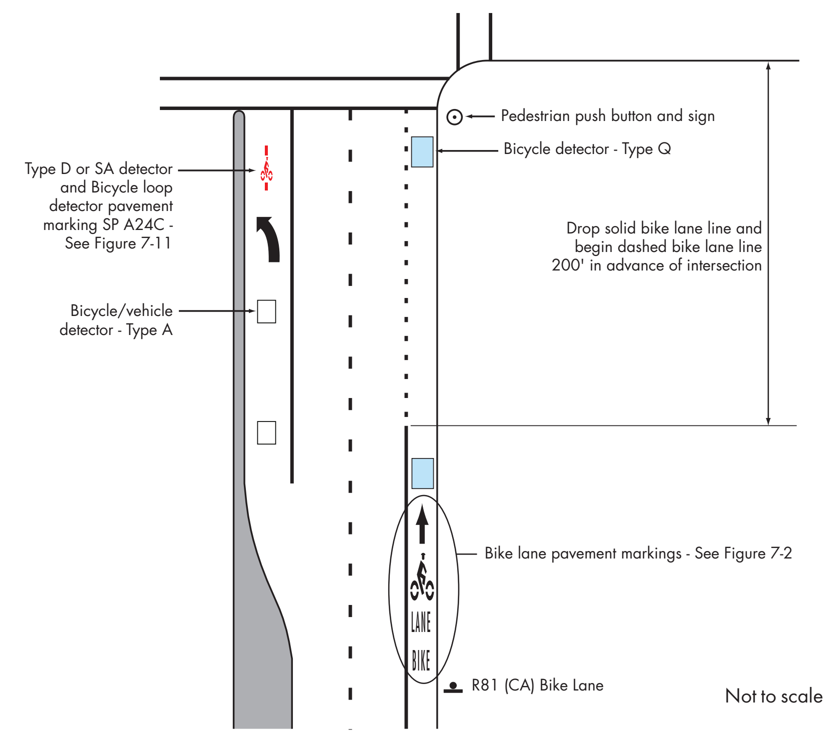


Figure 7-8:
Bike Lane Striping and Detector Layout at Signalized Intersection Approach

7.1.6 One-Way Street, Bike Lanes and Contra Flow Bike Lanes

Caltrans Standard

HDM § 301.2 (1)states "If bike lanes are to be located on one-way streets, they may be placed on either or both sides of the street. When only one bicycle lane is provided, it should be located on the side of the street that presents the lowest number of conflicts for bicyclists which facilitates turning movements and access to destinations on the street."

VTA Best Practice

The recommended striping for a bike lane on the left side of a one-way street is depicted in Figure 7-10A. If there is an exclusive left-turn lane, the bike lane is placed on its right, as shown in Figure 7-10B. The primary advantage of placing a bike lane on the left side is to avoid the leap-frogging between bicyclists and buses that occurs on the right. If the street is not a bus route or buses are infrequent (e.g. 2 per hour), other considerations in selecting the location of the bike lane are listed below. The designer should consult with the local BAC to decide the best location if there are conflicting priorities.

Factors to consider when selecting which side of a one-way street to place the bike lane are:

- Presence of on-street parking: if parking is permitted on only one side of the street, the side without on-street parking is preferred;
- Major attractor/popular destinations (if any): if, for example, a university fronts on one side of the street, the side fronting the attractor is preferred;
- Bike turning movement volumes: the side of the street with the most cyclist turns at intersections is preferred;
- Motor vehicle turning movement volumes: the side of the street with the least number of motorist right or left turns at intersections and driveways is preferred.

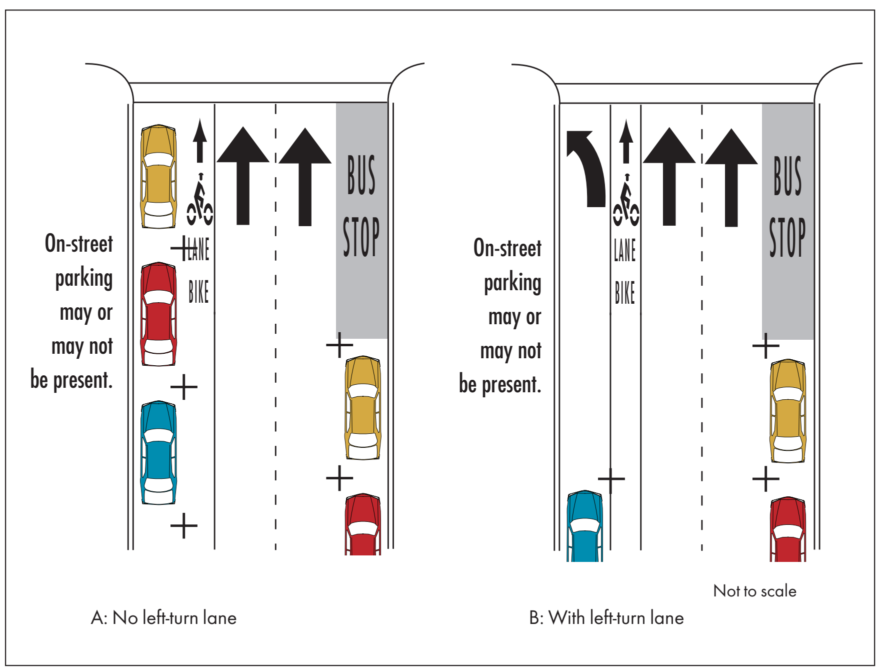
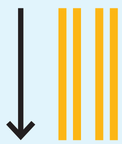


Figure 7-10:
Bike Lanes and One-Way Streets

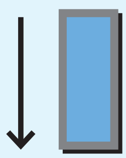
TECH TIP

Median options

Double Yellow Line (posted speed ≤25 mph)



Painted Median (double double yellow line) (posted speed ≥30 mph)



Raised Median Island (median width = 2 ft - 4 ft)

VTA Best Practice

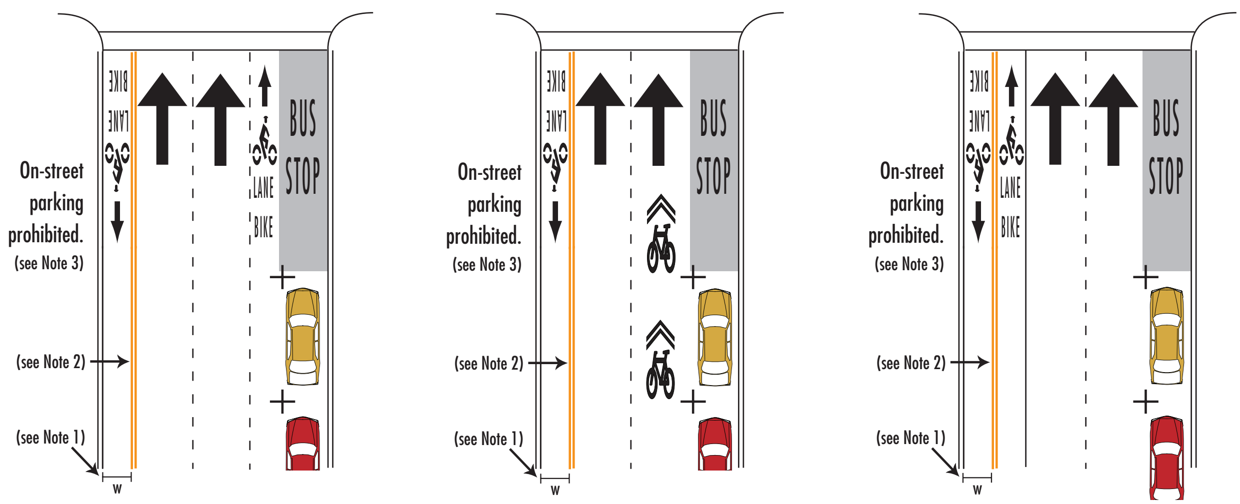
Contra flow bike lane:

In addition to or in lieu of the bike lane in the same direction of travel, many cities have found it beneficial to provide a contra flow bike lane on one-way streets. In this way, bicyclists have legal two-way circulation on the street thereby improving their mobility and access and reducing travel time. Contra flow bike lanes have been shown to reduce wrong way riding on the street and to reduce bike riding on the sidewalk, which also improves pedestrian comfort and safety.

There are several variations for striping the contra flow bike lane depending on the available curb-to-curb width; these are presented in Figure 7-11.

There are also several options for separating the two directions of travel as shown in the side bar.

At cross streets controlled by STOP signs, install sign warning of bike traffic to the motorist's left.



Option A: One-way street with bike lane on right side and contra flow bike lane.

Option B: One-way street with contra flow bike lane and sharrows.

Option C: One-way street with bike lane on left side and contra flow bike lane.

Figure 7-11:
Contra Flow Bike Lane Options on One-Way Streets

Notes

1. w = minimum width of contra flow bike lane; w = 5 ft. except when adjacent to a raised median, then w = 6 ft; optimum width = 8 ft.
2. See side bar for median/centerline options between the two directions of travel.
3. See Section 7.5 Cycle Tracks if there is on-street parking on the contra flow bike lane side of the street.

Not to scale

7.1.7 Bike Lanes at Bus Stops

Bike lanes on streets with bus routes present challenges in designing the bus stops or pullouts vis à vis the bike lanes. In general, for near side bus stops, it is recommended to drop the bike lane stripe adjacent to the bus stop while for farside bus stops, the bike lane stripe is only recommend if the cyclist can remain in the bike lane while passing a bus in the stop. See Figure 7-12.

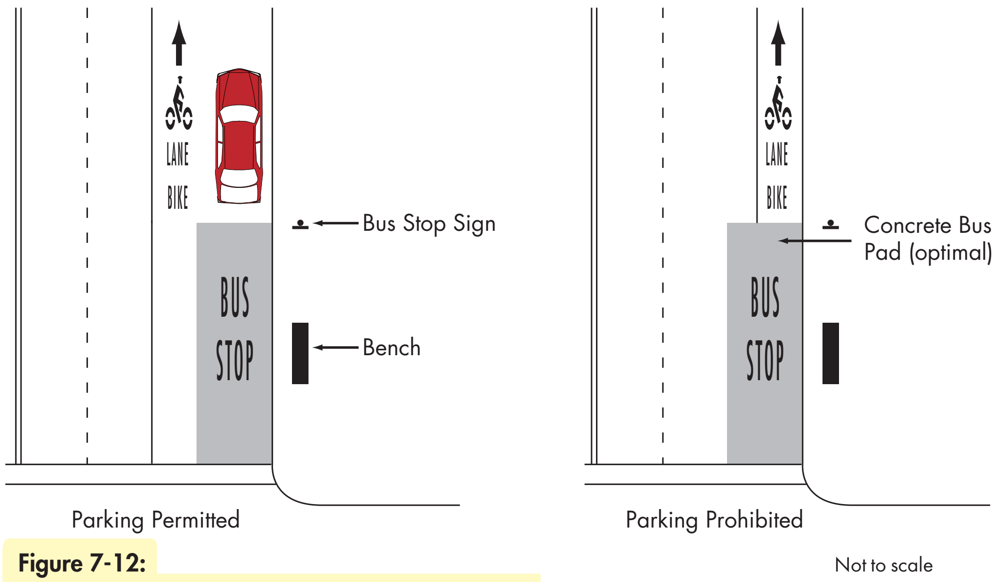


Figure 7-12:
Bike Lanes on Bus Routes (Farside Bus Stop)

Discussion

The weave that must take place between through bicyclists and buses pulling over to load and unload passengers is a concern whether or not bike lanes are striped on a roadway. The presence of bus routes on a roadway should not prevent the provision of bike lanes on that roadway.

Concrete Bus Pads

Portland cement concrete (PCC) pavement at all bus stops is preferred; asphalt pavement tends to ripple and crack over time. Figure 26 from VTA Bus Stop & Facility Standards indicates a structural section of 8.5 inch thick PCC over 8.5 inch thick aggregate base. Typical size of the pad is 10 feet wide by 55 feet in length for a standard 40' long coach.

Concrete bus pad on N. First Street, San Jose.

Bike Lanes Next to BRT or Bus Only Lane

If there is no exclusive BRT lane but there are bike lanes, this is essentially the situation shown previously in Figure 7-14. If there are BRT or Bus Only lanes, they can be provided either in the median or adjacent to the right-hand curb or parking lane. When the BRT/Bus Only lane is adjacent to the curb or parking lane, to reduce the weaving between bikes and buses, the bike lane should be provided to the left of BRT/ Bus Only lane as shown in Figure 7-13a.

A configuration where the BRT/Bus Only lane is in or adjacent to the median is shown in Figure 7-13b, within a 120-foot wide right of way. If there is on-street parking within the same 120-foot right of way, the dimensions are a little tighter as shown in Figure 7-13c. If the dimensions are so constrained that there can be no bike lanes (or wide shoulders), bicycles should be explicitly permitted to ride in the curbside lane, which should be as wide as possible by narrowing the inner lanes.

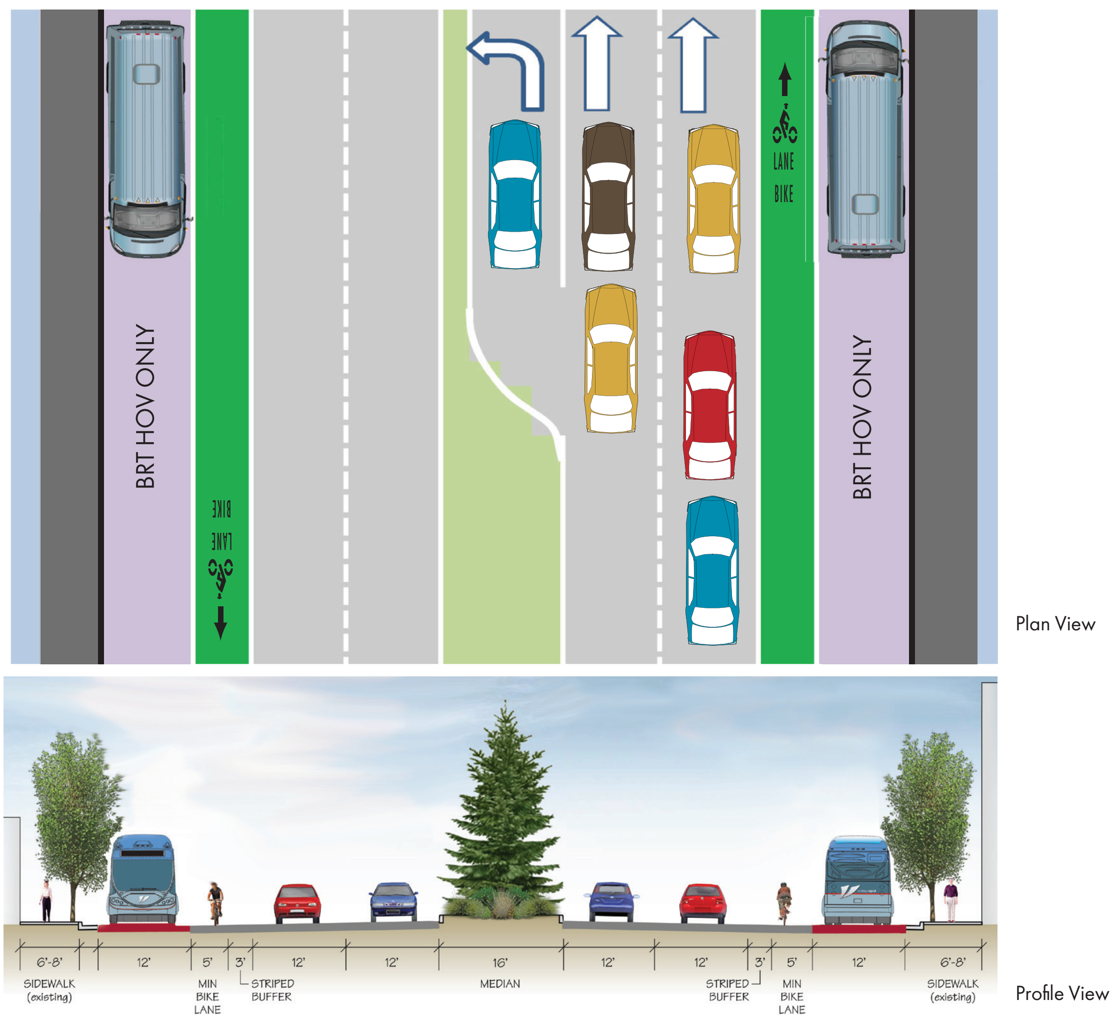
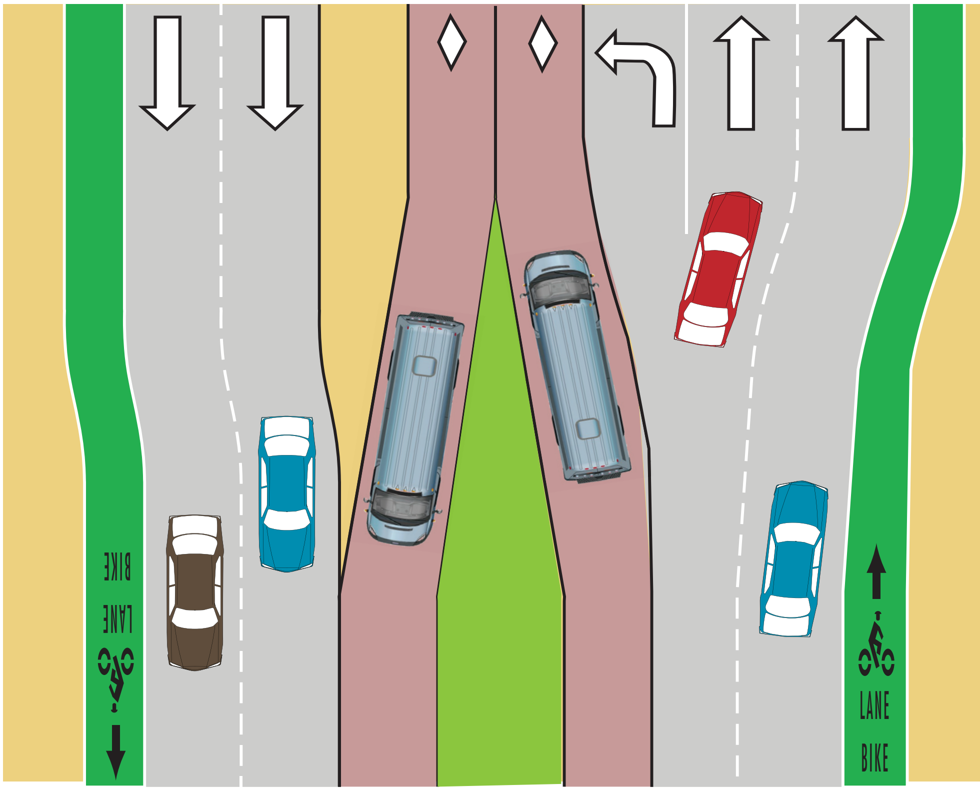


Figure 7-13a:
Curbside BRT – Dedicated Lanes with Bike Lanes

Plan View



Profile View

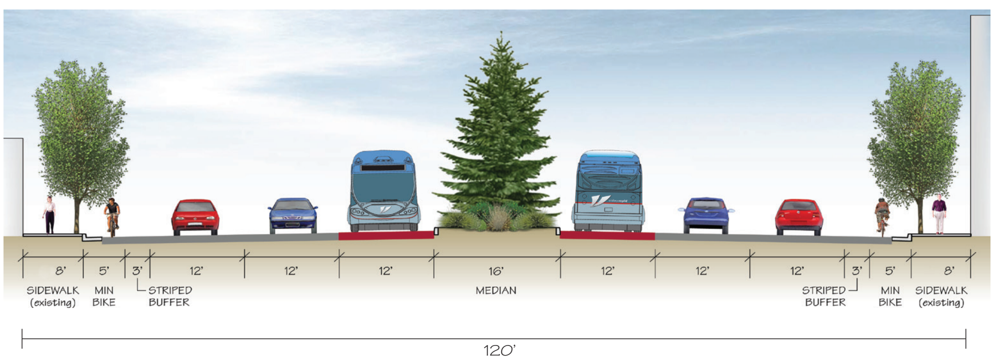


Figure 7-13b:
Median BRT – Dedicated Lanes with Bike Lanes and No Parking

Profile View

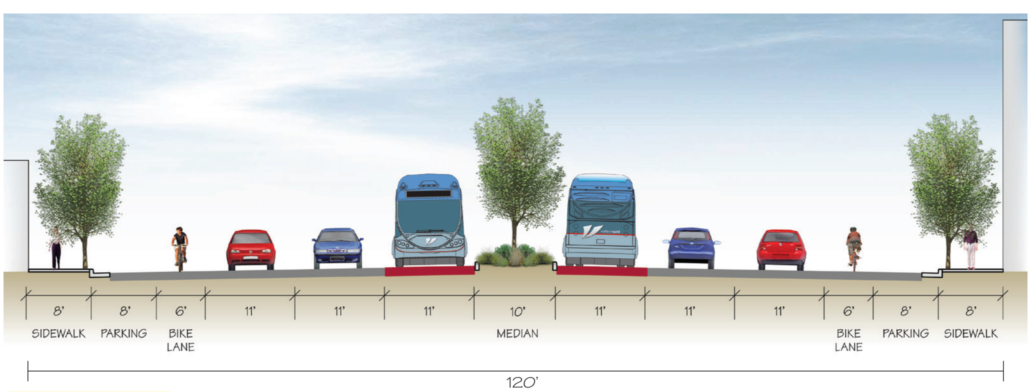


Figure 7-13c:
Median BRT – Dedicated Lanes with Bike Lanes and Parking

TECH TIP

See also:

- Caltrans Design Information Bulletin (DIB) 80-01
- FHWA: Roundabouts: an Informational Guide" at *http://www.fhwa.dot.gov/publications/research/safety/00067/index.cfm*
- *http://safety.fhwa.dot.gov/intersection/roundabouts/fhwasa10006/*

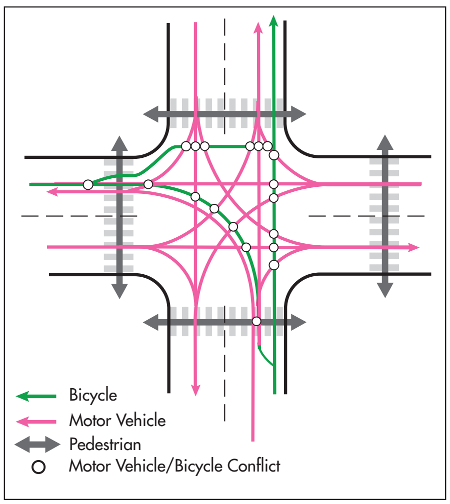


Figure 7-14: Bicycle Conflicts at Conventional Intersections

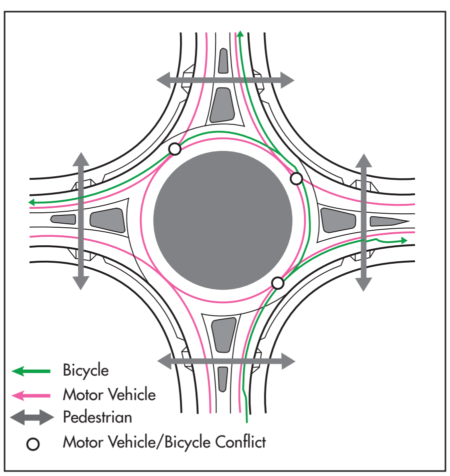


Figure 7-15: Bicycle Conflicts at Roundabouts

7.1.8 Bike Lanes and Modern Roundabouts

Modern roundabouts are not to be confused with smaller traffic calming circles found on residential streets and bicycle boulevards such as Bryant Street in Palo Alto, nor with large traffic circles also known as "rotaries" common in the northeastern US. Unlike rotaries, modern roundabouts are designed for maximum speeds within the roundabout of 15 to 23 mph, and traffic signals are not used to control entry and exit. The slower motor vehicle speeds make sharing with cyclists within the circular portion more compatible. This section will highlight the main benefits of roundabouts with respect to bicycling. For more information on all aspects of roundabout design, see manuals listed on the left.

Roundabouts in lieu of Stop Signs and Signals

Studies have shown that both the number of crashes and crash severity is greatly reduced at modern roundabouts compared to four-way stop controlled and signal-controlled intersections. As shown in Figure 7-14, a typical through cyclist faces six potential conflicts points from weaving with or crossing travel paths with motorists at a typical four-legged intersection. At a roundabout, there are only two such conflict points. See Figure 7-15. In addition, the traffic calming effect at the junction slows vehicle traffic, enabling cars and bicyclists to safely share the circular roadway. For these reasons, VTA BTG encourages one-lane roundabouts on bikeways in lieu of all-way stop sign and signal control where two 2-lane roadways intersect each other.

Designing for Bicycles

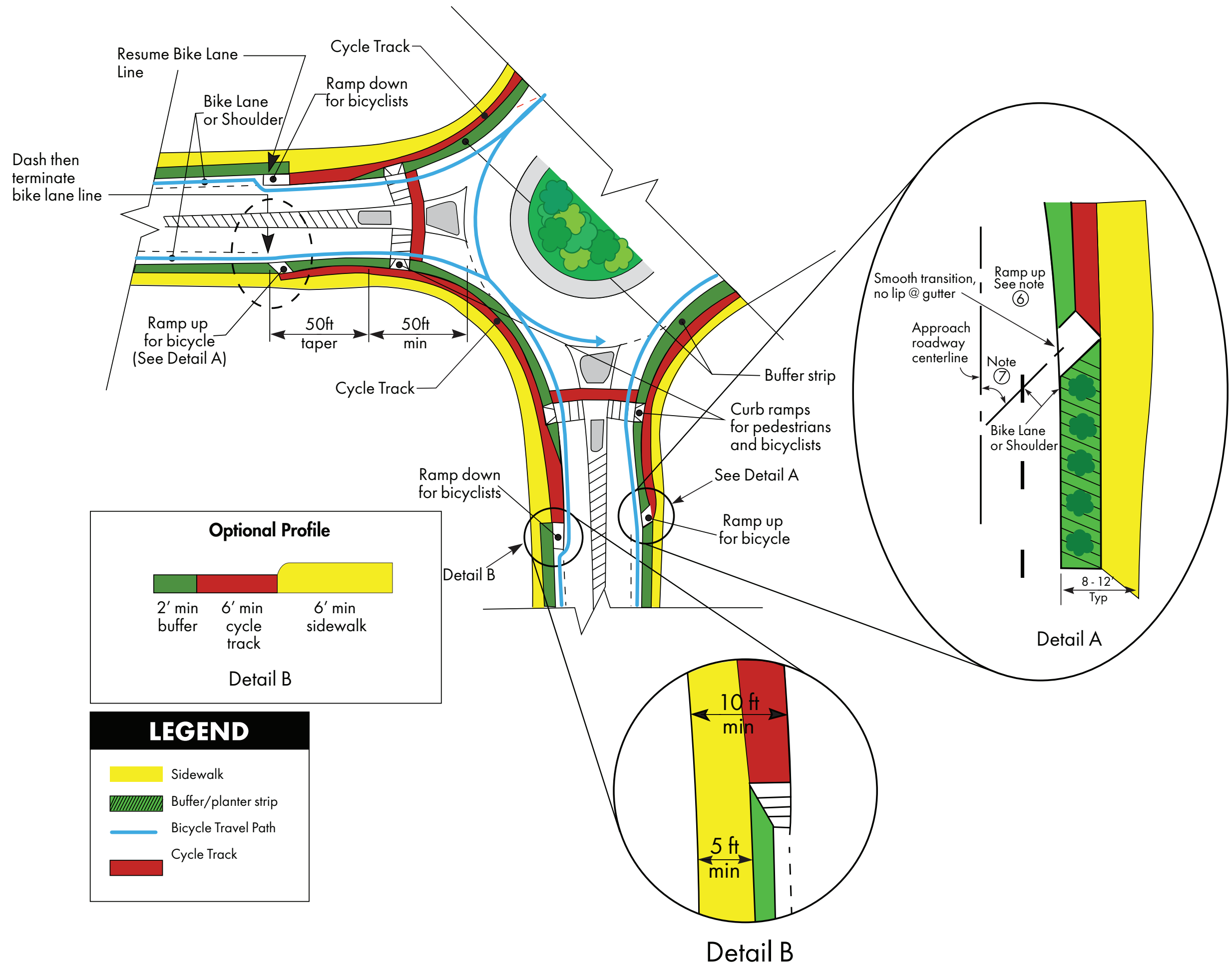
FHWA, AASHTO and Caltrans have all issued guidance on the design of modern roundabouts; the consensus is that one-lane roundabouts are very compatible with bicyclists.

See also PTG Chapter 3, page 3.10-3.14 for further information about modern roundabouts and guidance on pedestrian issues at roundabouts.

Roundabouts and Bike Lanes

Bike lanes are not continued into a roundabout. Bicyclists have two choices to traverse a roundabout as shown in Figure 7-16: they may proceed on the roadway by merging into the travel lane, or they may proceed on the perimeter of the roundabout which must be designed to accommodate both cyclists and pedestrians. Typically at one-lane roundabouts, most cyclists will choose the roadway but some new or young cyclists will prefer the shared use path on the perimeter.

Where vehicle, bicycle and/or pedestrian volumes are higher, consider designing the shared use path at the roundabout perimeter as a cycle track; the key design features are presented in Figure 7-16.



Notes for Figure 7-16

1. Each roundabout is unique and will require sound engineering judgement on the part of the desinger as to the appropriate solution and design details. This illustration is intended to show some of the details that pertain to bicyclists traversing a roundabout.
2. Bike lane line is terminated 100 feet prior to the roundabout (as measured from the outer edge of the circulatory roadway).
3. The bike lane line 50 feet prior to bike lane termination should be dashed.
4. A curb cut should be provided at the beginning of the taper so that cyclists wishing to proceed on the pathway have the option to do so without dismounting.
5. Pathway when shared with sidewalk should be at least 10 feet wide throughout the roundabout to accommodate mixed use, since it will function as a de facto shared use path around the perimeter of the roundabout. When feasible provide a 6-foot one-way bike path and an adjacent 8-foot sidewalk.
6. If cycle-track is not provided, cyclists on shared pathway should be cautioned to ride slowly when pedestrians are present.
7. The target value for this angle is 45 degrees (30 degrees minimum).
8. Ramp up as necessary to meet site conditions; the slope should not exceed 15%. Curbs should not be placed between the landscape strip and the ramp. There should be adequate stopping sight distance for bicyclists entering the shared use path to any potential or existing obstructions or pedestrians.

Figure 7-16:
Roundabout with Cycle Tracks

See also AASHTO "A Policy on Geometric Design of Highways and Streets" Chapter 7 Urban Arterials- Lane Widths

7.2 WIDE CURB LANES

Optimally, as stated in Chapter 3.1, an arterial or a collector roadway with 5,000 vehicles per day or more should have bike lanes. However, when bike lanes are not provided, the curb lane (outside through lane) should have an optimum width of 15 feet as illustrated in Figure 7-17.

Wide curb lanes also help trucks and buses, which predominantly use the curb lane. Such a curb lane of 15 feet (assuming no parking) is wide enough for most motor vehicles to pass a bicyclist without changing lanes. Curb lanes of thirteen feet or less are very intimidating and dangerous to bicyclists because it is difficult for motor vehicles (especially trucks and buses) to safely pass a bicyclist without straddling the lane line. This is compounded by the presence of a wide gutter pan as discussed in Chapter 3.2.

To implement wide outside lanes on multi-lane roadways where roadway pavement widening is not practicable, it is recommended to narrow the inner lanes and/or left-turn lanes and/or median in order to provide more width in the outer lane. Many cities have narrowed inner travel lanes to eleven or even ten feet (and left-turn lanes even narrower); AASHTO supports reducing travel lanes to eleven feet on arterials, (and to nine feet on residential streets), which allows for greater width in the outer through lane.

NOTE

A separate bike path paralleling the roadway (aka sidepath) does not substitute for providing wide curb lanes on the arterial. See section 7.5 for discussion of cycle tracks.

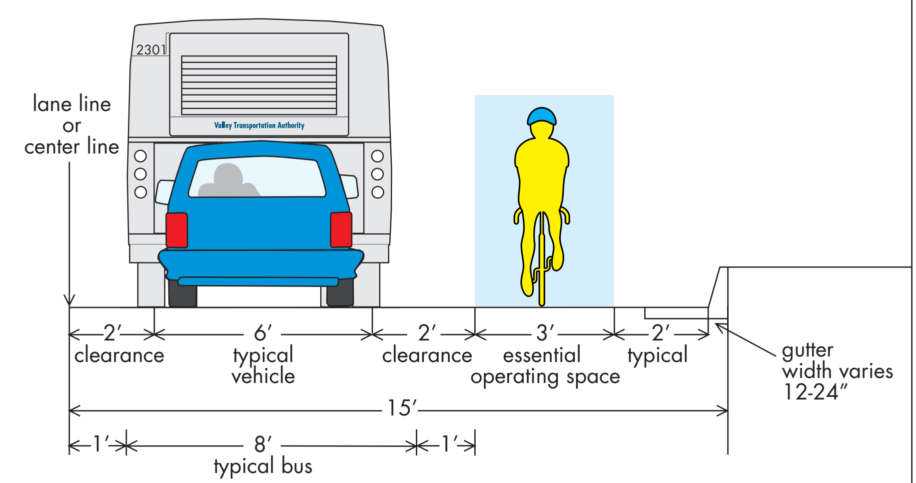


Figure 7-17:
Bicycle Operating Space in Typical Travel Lane

7.3 SHARED ROADWAY BICYCLE MARKING (SHARROW)

The “Sharrow” is used to inform both motorists and bicyclists of the safe positioning of the bicycle on a roadway without bike lanes or shoulders. It is intended to reduce the chance of drivers opening doors of parked vehicles in the path of bicyclists and to alert road users within a narrow traveled way of the lateral location where bicyclists ride. They have been shown to reduce wrong-way riding and sidewalk riding, which are associated with increased risk of collisions.

A typical layout is depicted in Figure 7-18.

NOTE

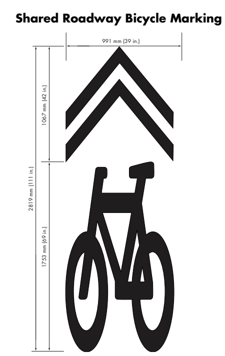
Sharrows are intended for use on existing roadways where bike lanes cannot fit. Bike lanes are strongly preferred over sharrows, and new or widened arterials are to be designed with bike lanes as discussed in Chapter 3.1 and Chapter 7.1.

7.3.1 Roadway Characteristics

Caltrans MUTCD 9C.07 (CA)

Standard:

Shared Lane Markings shall not be used on shoulders or in designated bicycle lanes.



MUTCD Figure 9C-07

Guidance:

Except as provided in Paragraph 02a, (See option below) the Shared Lane Marking should not be placed on roadways that have a speed limit above 35 mph.

Option:

The Shared Lane Marking may be placed on roadways that have a speed limit above 35 mph, where there is bicycle travel and there is no marked bicycle lane or shared-use path and the right-hand traffic lane is too narrow to allow automobiles to safely pass bicyclists.

VTA Best Practice

In addition to the above, VTA recommends that the roadway:

- Be a designated bike route
- Have an ADT > 4,000 for a two-lane road or
- ADT > 12,000 for a four-lane road

For roadways with no on-street parking, VTA recommends that the outside lane be 14 feet (4.2 m) or less.

D11-1

Sharrow pavement marking without parking on San Antonio Road.

7.3.2 Placement

Caltrans Standard

- Lateral placement: centerline of symbol should be 11 ft min. (3.3 m) from edge of curb where there is on-street parking.
- Longitudinal placement: immediately after an intersection and spaced at intervals not greater than 250 feet (75 m).
- Where there is no onstreet parking, the center line of the symbol should be at least four feet from the face of curb, or edge of pavement when there is no curb.

VTA Best Practice

VTA recommends that the lateral placement be 12 feet (3.6 m) based on the findings of a City of San Francisco study.

The lateral distance may be increased as needed for roadway and traffic conditions.

For roadways with no parking, centerline of symbol should be 3.0 ft min. (0.9 m), from gutter seam.

7.3.3 Signage

VTA Best Practice

Urban-Install Bike Route D11-1 or other guide sign; see Chapter 8.

Caltrans Option

Rural-the Share the Road Sign installation (W16-1P & W11-1) may be used to supplement the Shared Roadway Bicycle Marking. Share the Road signs should be installed after every major intersection and at one-half mile intervals.

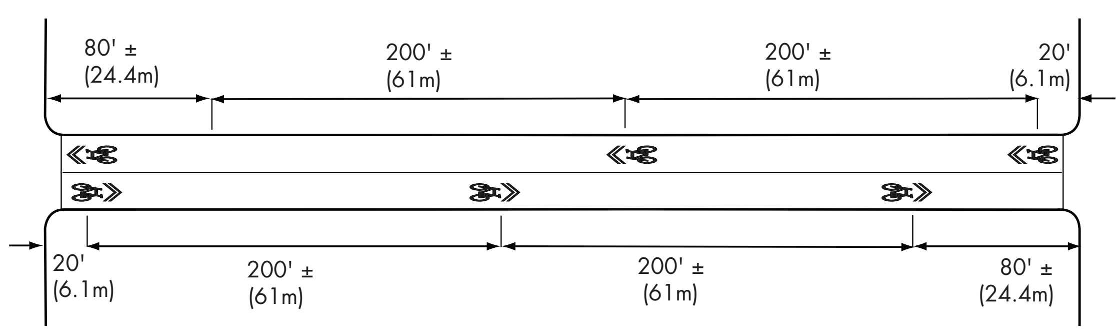


Figure 7-18:
Typical Sharrow Pavement Marking Installation

7.4 RURAL ROADS AND STATE HIGHWAYS

In rural and semi-rural areas where roads have (and are likely to continue to have) low traffic volumes, narrow travel lanes, narrow (or no) shoulders, no sidewalks, and typically drainage ditches rather than curb, gutters and even storm drains, bicycle and pedestrian accommodation can be challenging. Although the numbers of bicycles and pedestrians may appear insignificant, studies have shown that many more individuals will choose to walk and bike if they perceive that there are safe options.

In Santa Clara County, typical locations that have roadways with semi-rural characteristics are Los Altos Hills, parts of Los Gatos, Saratoga and Palo Alto, and some county roads. In these areas, there is existing and latent demand for walking and bicycling by adults as well as children to such destinations as schools, parks, neighbors' houses, and local businesses.

Many county roads are also in truly rural areas with agricultural, pastural or natural frontage. Typical origins and destinations are few and far between, thus pedestrian activity is extremely low. However, there is existing and latent bicycling demand to travel along these public roads by both residents and visitors (including tourists).

Finally, although traffic volumes may not be low, sections of some state highways (that are not freeways) outside of urban areas also have these cross sectional elements such as State Route 9 (Congress Springs Road), State Route 35 (Skyline Blvd.), State Route 152 (Hecker Pass and Pacheco Pass Highways) and State Route 130 (Mount Hamilton Road). Bicyclists and pedestrians must be accommodated on these roads as well.

AASHTO and others recognize that low volume roads (<2000 vpd) do not need as wide shoulders as roads with higher traffic. Table 7-1 depicts the recommended minimum shoulder widths for rural roads under three volume conditions. VTA Best Practice to accommodate bicyclists for various roadway conditions is presented on the following pages.

Table 7-1
Minimum Lane and Shoulder Widths for Two Lane Rural Highways Recommended by AASHTO

		<10 % trucks AASHTO/1/			AASHTO Greenbook Table 7-3 Rural Arterials /2/ /3/	
Vehicles per Day (vpd)	**Running Speed /1/ Design Speed /2/**	Lane Width (normal terrain)	Shoulder Width (normal terrain)	Shoulder Width (mountainous terrain)	Travel Lane Width	Shoulder Width
<750	Under 50 mph	9 ft.	2 ft.	1 ft.	11 ft. (12 for speed of 60+)	4 ft.
	50+ mph	10 ft.	2 ft.	1 ft.	11 ft. (12 for speed of 60+)	4 ft.
750-2000	Under 50 mph	10 ft.	2 ft.	1 ft.	11 ft.	6 ft.
	50+ mph	11 ft.	3 ft.	2 ft.	11 ft. (up to 1500 vpd)	6 ft.
2000+	All	11 ft.	6 ft.	5 ft.	12 ft. (over 1500 vpd)	8 ft.

/1/ AASHTO Highway Safety Design and Operations Guide, Table 4-1, 1997

/2/ AASHTO Policy on Geometric Design of Highways and Streets,2011, Table 7-3.

/3/ No variations were presented for different terrains or percent trucks other than to state in Chapter 4 that 2 ft min shoulder should be considered for low volume highways, and 4 ft shoulders should be considered where bicycles and pedestrians are to be accommodated on the shoulder.

NOTES

FHWA Safety Program brochure states that "a walkway is defined as a continuous way designated for pedestrians and separated from motor vehicle traffic by a space or barrier. A shoulder provides a gravel or paved highway area for pedestrians to walk next to the roadway particularly in rural areas where sidewalk and pathway s are not feasible. "

Source: US DOT, FHWA, An Analysis of Factors Contributing to "Walking Along Roadway" Crashes; FHWA-RD-01-101, (Washington DC, 2001

7.4.1 Shoulders vs. Roadside Paths

The two main ways of accommodating pedestrians and bicycles in a rural or semi-rual context are on the shoulders or on a pathway separated from the road. In some contexts, both may be appropriate. The chosen solution should be determined in conjunction with the local community, and should be based on a number of factors including:

- Environmental: terrain, adjacent vegetation, location of mature trees and riparian areas;
- Man-made: land use frontage and density, the proximity and location of elementary, middle and high schools, width of the right of way, ease of acquiring additional right of way; and
- Demographic: the number of school-age pedestrians and bicyclists, the existing and potential number of bicyclists and pedestrians and existing and projected motor vehicle traffic volumes and speeds.

In addition, if night time use by pedestrians is anticipated, every attempt should be made to provide a wide shoulder or separate walkway, as the fatality rates for pedestrians walking on rural roadways is disproportionately high and shoulders can reduce this crash type by between 71% and 88%.

Shoulders are discussed below in the remainder of Section 7.4 and roadside paths are discussed in Section 9.5.

7.4.2 Shoulders vs. Bike Lanes on Rural Roads

In general, in rural areas with low traffic volumes, wide (four to eight foot) shoulders are not necessary and may also be infeasible for economic topographic and environmental reasons. Where volumes, speeds and topography allow, then wider shoulders are preferable. Guidance for rural shoulder widths is given in Section 7.4.3.

Where shoulders are wide enough to meet bike lane width standards, it is often appropriate and preferable that they remain undesignated, i.e. not be signed and striped as Bike Lanes, as long as they are paved and maintained. An example is on County Expressways where the intersections are widely spaced and on state highways outside of urban areas when there is no fronting land use development.

Given that there are legal differences and practical differences between shoulders and bike lanes, the engineer must consider all factors before deciding to implement one versus the other. These issues are listed below and discussed in more detail in Section 7.4.4 “Design Considerations for Rural Roads”.

Uvas Creek Road with widened shoulders

Legal positioning of bicycles in bike lanes vs. shoulders

- Bicyclists riding at less than the speed of traffic must use the bike lane
- Bicyclists (and other slow moving vehicles) may use the shoulder but are not required to do so. Bicyclists may also use the shoulder even when they are not traveling slowly.
- Bicyclists on shoulders must be operated in the same direction as vehicles.

Legal positioning of motor vehicle with respect to the shoulder stripe/ bike lane stripe

- Motorists may not drive in the shoulder unless they are “traveling so slowly as to impede the normal movement of traffic”.
- Motor vehicles in a shared through/right turn lane must enter the bike lane in order to make a right-turn (CVC §21717). However, motor vehicles are not allowed to enter a shoulder to turn right.

Parking

Parking is allowed in shoulders unless specifically prohibited by signing. If parking is common, then a shoulder does not provide a good bike facility.

Striping at intersections and right-turn lanes

- The shoulder striping at the approach to intersections follows the curb return around the corner or serves as the curb return. Bike lane striping is either dashed or terminated completely 100 - 200 feet in advance of the intersection.
- Shoulders remain on the right side of right turn lanes; whereas bike lanes are placed to the left of right-turn lanes.

Pedestrians and Joggers

- Pedestrians are allowed to use the shoulder.
- Pedestrians are only allowed to use a bike lane when there is no adjacent pedestrian facility (CVC§21066). This is likely to be the case in the locations where shoulders are preferable to bike lanes.

LOCAL PRACTICE

The County of Santa Clara’s Bicycle Accommodation Guidelines for County Expressways is presented separately in Chapter 11 of this manual.

PERTINENT CVC SECTION

Pursuant to CVC §21208(a), bicyclists operating “at a speed less than the normal speed of traffic. “shall ride within the bicycle lane “ except when “passing another bicycle, vehicle or pedestrian in the lane”, when preparing for a left-turn, or “when reasonably necessary ...to avoid debris or other hazardous conditions”.

PERTINENT STATE LAW

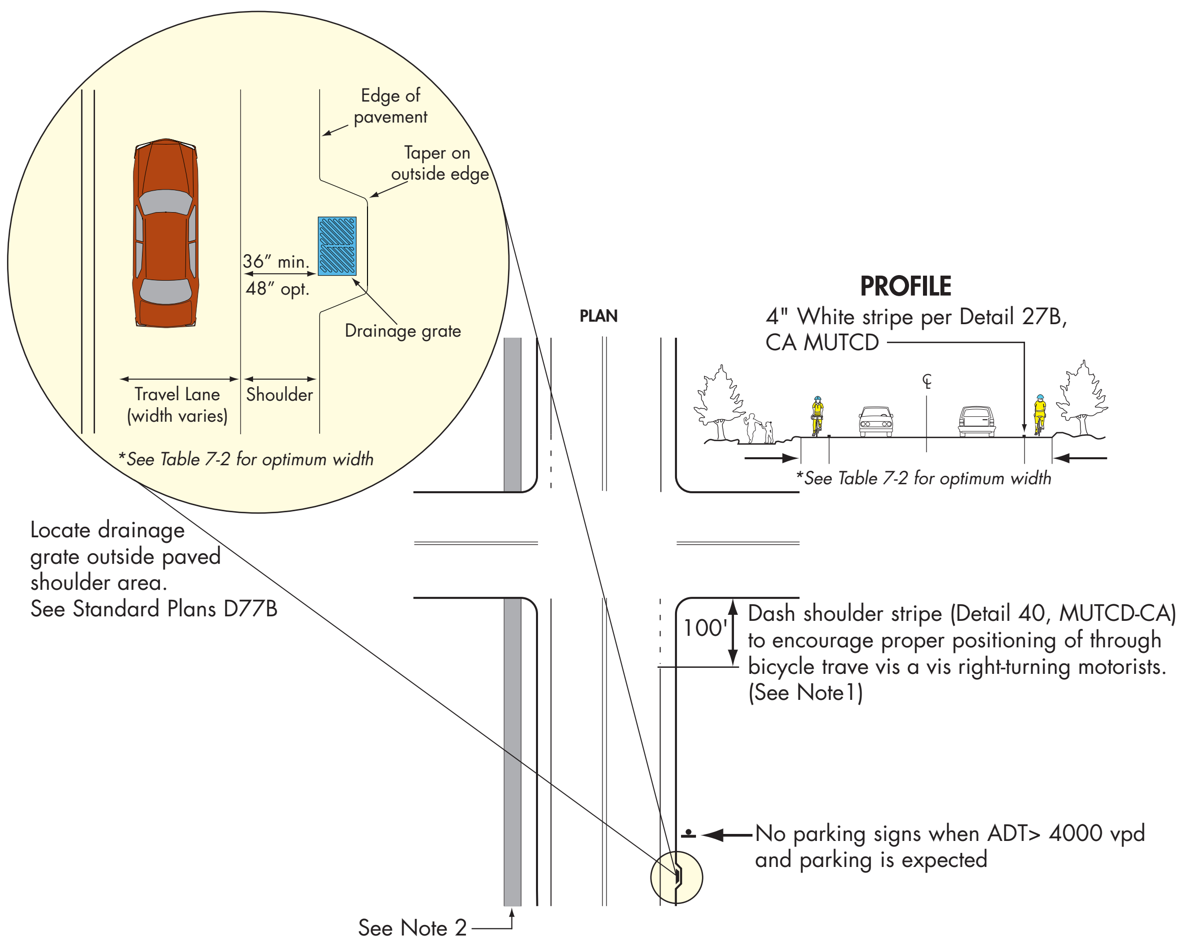
CVC§21754(e) .. a slow moving vehicle “shall be driven in the right hand lane of traffic or as close as practicable to the right-hand edge or curb” of the roadway. CVC§21650(f) a vehicle may utilize the shoulder when “traveling so slowly as to impede the normal movement of traffic”.

Table 7-2 Optimum Shoulder Widths	
Posted Speed (mph)	**Width (feet)**
0 - 30	4
35 - 40	6
45 or more	8

7.4.3 Rural Road Shoulders and Cross Sections

The shoulder width should increase with the posted speed, similar to bike lane widths. As presented in Table 7-2, optimally, the minimum shoulder width is 4 feet and is 6 feet for speeds between 35 and 40 mph, and 8 feet for speeds greater than or equal to 45 mph. Rumble strips must only be placed on shoulders five feet or wider as discussed in Section 7.4.5.

A typical application of a wide shoulder on a rural road and other pertinent design elements is illustrated in Figure 7-19. In constrained right-of-way, 4-foot shoulders may not be feasible as discussed on the next page.



Notes

1. For roadways with posted speeds of 45 mph or more, terminate solid shoulder stripe 200 feet in advance of intersection. See also Chapter 11.
2. When there is a localized increase in the number of pedestrians, provide a pathway so pedestrians do not walk on Shoulder. See also Section 9.5
3 For roadways with less than 2000 vpd, see Table 7-1.

Figure 7-19:
Wide Shoulders - Bicycle-Friendly Details

Rural Roads in Constrained Right of Way

In extremely constrained locations due to topography or environmental limitations, existing roadways may have less than twenty feet of pavement, and it may not be feasible to add even a 2-foot shoulder. Also, on extremely low volume roads, vehicles and bicyclists can share a road with narrow or no shoulders. For low volume highways, (under 2,000 vpd) the guidelines set forth in Table 4-1 on pp. 54 of AASHTO's Highway Safety Design and Operations Guide, 1997, reproduced in Table 7-1 on page 7-21.

Figure 7-20 illustrates a typical existing condition for a rural road in Santa Clara County, and the typical widening for a shoulder, where feasible.

TECH NOTE

On roads with more than 3000 vpd, bicycle turnouts, (essentially shoulders > 4.0 feet wide) should be provided approximately every 0.5 mile where feasible feet so that following traffic can safely pass the more slowly moving bicyclists.

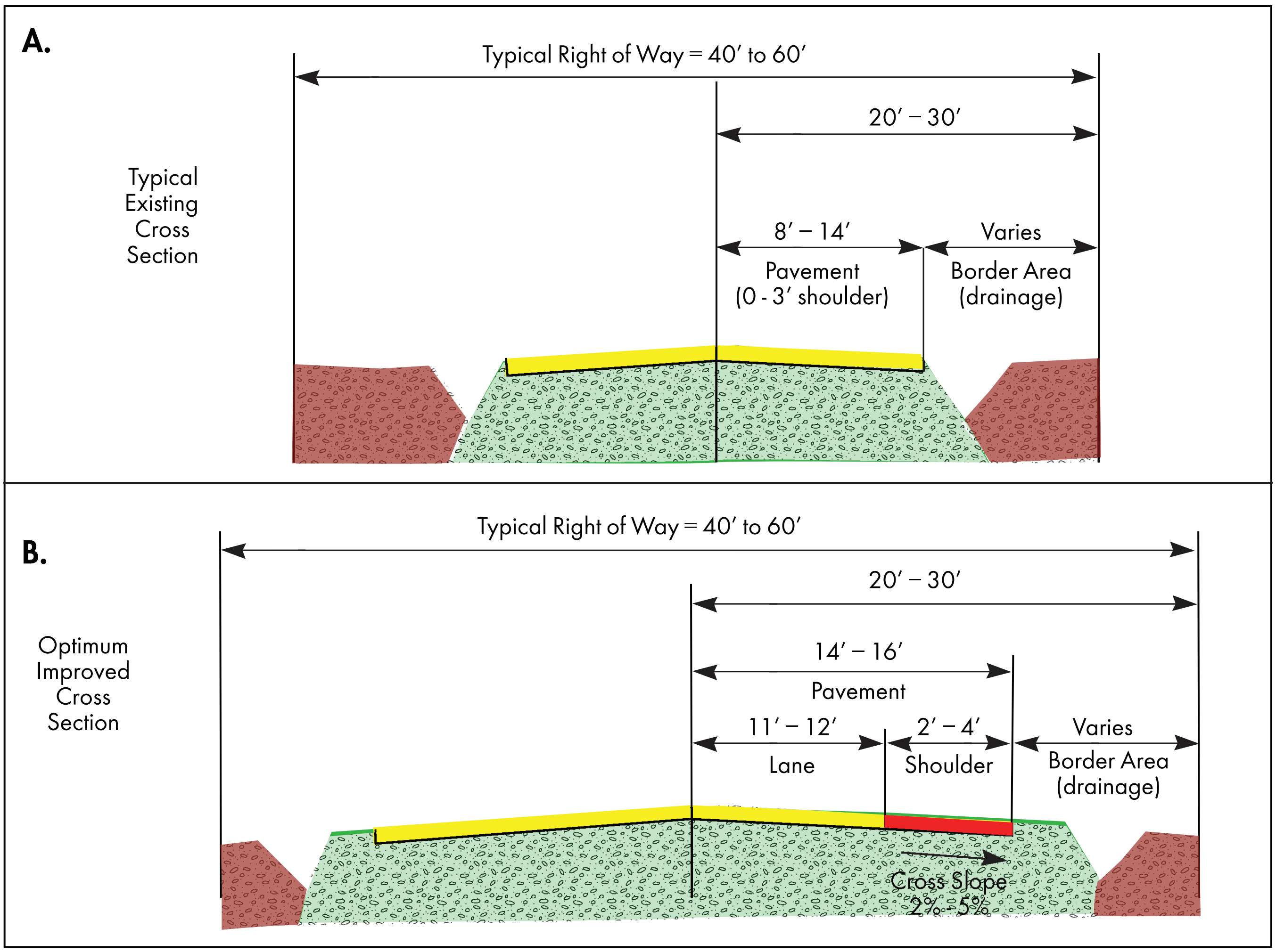


Figure 7-20:
Rural Road Cross Section on Constrained Right of Way

Roadside Bike Path in Holland

Rural Roads in Expanded Right of Way

Where right of way and topography permit, consideration should be given to providing both well designed shoulders for road cyclists and a wide roadside path for others. The roadside path will serve pedestrians and those cyclists who are not comfortable riding on the shoulder, even on roads with low traffic volumes. The wide shoulder will be used by road cyclists and it will also provide all the other benefits of shoulders outlined in the AASHTO Greenbook. This cross section is most appropriate where there is a latent demand for bike travel due to the origin(s) and destination(s) along the corridor that would attract more than just the "through" cyclists. By definition, rural roads do not have fronting land uses but there may be a trip attractor 10 or 20 miles down the rural road whose patrons would choose to bicycle if there were a bikeway that suited their needs. Such attractors in rural areas could include, but are not limited to, wineries, music venues or amphitheatres, lakes and reservoirs, public parks and recreation areas. Such roadside paths are common in The Netherlands where, fortunately for them, topography is not an issue.

Figure 7-21 depicts a typical cross-section for a rural road with a separate bike path. Key issues to address at the design stage are: sight distance to the roadway, intersections, and maintenance. For details regarding the design of a bike path, see Chapter 9.

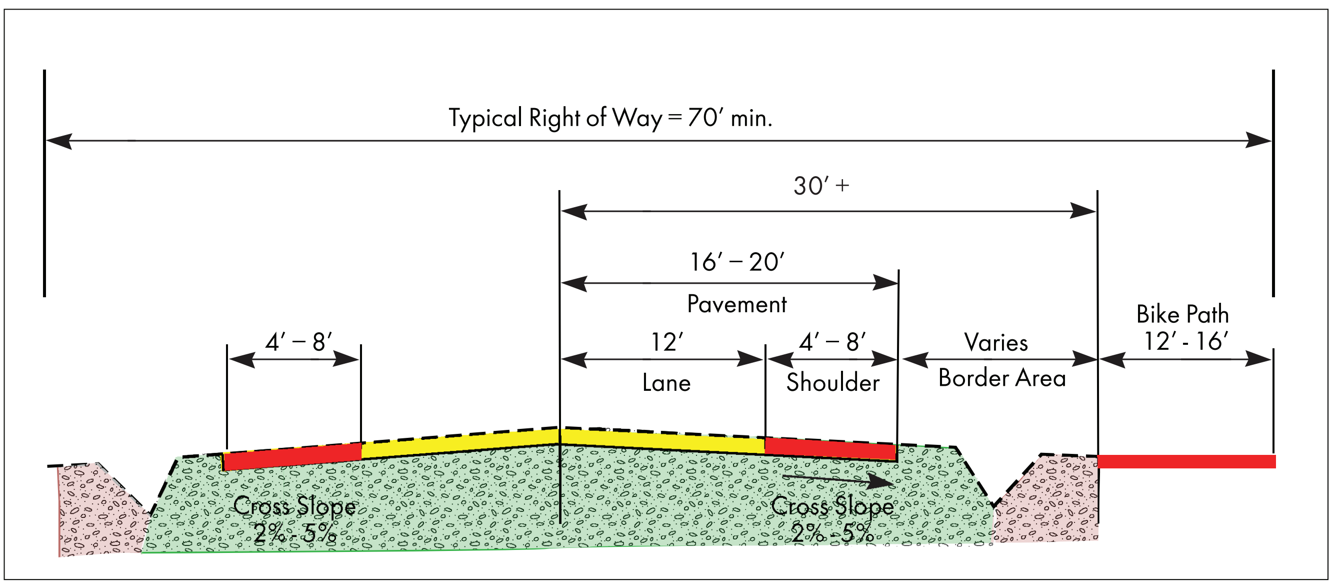


Figure 7-21:
Rural Road with Shoulder and Bike Path

W11-1/W16-1p SHARE THE ROAD Plaque

W11-1

W16-1P

Caltrans Standard

Option: In situations where there is a need to warn motorists to watch for bicyclists traveling along the highway, the SHARE THE ROAD (W16-1P) plaque may be used in conjunction with the W11-1 sign.

Guidance:

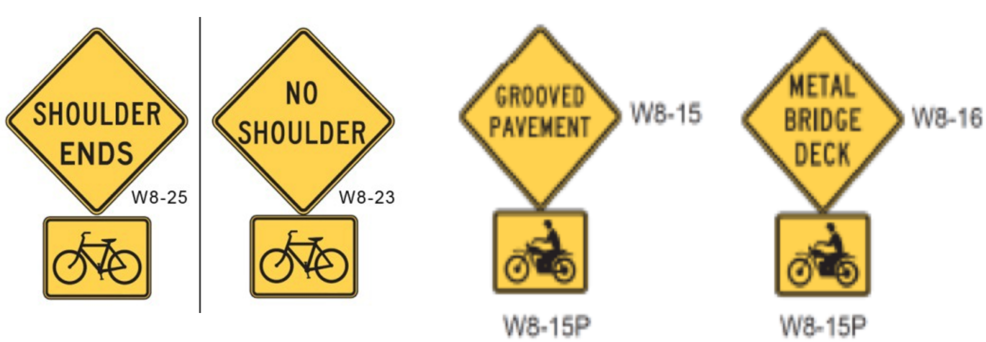
If used, other advance bicycle warning signs should be installed at least 50 feet in advance of the beginning of the condition.

VTA Best Practice

Consider the Share the Road sign in rural areas, where the following conditions exist (See R4-11, Chapter 3.1, for urban areas)

- On rural roads, where bicyclists are more frequent than land use would indicate and the shoulder is less than 4 feet wide; post approximately every 1 mile.
- Where the shoulder is four or more feet wide but is unridable for a bicyclist, e.g. the shoulder is unpaved or the pavement is cracked or uneven. (CVC allows cyclists to use the shoulder but does not require them to use it).
- Where the shoulder varies such that at times cyclists can ride within the shoulder and at other times the shoulder is less than 4 feet and bicyclists must ride in the travel portion of the roadway, (e.g. State Route 9) post the share the road sign at the point where the shoulder narrows.

In advance of the shoulder narrowing, consider posting the W8-25 Shoulder Ends sign with a bicycle plaque to warn bicyclists of the upcoming condition; this is similar to warning signs W8-15 and W8-16 and plaque warning motorcyclists of conditions that are of particular concern to their vehicle.



NOTES

The W16-1p Share the Road plaque was added to the MUTCD via amendment in January 9, 1997. The Federal Register reveals that it was in response to both: (1) requests from communities in Virginia and California for a new golf cart symbol and a new word message sign to convey the "share the road" concept; and (2) requests for a word message sign to be used with the farm machinery symbol, the bicycle symbol, and other symbols to warn drivers to share the road with other modes of transportation. The FHWA conducted research on the ''Share the Road with Farm Equipment'' combination; it was understood by 92% of those surveyed.

Wide shoulders as in the top photo provide room for cyclists as well as disable motorists; the soft shoulder in the lower photo is adequate for pedestrians in good weather, but is not suitable for cyclists to ride in.

7.4.4 Design Considerations for Rural Roads

Issues that should be addressed to accommodate bicyclists on rural roads include the following: (see also Section 7.4.3 for a discussion of shoulder width and Section 7.4.5 for Shoulder Rumble Strips and Figure 7-20 for a typical wide shoulder application).

Parking

When a designated bike route has shoulders, No Parking signs should be installed if traffic volumes exceed 4000 vpd and parking in the shoulder would otherwise be expected.

Pedestrians

If there is a reasonable expectation that there will be pedestrian activity, an all-weather pedestrian pathway should be provided so that bicyclists and pedestrians do not share the shoulder.

Shoulder Cross Slope

The cross slope for a paved highway right shoulder in normal tangent sections, is between 2% and 5 % away from the traveled way per HDM §302.2; AASHTO cites 2- 6%. In contrast, the standard cross slope for a bike lane is 1.5 to 3%, (2% for new construction) since it is part of the travel way) see HDM §301. According to the FHWA, there was a concern that the minimal cross slope (i.e. 2% vs 6%) could impede water flow across the shoulder allowing sediment to accumulate, but evaluation of paved shoulders over time has alleviated these concerns. [1] In addition, the maximum cross slope of an ADA facility is 2%, [2] , so by meeting the cross slope standard for a travel lane in new construction, the shoulder becomes an ADA-compliant facility.

Intersections

On roads with significant bicycle traffic, the shoulder stripe should be dropped in 100 feet in advance of the intersection, just as a bike lane stripe is. This is illustrated in Chapter 11.

Right-Turn Lanes

While right-turn lanes are not common in the settings where shoulders are used, there may be instances where a roadway with a shoulder also has a dedicated right-turn only lane. In these cases, the shoulder stripe should terminate in advance of the right-turn lane so that bicyclists are not tempted to proceed straight through the intersection from the shoulder area. They should merge left into the through lane, according to the rules of the road. Providing a bike lane-type treatment between the through lane and the right-turn lane is recommended. This is illustrated in Chapter 11.

Left-Turn Lanes

Where left-turn lanes are provided at intersections or driveways by narrowing the roadway shoulders, the shoulder width should not be reduced to less than 48 inches.

[1] *FHWA "Shoulder and Bikeway Best Practice Policy". FHWA-SA-11-018*

[2] *U.S. Access Board, "Public Rights of Way"; http://www.access-board.gov/prowac*

Longitudinal Joints
The joint between the shoulder and the travel lane should be smooth. Refer to Figure 4-1 of this manual for how to conduct a wedge cut prior to the overlay or shoulder widening.


This drainage grate located off of the shoulder will not force cyclists into the travel lane in order to avoid it.

Drainage Grates
Grates should be placed outside the paved shoulder area. Bicyclists should not be expected to ride over drainage grates. If the grate encroaches on the shoulder, the grate must be bicycle proof per HDM § 837 and there must be a minimum of 36 inches of clear asphalt, optimally 48 inches, as depicted in Figure 7-20. See also: Chapter 3.2.

Asphalt Berms
When asphalt berms are constructed on roadway shoulders to divert storm water into catch basins, they should be constructed in a manner that would not obstruct bicyclists from using the shoulder or transitioning between the shoulder and the travel lane.

Driveway Aprons
Unpaved driveways should be paved for the first 15 feet from the roadway to minimize dirt and gravel migration onto the shoulder.


Centerline rumble strip on Highway 9 in Saratoga, where there is a wide shoulder.

Bus Stops
Bus stops and particularly bus layover points should be designed to minimally impact other roadway and shoulder users. Ideally, especially on high speed roads, the shoulder width is increased to 12 feet so that a cyclist can pass the bus on the left and remain within the shoulder. Also, the structural pavement section is stronger than a typical shoulder. See VTA CDT Manual Appendix A, pages A-5 to A-7 and Figures A-10 and A-15 for VTA Standards for bus duckouts and pavement sections.

Centerline Rumble Strips
Centerline rumble strips are used as a countermeasure for head-on collisions on rural undivided roads. However when used on roads with narrow or no shoulders, many motorists refrain from crossing the centerline, even when safe to do so, to pass a bicyclist. This results in many motorists passing bicyclists at very close range. Best practice is to only place centerline rumble strips where there are wide shoulders, so that there is no temptation to pass cyclists with less than the recommended three feet of clearance. For problem areas with narrow or no, shoulders, first provide wide shoulders to see if that ameliorates the problem. Centerline rumble strips should be a last resort.

TECH TIP

Shoulder rumble strips are 5/16" +/- 1/16" indentations that extend along the highway shoulder. The maximum width of shoulder rumble strips is 300 mm (12 in).

Source: Caltrans Standard Plans A40.

7.4.5 Shoulder Rumble Strips

On shoulders, rumble strips are typically depressed grooves rather than raised pavement markers. Such rumble strips are typically needed only on highways with few interchanges and long tangents to reduce drift-off-road accidents. If a location is experiencing such accidents and rumble strips are being considered, shoulder rumble strips are an appropriate counter measure. However, they must be designed and installed so that they do not adversely impact bicyclists using the shoulder.

VTA Best Practice:

Where bicycles are permitted, shoulder rumble strips should not be used unless approximately 1.5 m (5 ft) of clear shoulder width for bicycle use is available between the rumble strips and the outer edge of the shoulder.

Caltrans:

Standard ground-in rumble strip treatments that are greater than 8.5 mm (0.33 in) +/- 1.5 mm (0.06 in) depth shall not be installed on shoulders where bicyclists are allowed.

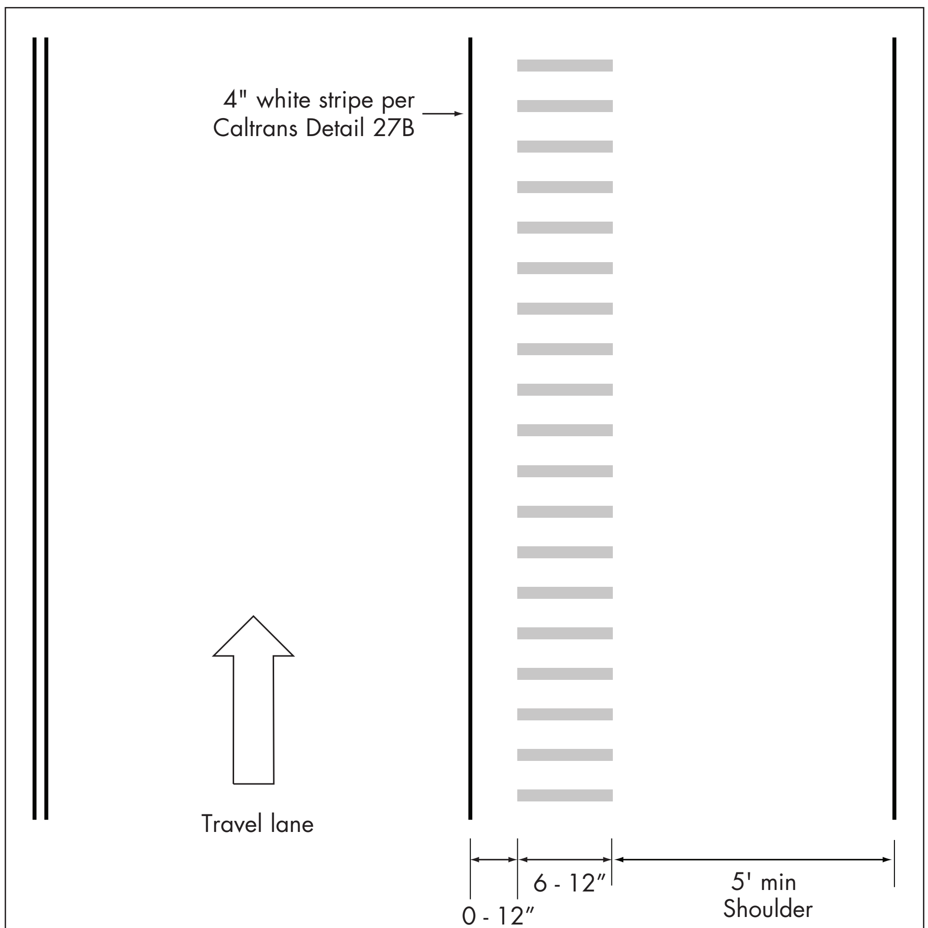


Figure 7-22:
Shoulder Rumble Strip Details

7.5 CYCLE TRACKS

Cycle tracks are a relatively new to the United States, but have been used in some countries for decades. They are a distinctly urban approach to accommodating bicyclists in a dense setting that also must accommodate large numbers of pedestrians and various types of motorized vehicles. Not coincidentally, cycle tracks first appeared in the United States in our most dense urban place, Manhattan.

New York's One-way Cycle Track on a One-Way Street.

7.5.1 Not a Side Path

The first point to be made about cycle tracks is to distinguish them from the type of bike path known as a "side path". While a side path is also built within the roadway right of way or immediately adjacent to it, it is distinct from a cycle track in several ways as presented below in Table 7.3.

Table 7-3
Differences Between a Side Path and a Cycle Track

	Side Paths	Cycle Tracks
Setting	Urban, suburban & rural locations	Urban settings
Type of roadway	No consensus. Typically built wherever right of way was available, often abandoned rail rights of way.	Typically on major streets.
Directional	Two-way (unless two parallel paths are built, which is rare).	Can be one-way or two-way.
Shared use with pedestrians	Yes, shared use all the time (unless optional adjacent pedestrian path is provided, which is rare.)	No shared use, bicycles only.
Intersection control	Historically, not addressed very well.	Typically, bicycle signal heads provide a separate phase for bicycles and the conflicting vehicle turning traffic.

A cycle track is not a side path like this side path in Denver.

New York Cycle Tracks; Note Left-turn under Signal Control

TECH TIP

The MUTCD is for Traffic Control Devices whereas the HDM contains road and bikeway design standards and guidance.

The FHWA has stated that the following are not a traffic control device, so there is no MUTCD restriction on their use.

- Protected cycle tracks, both one-way and two-way bicycle facilities
- Raised cycle tracks, both one-way and two-way bicycle facilities

NOTE:

See also NACTO Urban Bikeway Design Guide at http://nacto.org/cities-for-cycling/design-guide/)

7.5.2 Conformance with CA MUTCD

The FHWA has determined that cycle tracks are not a traffic control device (TCD). therefore there is no MUTCD restriction on their use. That being said, it's up to each designer to select the signage and pavement markings deemed appropriate.

Table 7.4 presents the elements of cycle tracks that are road design issues versus those that are Traffic Control Devices (TCD).

Table 7.4 Cycle Track Elements

Elements of Cycle Tracks That Are Road Design	Elements of Cycle Tracks That Are TCD's
Pavement material	Color of pavement if used to control traffic or delineate travel
Raised medians if any separating cycle tracks from other road elements	Traffic signals, bicycle signal heads, and assigning right-of-way.
Elevation of cycle track with respect to roadway and sidewalk.	Signage
Location of cycle track with respect to sidewalks	Pavement markings
Location of cycle track with respect to on-street parking, if any.	

Road design standards are contained in the HDM in California for state highways, and local agencies typically adopt AASHTO Green Book for local streets. Due to California SHC §890-891, bikeway design for both local and state roads is covered by the HDM in California, and it currently does not address cycle tracks. However, the various elements that compose a cycle track listed in Table 7-4 are currently in California standards, including the bicycle signal head, which is a key component of the intersection design on a street with a cycle track. (See Chapter 6.3).

Also, since a cycle track can be considered a very specific type of side path, i.e. a side path with very specific design parameters, designers can choose to design a cycle track as a side path with an adjacent pedestrian path (the sidewalks) and meet HDM standards for such a facility. Like any other facility, where the standard cannot be met, the designer would document the reasons why.

7.5.3 Cycle Track Design

VTA Best Practice

Figure 7-23 presents a typical cycle track that meets the current HDM standards.

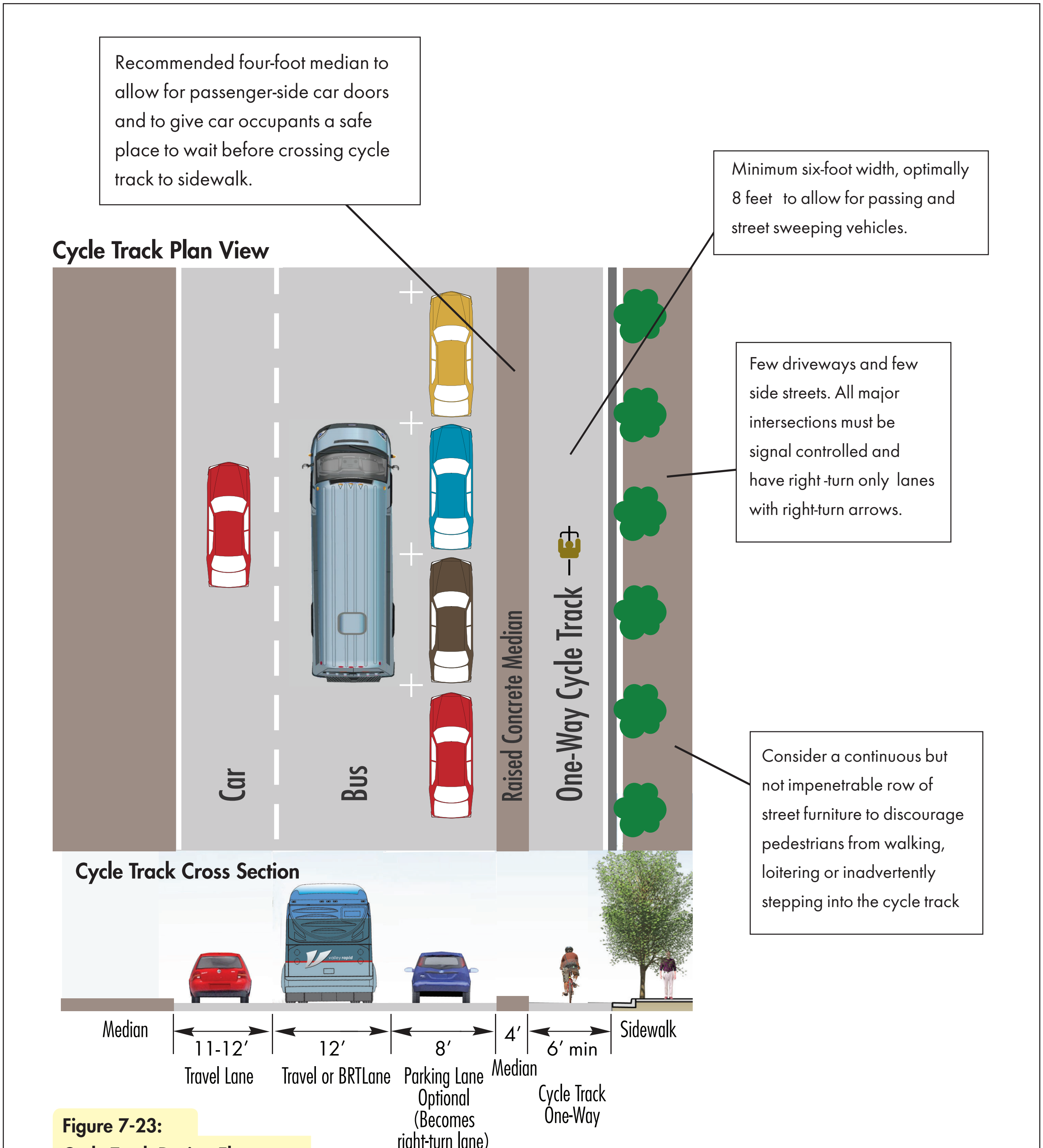


Figure 7-23:
Cycle Track Design Elements

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8 LOCAL ROADS AS BIKEWAYS

Residential roadways can make excellent bike routes particularly if they are designed and/or retrofitted for speeds of less than 25 mph. The street design should balance cyclists' needs for wider lanes with the trend for narrower cross-sections to discourage speeding. For traffic volumes less than 2,000 vpd, a roadway width of 30 feet maximum will reinforce slow speeds while bicyclists can comfortably share the full lane due to the low traffic volumes. Curb radii should be 15 feet maximum to discourage fast right turns.

Roadway and neighborhood design features should be incorporated that support bicycling and walking. These include pathways to neighborhood schools; connections between abutting cul-de-sacs, and other integrated well-lit short-cuts and pathways for non-motorized users to access adjacent neighborhoods, parks, retail areas, shopping centers, and commercial districts. I

This chapter presents guidance on accomplishing the above concepts. In addition to general guidance on planning and implementing bike routes, there is specific guidance on designing bicycle boulevards and bicycle-compatible traffic calming devices. Lastly, this chapter presents the Dutch concept of woonerfs, also known as shared spaces, a bike-friendly traffic calming street design that goes beyond spot devices and redesigns the entire roadway and sidewalk space building face to building face.

IN THIS CHAPTER:

I *See VTA's PTG Section 3.1A and Figure 3.4 for more guidance on curb rodii.*

Typical residential street in Mountain View.

8. 1 BIKE ROUTES AND SIGNED SHARED ROADWAYS

8.1.1 Terminology

The AASHTO Bike Guide discontinued the use of the term "Bike Route" in its 1999 revision. It now refers to this type of bikeway as a "Signed Shared Roadway" since all roadways are shared roadways but only some are signed as a designated bike route. Caltrans HDM uses the terms "Class 3" and "Bike Route". The BTG will use the term Signed Bike Route.

8.1.2 Features of a Signed Bike Route

Caltrans Standard

As discussed in HDM 1003.3(1), it is recommended that a signed bike route have some advantage for bicyclists over other streets that they might choose. A signed Bike Route should either:

- provide continuity in the overall bikeway network, or
- identify a route which is somehow preferable to immediately adjacent streets.

Examples of the latter include a road that is maintained to a higher standard, has wide curb lanes or wide shoulders, has traffic-calming and/or directly serves major destinations, is less circuitous, or provides direct access to a bike bridge.

1 An appropriate application would be a street that has all the design features described in Chapters 3, 4, 5 and 6 of this manual rather than a parallel arterial that has few of those features.

VTA Best Practice

If local/residential streets are signed bike routes, they should meet as many of the conditions below as possible:

- ADT < 2,000
- Standard street lighting
- Directional signing (see Section 8.1.3)

NOTE: With two additional design features, it is essentially a "bike boulevard" which is described more fully in Section 8.2. These design features are:

- STOP signs positioned to give right-of-way to travel on the bike route
- Aids to cross arterials (e.g. traffic signals, median refuge, in roadway lighted crosswalks)

See Section 3.5 for guidance on arterials and collectors as signed bike routes.

8.1.3 Guide Signs for Bike Routes

D11-1

Caltrans Standard

Signed Bike Routes are marked with the D11-1 sign or the SG 45 (CA) sign described below.

The following are options for alternative and additional signage for bike routes and destinations from MUTCD-CA. Optimally, destination signage for bicyclists would be included, particularly on trails where bicyclists do not have the use of motorist information signage.

VTA Best Practice

SG-45 (CA)

Numbered Bike Route Sign (SG-45 (CA) Numbering bike routes such as Bike Route sign SG-45 (CA) helps cyclists follow a signed bike route, particularly those that turn and jog onto other roads, bike bridges or paths. The SG-45 (CA) sign is designed so that local jurisdictions can insert a custom logo.

SG-45 (CA)

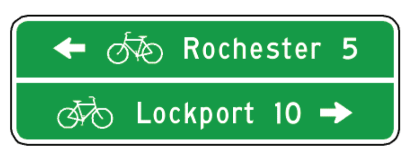
Numbered bike route signs should be used to identify the cross-county bicycle corridors. In certain applications, particularly trails, a name can be used instead of a number (e.g. the San Tomas Aquino trail through Santa Clara, Cupertino and Campbell). A distinctive logo for the County should be designed for the SG-45 (CA) sign. If a route is given a name or number by a Member Agency, it should be consistent with the countywide route numbering or naming system.

Destination signing (MUTCD D-1 series) should be used on trails, bike lanes and bike routes. Indicating the distances to these destinations is recommended where appropriate as both education and encouragement to cyclists and the general public.

D11-1C

Three options for bike guide signing are:

- Supplementary placard on the D11-1 or SG 45 sign (or R81(CA) bike lane sign) indicating the destination and distance;
- Inserting direction, destination, and/or route name in place of the "BIKE ROUTE" wording on the D11-1 sign
- Use of the guide sign series D1-2 in MUTCD



D1-2C

MUTCD guidance for the D1 sign series states:

Bike symbol: The bicycle symbol should be to the left of the destination legend and placed next to each destination or group of destinations.

Distance: The distance figures, if used, shall be placed to the right of the destination names.

Arrows: The directional arrows should be horizontal or vertical unless a sloping arrow will convey a clearer indication of the direction to be followed. If an arrow is at the extreme left, the bicycle symbol shall be placed to the right of the respective arrow.

8.2 BIKE BOULEVARDS

Bike Boulevard sign in use on Bryant Street in Palo Alto.

A bicycle boulevard is a typical residential street where bicycle traffic is given the right-of-way wherever feasible. Palo Alto created the County's (and the country's) first bike boulevard by removing unnecessary STOP signs along Bryant Street, which dramatically improved the travel time for bicyclists. To prevent automobile traffic from diverting to the bike boulevard, traffic calming measures can be installed to restrict or discourage motorized traffic. See Figure 8-1.

Residential streets meeting the following conditions are optimum locations for bicycle boulevards:

- Existing low vehicle volumes;
- Very little commercial frontage;
- Roadway is parallel to a major arterial or a high-traffic collector street (within approximately 0.25 mile);
- Not a transit or truck route;
- Roadway is reasonably continuous, i.e. it extends over at least two miles; it should have few jogs with main segments at least 0.5 miles long.

W4-4p

AT TWO-WAY STOP SIGN CONTROLLED INTERSECTION

Cross-Traffic Does Not Stop (W4-4p) -These signs may be used to supplement standard markings at intersections which have been converted from 4-way stop to 2-way stop, or when 2-way stop signs have been rotated as in the implementation of a bicycle boulevard. Generally, they are used for a limited time until the traffic is used to the change.

Typically, the following treatments are needed to fully create a full functioning bike boulevard:

1. Whenever possible, STOP signs are positioned so that the bike boulevard has the right of way.
2. Installing traffic control devices so that bicyclists on bike routes can easily cross major streets and arterials.
3. If necessary, installing traffic calming measures, such as traffic circles or semi-diverters, in selected locations to ensure that motor vehicles do not divert to the bicycle boulevard. See Figures 8.2 and 8.3.

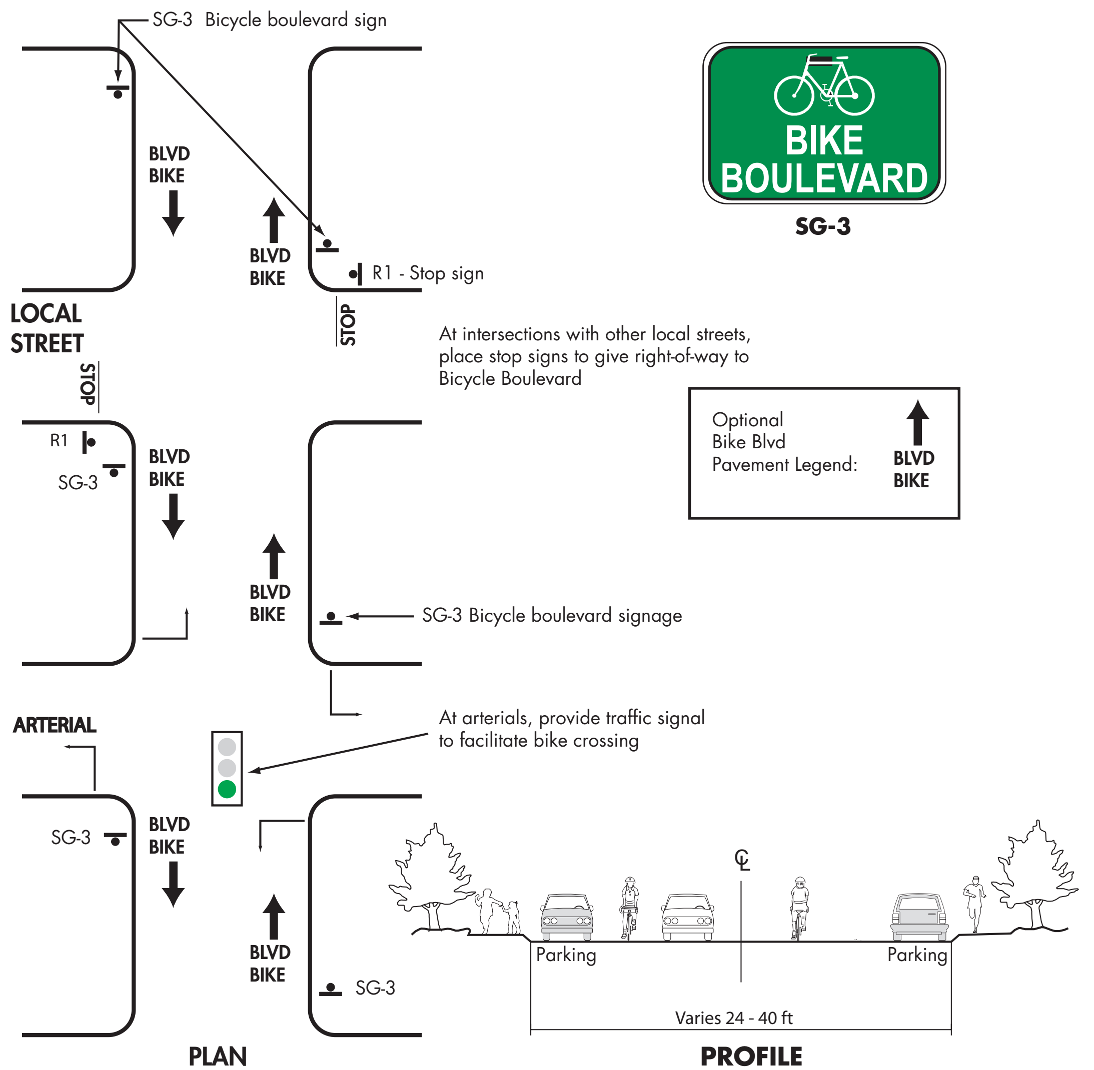
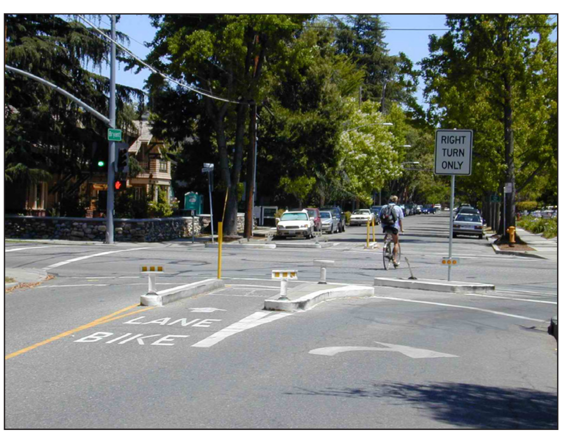


Figure 8-1:
Bicycle Boulevard Typical Treatment

Not to scale



Bryant Street at Embarcadero Road in Palo Alto, where bikes may proceed straight but motor vehicles must turn right.

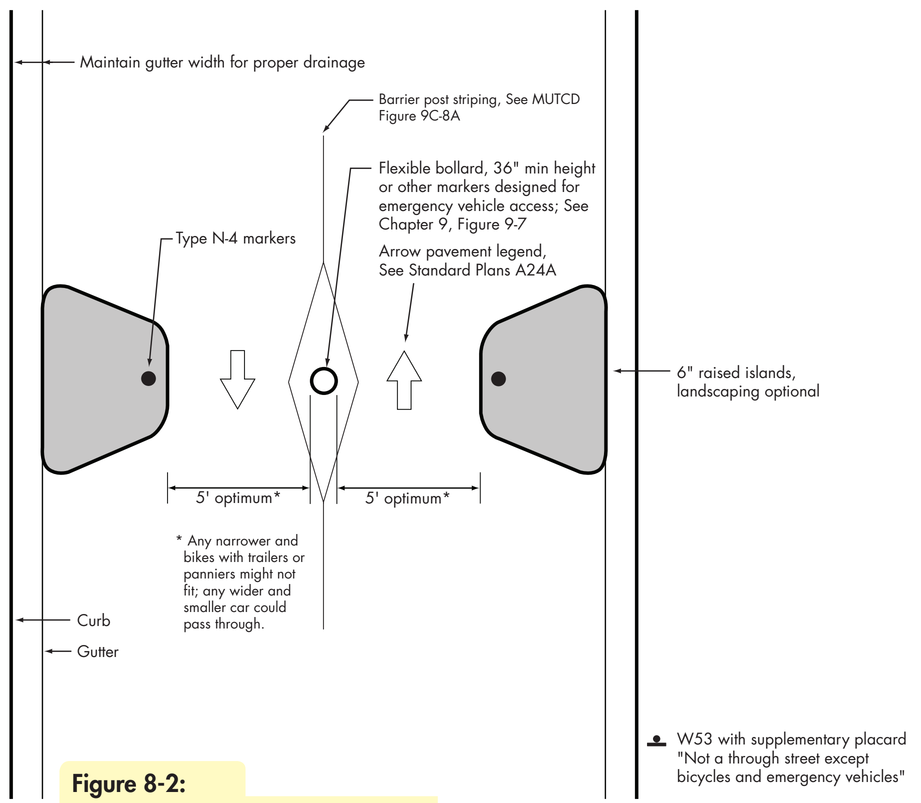


Figure 8-2:
Barrier Design: Bicycle Boulevard

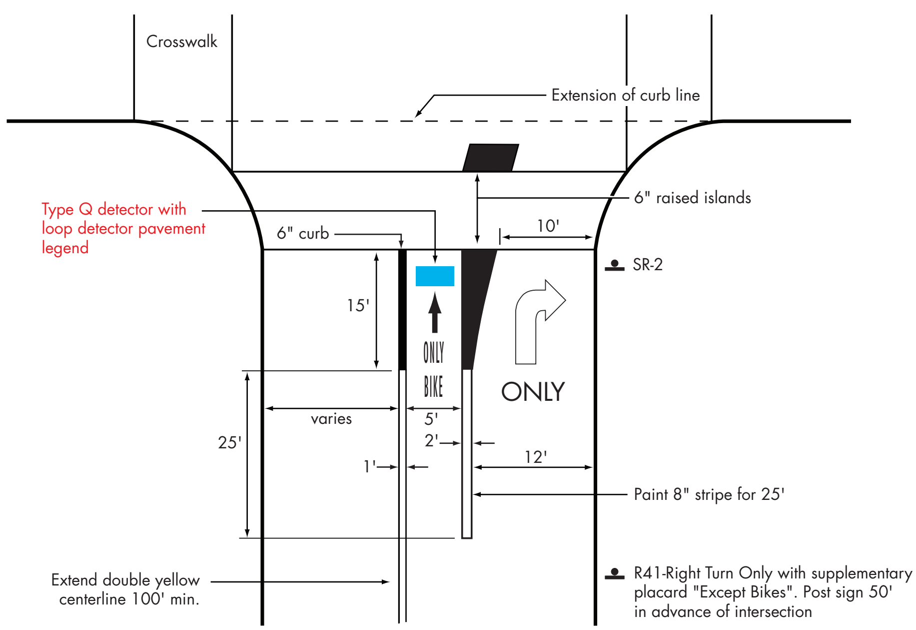


Figure 8-3:
Forced Right-Turn Channelization

8.3 BICYCLE-FRIENDLY TRAFFIC CALMING

Traffic Calming techniques provide many benefits for bicyclists, not the least of which is slowing traffic, which reduces the incidence and severity of injuries. However, the specific design of individual strategies can make the difference between being beneficial or innocuous to bicycles and being an obstruction or deterrent to bicycling. I

I *Also see "Traffic Calming in Practice" Institute of Transportation Engineers.*

8.3.1 Speed Humps

Sinusoidal speed humps (see Figure 8-4) have been shown to cause the least discomfort to bicyclists while still providing the traffic calming benefits to motorists. The design shown in Figure 8-4, from Toronto, Ontario, is designed to slow auto travel to 18 mpg. Molded rubber speed humps have shown promise in Portland, Oregon; they have advantages in that they can be quickly removed and relocated.

8.3.2 Speed Lumps

Speed lumps are like speed humps but with gaps for the wheels of emergency vehicle to travel through. The idea is that larger vehicles like fire trucks are able to straddle the humps and are not adversely impacted whereas passenger cars must still pass over the hump with at least one wheel. Bicyclists can also benefit by using the gap in the Lumps.

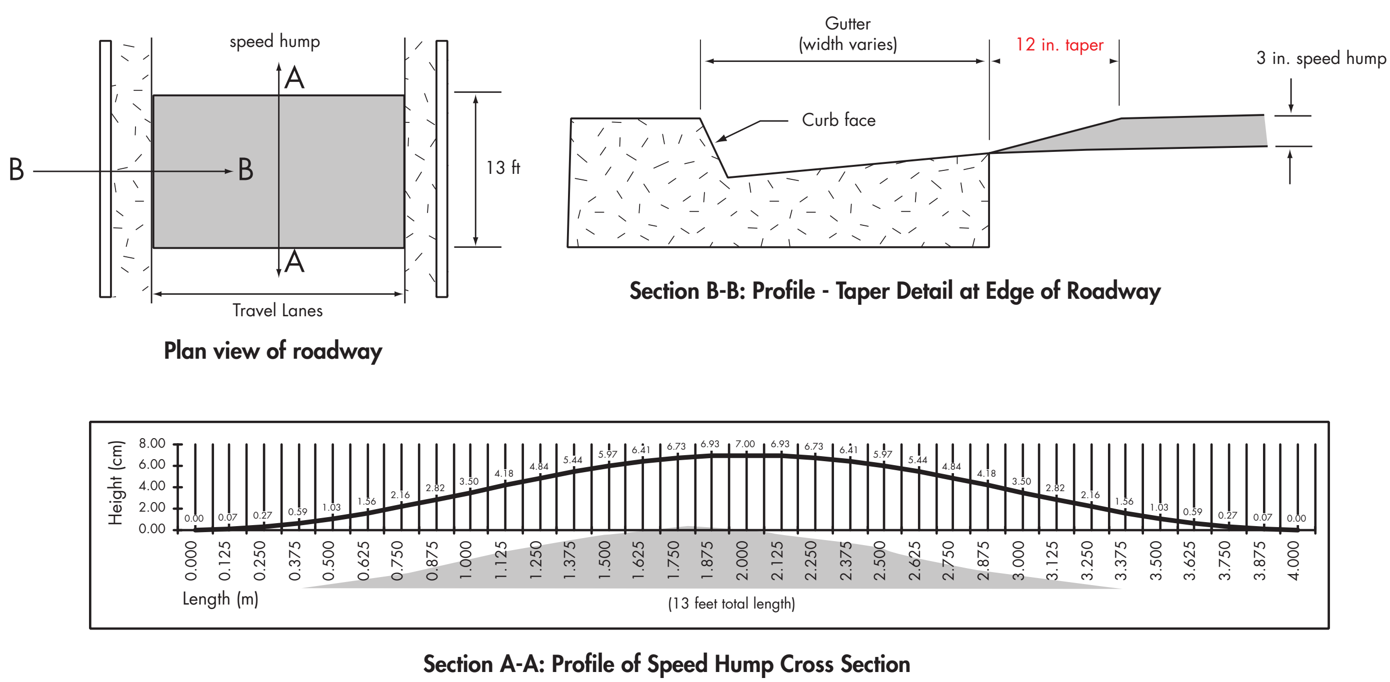


Figure 8-4: Sinusoidal Speed Hump

Not to scale

8.3.3 Medians

Center raised medians have been used to improve safety, aesthetics, and also to provide some measure of traffic calming. When designing roadways with medians, bike lanes should be included or the curb-to-curb width should be 15 feet to enable motorists to safely pass bicyclists. Fire Departments may also have their own minimum standards. Also, curb-cuts should be considered to facilitate bicycle crossings where there is no median break.

Residential traffic circles at two consecutive intersections provide better traffic calming effects.

8.3.4 Bulb-outs

On local or collector streets with speed limits of 25 mph, bulb-outs should be designed such that 14 feet of lane width remains, so that bicycles and cars can both safely pass through the narrowed opening.

For streets with higher speed limits, see Section 3.6 for bulb-outs on streets without bike lanes and Section 7.1.3 for bulb-outs on streets with bike lanes.

8.3.5 Traffic Circles

Traffic circles on bike routes should be implemented in consultation with the local Bicycle Advisory Committee. They should be designed such that motorists and cyclists enter single file; sharrows can help to encourage this behavior. At a standard four-way intersection, two approaches should be controlled by STOP signs with the right-of-way ideally given to the bike route. Four-way stop control is redundant and unnecessary. Alternatively, the traffic circle should be designed as a full Modern Roundabout (see below).

8.3.6 Roundabout

At intersections of neighborhood street with volumes at or approaching the need for 4-way stop sign control, consider use of a Roundabout instead. Modern Roundabouts have YIELD on entry control and deflection for entering vehicles. See Section 7.1.8 for roundabouts on a street with bike lanes.

TECH TIP

See also TECH TIP in Section 5.3.1 for the use of roundabouts at freeway ramp intersections and in Section 9.2.2 for use of roundabouts at the intersection of two bike paths.

8.3.7 Forced Right-Turns

Forced right-turns are one of the strategies that can be used on bicycle boulevards or other locations to discourage non-local motor vehicle traffic from using the roadway in question. (See Figure 8-3).

8.4 WOONERFS - A.K.A. SHARED STREETS

This section presents guidance for traffic calming residential streets modeled after the Dutch design known as a woonerf. A woonerf literally translated means "living yard" (as in "living room") and was introduced in the Netherlands in the 1970's. It is a residential street designed to be a safe setting for bicycles, pedestrians, residents meeting and talking and even children at play. The concept has spread throughout both Holland and Germany, and also to England where they are known as Home Zones. The concept is slowly gaining acceptance in the United States, with examples found in Boulder, CO and New Jersey.

According to the City of Munich guidelines, the underlying assumptions, are:

- There are no separate travel lanes or sidewalks.
- Pedestrians may use the entire street width.
- Children are permitted to play everywhere.
- Vehicle traffic speed is limited to a walking pace (four to seven kilometers per hour, i.e., 2.5 to 4.5 mph).
- Drivers may neither endanger nor hinder pedestrians; if necessary, drivers must wait.
- Pedestrians may not unnecessarily hinder car traffic.
- Parking is only permitted in designated areas.

The idea behind these elements is that while cars are permitted, they are "guests" who defer to other modes and activities. The mixed-used shared space is realized by the lack of curbs and sidewalks. The landscape and hardscape design is what reduces car speeds to about 4-5 mph. The entire ground surface between buildings has a variety of pavements and pavement design, street furniture, planters and strategically-placed parking, essentially creating a linear plaza. The woonerf concept is ideal for American-style cul-de-sacs, which have no through traffic and have extremely low traffic volumes. Woonerfs are potentially applicable to any residential street that does not need to accommodate "through" traffic, i.e. traffic that does not have an origin or destination in the neighborhood.

Commercial streets can also incorporate woonerf-type concepts and the Dutch even have a different word for a commercial street so designed, called a "winkelerf".

The following pages are intended to help agencies initiate the planning and design process of adding these to their circulation element and/or traffic calming toolbox.

NOTE

VTA's Pedestrian Technical Guidelines and Community Design and Transportation Manual both support woonerfs. See CDT Practice 4-6 and PTG Figure 6.1.2.

LOCAL PRACTICE

The City of Sunnyvale has redesigned San Andreas Court as a woonerf, in conjunction with the Mathilda Avenue/Caltrain overcrossing renovation to connect California Avenue to the pedestrian ramps.

Dutch and German sign to mark entry point of a woonerf.

Dutch and German sign to indicate the exit point of a woonerf.

30 kph (18 mph) zones in Munich are marked at all entry points with signs.

TECH TIP

Woonerfs, while immensely popular, are just one of the levels of traffic calming used in the Netherlands and Germany. Less restrictive measures are 30 km (18 mph) zones, and more restrictive measures are Pedestrian-only Streets (no vehicles). Munich and Berlin have another variation called a Spielstrasse, literally a "ie. game street", where all types of out-door recreation from tennis to soccer, for both children and adults, are permitted, and cars are prohibited.

Operational Issues to be Set by Vehicle Code and/or Ordinance

- *Speed limit.*
- *Pedestrians are allowed to be anywhere on the woonerf.*
- *Motor vehicles traffic may not hinder or endanger pedestrians.*
- *Parking permitted only where designated.*
- *Pedestrians may not unnecessarily hinder vehicle movement.*

Design Details to be Addressed by Ordinance or City Guidelines

- *Maximum straight road length (typically 150 feet).*
- *Maximum speed (typically 5 mph).*
- *Maximum traffic volume: 200 vehicles per hour during the peak hour.*
- *Minimum setback to the dwelling units.*
- *Accessibility to emergency vehicles.*
- *Minimum and maximum spacing of the woonerf design elements.*
- *Adequate parking for the residents; Disabled parking for residents placed close to dwelling unit, as needed.*
- *No curbs; alternatively provide lengthy breaks in the curbs; if there is a curb, both ends must be marked by a planter box, tree, etc.*
- *Signs at each entry and exit point.*
- *Maximum length or number of consecutive blocks that can be designed as woonerf.*
- *Space for landscaping, play areas and meeting areas.*

8.4.1 Residential Woonerf Types and Best Practices

This section describes the essential elements for residential streets designed as woonerfs either as new construction or retrofits. Since many residential settings in the United States and Santa Clara County have front yards, and are therefore different from the typical Europe-woonerf, eliminating curbs and sidewalks might not work in some contexts. Accordingly, this section presents guidance for three types of residential woonerfs, with suggested terms to differentiate them.

- 8.4.2 Cul-de-sac (OASIS)
- 8.4.3 Euro-style: building face to building face (MURMUR)
- 8.4.4 American-style-with front yards and driveways (LANE Yard)

Within each of the categories, the street is unique and the actual geometrics and design need to fit the physical constraints and neighborhood desires.

VTA Best Practice – Residential Woonerf

Essential elements of a woonerf are:

1. Modes are not separated; there are no travel lanes or sidewalks.
2. The entire width is inviting for children to play & residents to chat. Although there may be designated areas for these purposes, they are not restricted to these areas.
3. The landscape and hardscape design indicates that the entire area is for all users. Speed limit is enforced by design: traffic is naturally slowed by the presence of trees, planters, parallel and / or perpendicular parking, and other street furniture, as well as the look and feel of the pavement.
4. Black asphalt is discouraged; pavement type is varied by:
    - Material
    - Shape
    - Pattern
    - Color
    - Texture
5. Parking areas are sited and designed with the goal of reducing the line of sight to reinforce the 5 mph speed limit. If retrofitting an existing street, work with residents to include same number of on-street parking spaces as existing, if that is their desire. (20 feet of curb space is approximately equal to one parking space).
6. Clearly marked entry points; drivers should intuitively understand when they are about to enter this zone.

LOCAL PRACTICE

No single term has caught on in the United States to replace “woonerf”; “Home Zone” is used in the United Kingdom and “Shared Road” and “Shared Space” are sometimes used in the United States. Suggested terms local agencies might consider are:

1. OASIS: Open Air Social Interaction Space
2. MURMUR: Multi User Road
3. Street Yard or Lane Yard LANE: Local Area for Neighbors to Enjoy

TECH TIP

To reduce costs when retrofitting an existing street, consider the existing location of:

- Drainage
- Driveways
- Lighting
- Utilities

NOTE

OASIS – Open Air Social Interaction Space

8.4.2 Cul-de-Sac Woonerf OASIS

Discussion

Cul-de-sacs are ideal locations to be designed or retrofited with woonerf design concepts for three reasons: 1) they do not carry any through traffic, 2) typical traffic volume is between 50 and 200 vehicles per day; and 3) speeds are (or can be) slow, (since cul-de-sacs are typically short, cars do not have time to accelerate to 25 mph). For these reasons, historically, cul-de-sacs were **the** place in the neighborhood where kids could play street games without parents worrying about their safety.

Despite these three nearly universal features of cul-de-sacs, most have been designed as a standard residential street, with 32 to 40 feet of pavement width, and often separate sidewalks. A typical standard detail for a cul-de-sac is presented in Figure 8-5a.

A more bike-friendly and pedestrian -friendly placemaking alternative is to design the entire public right of way within the cul-de-sac as a mixed-use shared space, i.e. a woonerf. This would enhance the intimate feel of a cul-de-sac, provide a large space for children to play, and for adults to meet and socialize.

VTA Best Practice – Standard Detail for a Cul-de-Sac OASIS

Replace the standard detail for a typical cul-de-sac with woonerf-design concepts.

Figure 8-5b illustrates a conceptual layout for a cul-de-sac; it assumes that the fronting dwelling units have privately-owned front yards, as is most common in Santa Clara County. The entire publicly-owned right of way becomes a mixed-use shared space.

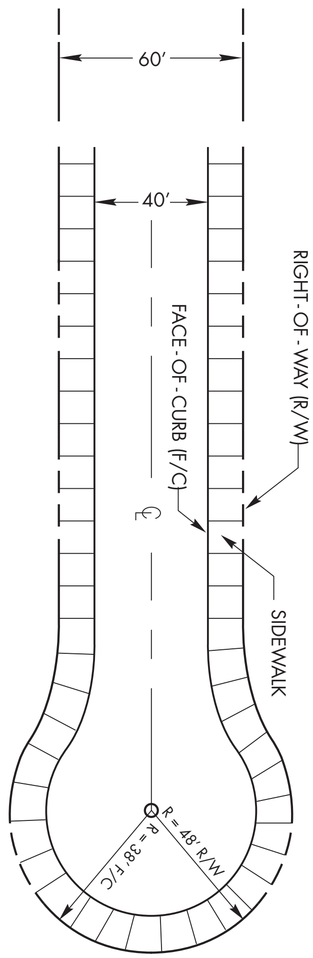


Figure 8-5a:
Typical Cul-de-Sac Standard Detail

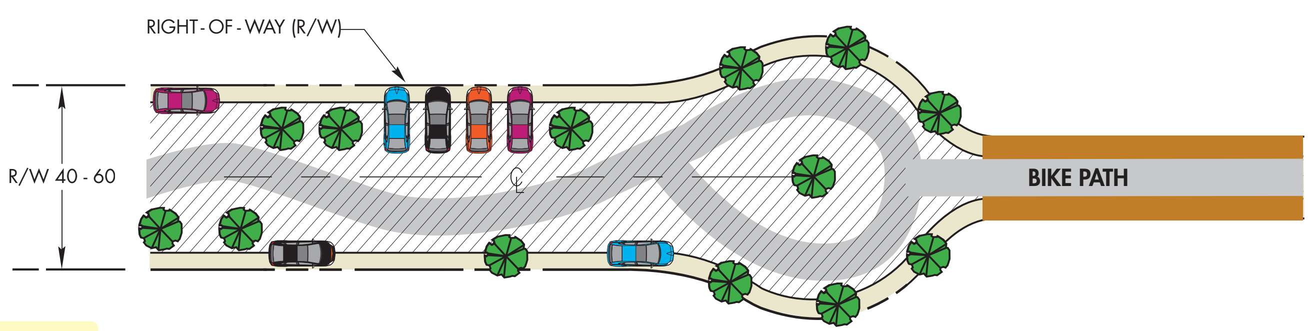


Figure 8-5b:
Cul-de-Sac Woonerf Conceptual Layout

8.4.3 Residential Woonerf – Euro Style MURMUR

NOTE

MURMUR – Multi User Roadway

Discussion

A euro-style woonerf is a street without sidewalks, curbs and gutters where the entire width from building face to building face is public shared space, and there are no designated travel lanes or sidewalks.

VTA Best Practice – Residential Woonerf – Euro Style MURMUR

In Santa Clara County, this design may be appropriate for new construction where there are no private front yards or only minimal private yards, such as in townhouse developments. It may also be appropriate for retrofitting residential streets with primarily multifamily dwellings. It is particularly workable where the dwelling units do not have driveways, such as housing developments with alleys or other places for residents to park their cars.

Figure 8-6 depicts typical European-style woonerf design elements.

**Figure 8-6:
Example of a European Woonerf**

This bench disguises the parked cars, making the street more attractive and also providing a place for adults to sit while children play.

NOTE

LANE Yard –
Local
Area for
Neighbors to
Enjoy

Note that delivery trucks can still be accommodated in the Berlin variation, called verkehrsberuhigten (plural).

This verkehrsberuhigte, or traffic calmed area, in Berlin retains sidewalks adjacent to the buildings, can be readily applied to typical American single family neighborhoods.

8.4.4 Residential Woonerf – American Style LANE Yard

Discussion

While not all homes in the greater San Francisco Bay Area have sidewalks, most single family homes in Santa Clara County and even some town homes, have private front yards. This is the key challenge to developing a true woonerf. Therefore an example of incorporating the woonerf-style design concept on a street where yards and curb /gutter and sidewalks must be retained is presented in Figure 8-7.

VTA Best Practice – Residential Woonerf – American Style LANE Yard

Residential woonerf design that retains sidewalks, curbs and gutters could be applied to new developments or to retrofit older suburban streets with front yards, curbs and gutters.

Figure 8-7 depicts a woonerf that retains existing sidewalks, driveways, curb and gutter.

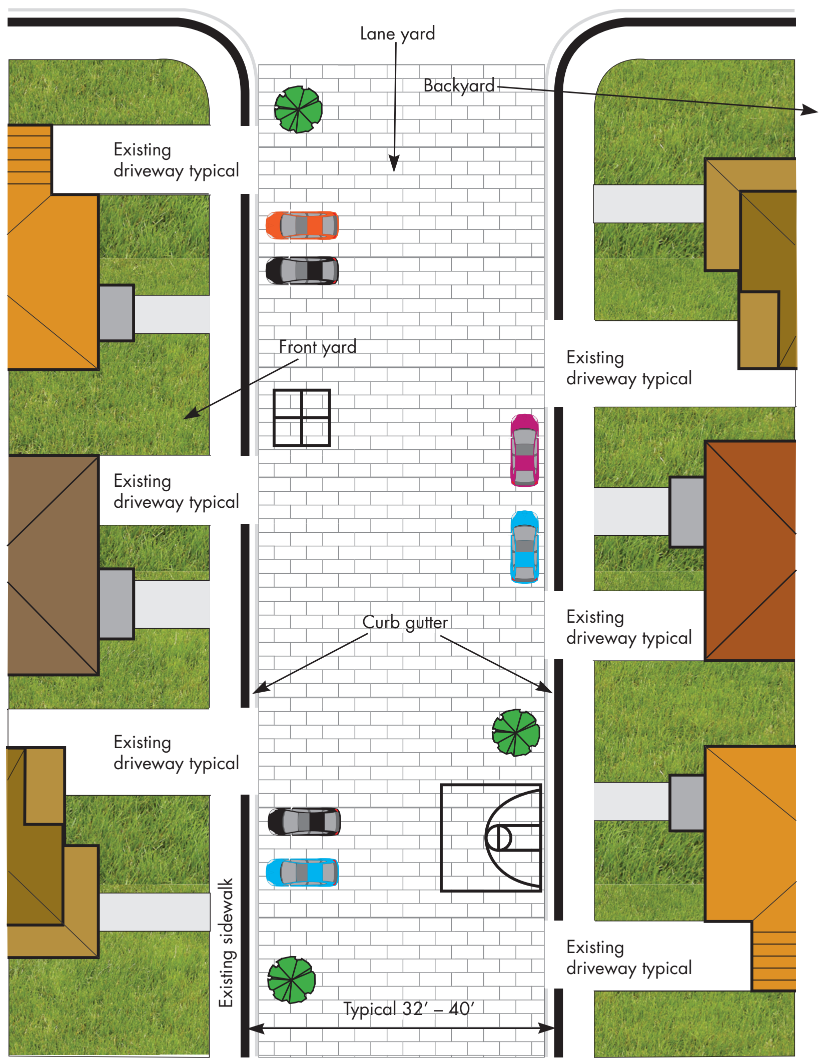


Figure 8-7:
Residential Woonerf Retaining Curb, Gutter and Sidewalk

8.4.5 Commercial Street Traffic Calming A.K.A. Winkelerf

Discussion

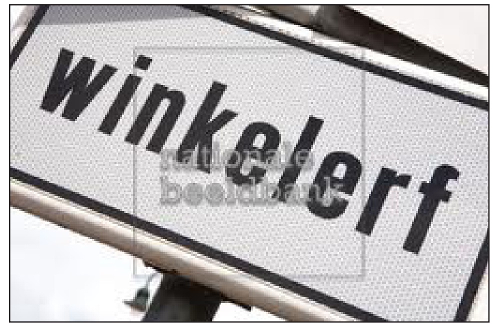
A winkelerf is a shared commercial street that uses unique design features to slow traffic. There is more traffic than on residential woonerf, but it still must go very slowly. A typical design eliminates the curbs to seamlessly merge street and sidewalk spaces; alternatively, bollards, texture tiles and landscaped areas, and/or special paving materials and patterns are used to designate the traffic lanes vs. pedestrian areas.

Parklets can be a key element of a commercial woonerf, and should be especially attractive to passersby since the traffic has been calmed. These are discussed in the next section 8.4.6.

VTA Best Practice – Commercial Street Winkelerf

The photos in the margin depict a commercial zone with the woonerf concept.

1. Traffic is slowed by the landscape and hardscape design e.g. trees, planters, parallel and /or perpendicular parking, parklets.
2. Pavement surface is a variety of patterns, shapes, materials, textures and/ or colors
3. On-street parking is retained at the existing quantity
4. The street design includes:
    - Pedestrian-scale lighting
    - Bike parking
    - Benches/seating for people to relax
    - Landscaping and trees
    - Parklets, if desired
5. To reduce costs, consider the existing location of:
    - Drainage
    - Driveways
    - Lighting
    - Utilities
6. To reduce costs, retain asphalt where parking is permitted since the parked cars would cover any new, more expensive, pavers.



Commercial street winkelerfs allow delivery trucks and also private vehicles if parking is permitted.

This commercial street in Milan, Italy (above photo) was converted to limited access for private vehicles similar to a winkelerf (below photo).

Parklets are publicly accessible spaces for enjoyment and use of the public.

8.4.6 Parklets

Discussion

A Parklet is the temporary use of space in the dedicated public right of way for public uses such as seating, art work, or bicycle racks. Typically an existing car parking space is converted but sometimes former bus stops or other red-curbed space can be used. Parklets are intended to function as street furniture, which enhances the overall streetscape.

Most often Parklets are privately constructed and maintained; each agency develops their own permit conditions for the placement and design of parklets. Suggestions are presented below.

VTA Best Practice – Parklets

Location

- Areas with heavy pedestrian activity and/or in areas where a more pedestrian-friendly environment is desired.
- Street has a parking lane into which the sidewalk can be extended without impacting the travel lane or bike lane.
- Parklet begins at least 30 feet (or one parking space in) from a corner.
- Street has a posted speed limit of 25 mph maximum and less than 3% slope.

Community Support and Public Access

- Typically, a parklet is initiated by a merchant or community group, and has the support of the adjacent business(es).
- Parklets must remain publicly accessible.

Design

- A platform is built to extend the grade of the sidewalk into the street. Material should be easy to maintain, install, and remove, if necessary. See Figure 8-8 for dimensions and other design details.
- The design of the parklet should contribute to the beauty and character of the neighborhood.
- The exact features to add are up to the discretion of the permit applicant, and typically include one or more of the following: benches, tables, chairs, planters, sculptures and bike parking.

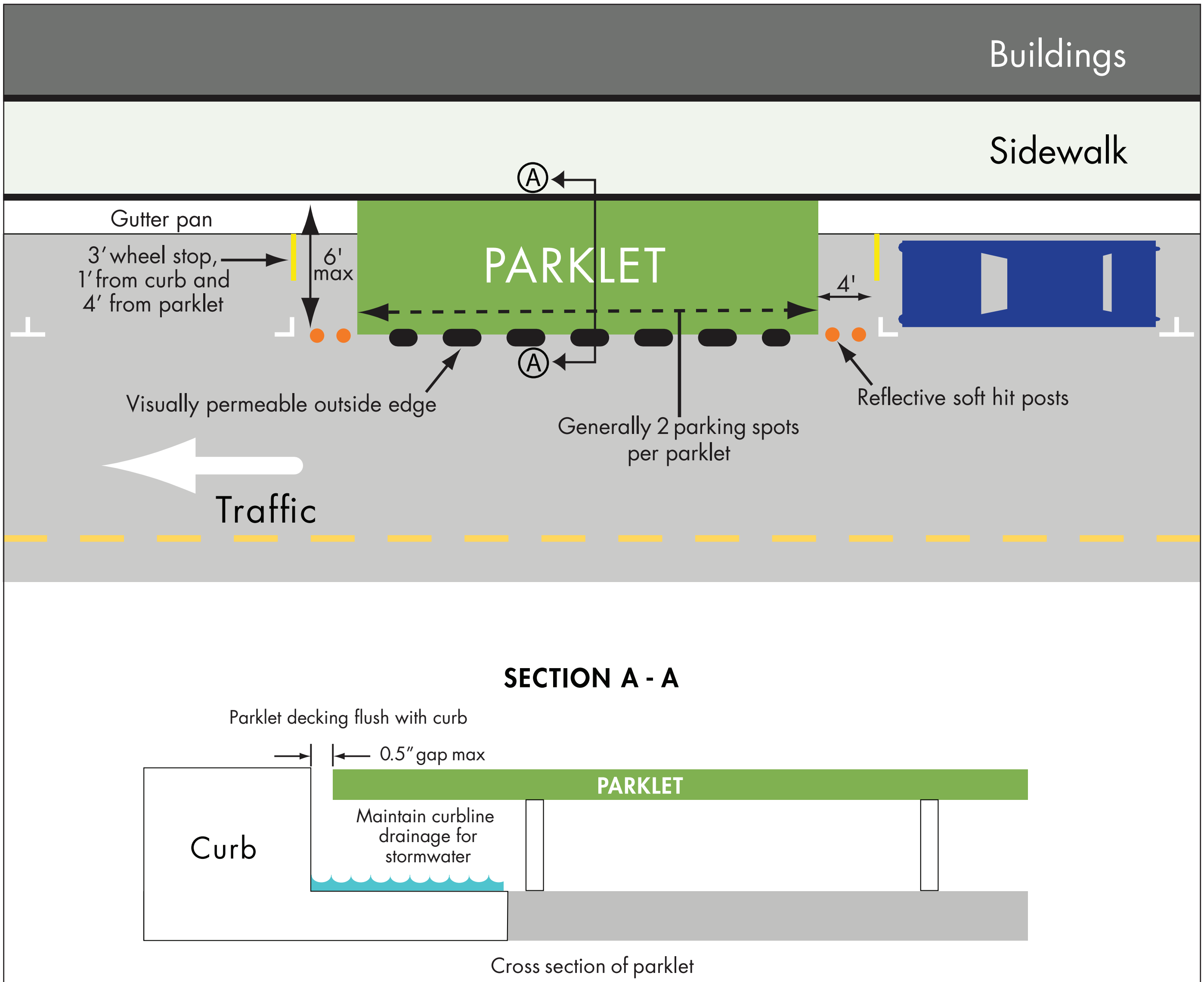


Figure 8-8:
Typical Parklet Layout

Not to scale

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