

Design Guidelines

These facility guidelines are intended to guide development of all bikeway facility types. The following section discusses general physical design guidelines.

Facility design guidelines have been tailored to local conditions, but are also consistent with national guidelines, such as the *AASHTO Guide to Development of Bicycle Facilities*. State guidelines are also referenced, specifically, Caltrans *Highway Design Manual, Chapter 1000, Bikeway Planning and Design* and the Caltrans *Traffic Manual*. Elements of these guidelines without relevance to the campus have been excluded.

Other documents referenced for specific guidelines and requirements can be found in the following links.

- *California Manual on Uniform Traffic Control Devices* (CA-MUTCD, 2012)
- http://www.dot.ca.gov/hq/traffops/signtech/mutcd-supp/ca_mutcd2012.htm
- *Manual on Uniform Traffic Control Devices* (MUTCD, 2009), http://mutcd.fhwa.dot.gov/kno_2009.htm
- *Highway Design Manual, Chapter 1000*, <http://www.dot.ca.gov/hq/oppd/hdm/pdf/chp1000.pdf>
- *AASHTO Guide to Development of Bicycle Facilities*, http://www.sccrtc.org/bikes/AASHTO_1999_BikeBook.pdf
- *Innovative Bicycle Treatments: An Informational Report*. Jumana Nabti and Matthew Ridgeway. ITE, Washington DC, 2002.
- *Bicycle Parking Guidelines*, 2nd Ed. Association of Pedestrian and Bicycle Professionals www.apbp.org
- *NACTO Urban Bikeway Design Guide*, <http://nacto.org/cities-for-cycling/>

Class 1 Multi-use Path Guidelines

Class 1 facilities are generally paved multi-use paths separated from motor vehicle traffic. Off-street routes are rarely constructed for the exclusive use of cyclists since other non-motorized user types will also find such facilities attractive. For that reason, the facilities recommended in this study should be considered multi-use routes that cyclists will share with other users. Recommended Class 1 paths are intended to provide commuting and recreational routes unimpeded by motor vehicle traffic.

No matter what their primary focus, most cyclists will find bicycle paths inviting routes to ride, especially if travel efficiency is secondary to enjoyment of cycling. Since these paths can augment the existing roadway system, they can extend circulation options for cyclists, making trips feasible that would not otherwise be possible if the cyclists had to depend exclusively on roadways, especially in areas where usable roads are limited. Casual riders and children would likely also appreciate the relative freedom from conflicts with motor vehicles compared to riding on typical roadways.

By law, the presence of a Class 1 route near an existing roadway does not justify prohibiting bicycles on the parallel or nearly parallel roadway. Where a bike plan calls for Class 1 routes parallel to the alignments of planned roadways, these roadways should still be designed to be compatible with bicycle use. Two reasons to retain parallel facilities are that an experienced cyclist may find Class 1 paths inappropriate because of intensive use by a number of user types, or the route may not be direct enough. By the same token, the Class 1 path will likely be much more attractive to less experienced cyclists than a parallel facility on an adjacent street.

The *AASHTO Guide for the Development of Bicycle Facilities* suggests the following grade restrictions and grade lengths for Class 1 facilities:

- 5-6 percent up to 800 feet
- 7 percent up to 400 feet
- 8 percent up to 300 feet
- 9 percent up to 200 feet
- 10 percent up to 100 feet
- 11+ percent up to 50 feet

In general, Class 1 facilities should not be placed immediately adjacent to roadways. Where such conditions exist, Class 1 facilities should be offset from the street as much as possible

and separated from it by a physical barrier. These measures are intended to promote safety for both cyclists and drivers by preventing unintended movement between the street and the Class 1 facility. (See Section 1003.1 (5) of the *Caltrans Highway Design Manual*.)

Shared Use Issues

Since off-street paths (Class 1) are generally regarded as multi-use and not for the exclusive use of cyclists, they must be designed for the safety of both cyclists and other expected user types. Heavy use on multi-use trails can create conflicts between different types of users. These conflicts can include speed differentials between inexperienced and experienced cyclists, as well as between pedestrians, joggers and in-line skaters, differences in the movements typical of particular user types, and even the kinds of groupings common to the different user types as they casually move down the pathway.

As long as volumes are low, the level of conflict between different user types can be managed without enforcement. However, even moderate increases in user volume can create substantial deterioration in level of service and safety. Conflicts between different user types are especially likely to occur on regionally significant recreational trails that attract a broad diversity of users. In general, paths expected to receive heavy use should be a minimum of 14 feet wide, paths expected to experience moderate use should be at least 12 feet wide and low volume paths can be 10 feet wide. Caltrans Class 1 requirements call for eight feet minimum paved width with a two foot clear zone on each side.



Rose Canyon Class 1 bike path



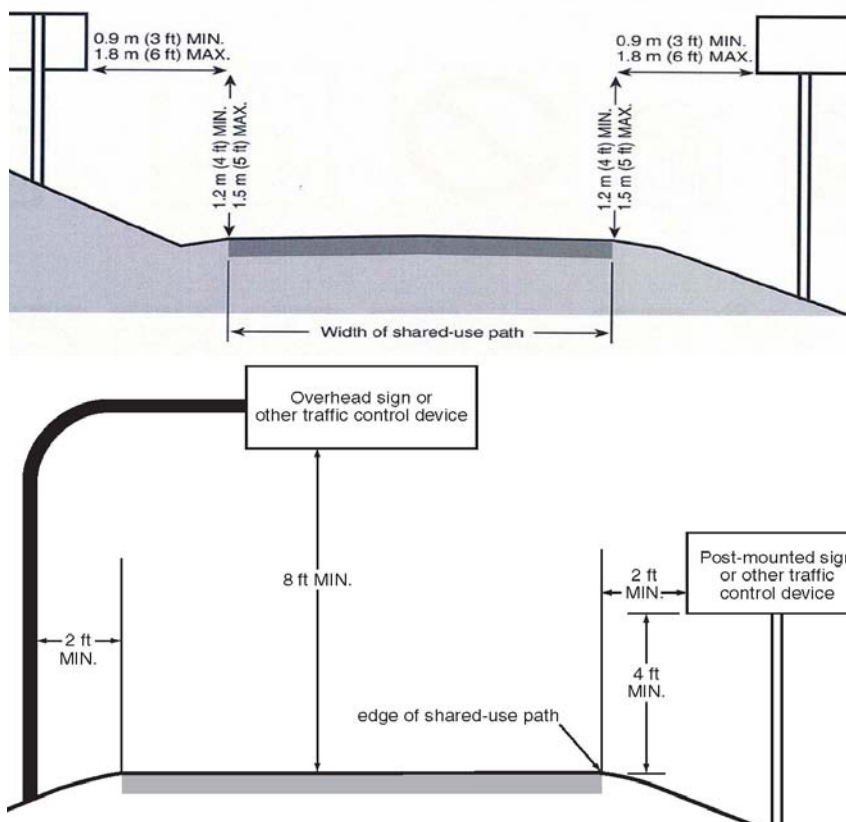
Class 1 bike path and adjacent natural surface trail (San Diego, CA)

Methods to reduce trail conflicts have included providing separate facilities for different groups, prohibiting certain user types, restricting certain uses to specific hours, widening existing facilities or marking lanes to regulate traffic flow. Examples of all of these types of actions occur along southern California's trails where conflicts between different user types can be especially severe during peak periods.

Compatibility of Multiple Use of Paths

Joint use of paths by cyclists and equestrians can pose problems due to the ease with which horses can be startled. Also, the requirements of a Class 1 bikeway facility include a solid surface, which is not desirable for equestrian use. Therefore, where either equestrian or cycling activity is expected to be high, separate trails are recommended. On facilities where Class 1 designation is not needed and the facility will be unpaved, mountain bikes and horses can share the trail if the is adequate space for passing, the expected volume of traf-

fic by both groups is low and available sight distances allow equestrians and cyclists to see and anticipate each other. Education of all path users in "trail etiquette" has also proven to be successful on shared paths.



CAMUTCD Figure 9B-1: Sign placement on shared-use paths

Roadside Obstacles

To make certain that as much of the paved surface as possible is usable, obstructions such as sign posts, light standards, utility poles and other similar appurtenances should be set back with at least a two foot minimum "shy distance" from the curb or pavement edge with exceptions for guard rail placement in certain instances. Three feet or more is desirable. Where there is currently insufficient width of paved surface to accommodate bicycle traffic, any placement of equipment should be set back far enough to allow room for future projects (widening, resurfacing) to bring the pavement width into conformance with these guidelines. Vertical clearance to obstructions should be a minimum of eight feet. Where practical, a vertical clearance of ten feet is desirable (See Section 1003.1 of the Caltrans *Highway Design Manual*.)

Class 2 Bike Lane Guidelines

The following are typical guidelines, as well as enhanced treatments for bike lanes. Other treatments not listed in these guidelines can be considered on a case-by-case basis when warranted.

Bike Lanes

Class 2 facilities are striped lanes for one-way bike travel on a street or highway. They are installed along streets in corridors where there is significant bicycle demand and where there are distinct needs that can be served by them. In streets with on-street parking, bike lanes are located between the parking area and the traffic lanes.

Design Guidelines

- Five foot minimum width for bike lanes located between the parking area and the traffic lanes.
- Four foot minimum width if no gutter exists.
- With a normal two foot gutter, the minimum bike lane width is five feet.

Recommendations

- Bike lanes are not advisable on long, steep downgrades, where bicycle speeds greater than 30 miles per hour are expected. If bike lanes are to be marked, additional width should be provided to accommodate higher bicycle speeds.
- If parking volume is substantial or turnover high, an additional one to two feet of width is desirable.

References

Caltrans *HDM Chapter 1000*, CAMUTCD, MUTCD

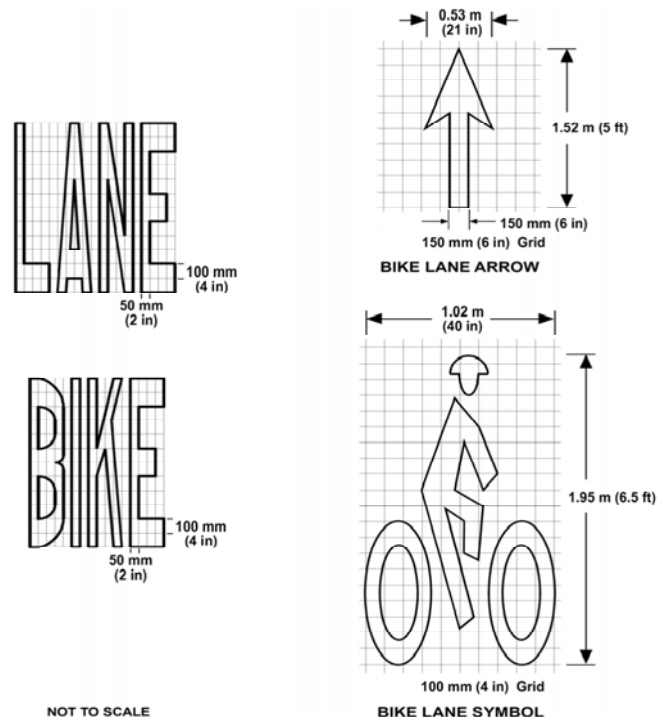


Figure 9C-6(CA): Bicycle Lane Markings (CAMUTCD)



Sign R81 (CAMUTCD)

Sign R81-A (CAMUTCD)

Sign R81-B (CAMUTCD)

Colored Bike Lanes/Weaving Areas

Description

Color is applied to bike lanes to enhance the visibility of cyclists on the bike lanes themselves, particularly at busy intersections where drivers must cross the bike lanes to make right turns. Color can be applied to the entire bike lane at high-risk locations where drivers are permitted to merge into or cross bike lanes.

Design Guidelines

- Signage and dimensional guidelines are the same as for standard Class 2 bike lanes
- Avoid using blue, which is commonly designated for disabled facilities. Green is now the standard color for colored bike lanes.

Recommendations

- Provide additional signage with matching color.
- Use color and markings consistently.
- Consider different coloring materials based on the location of the bike lanes, amount of traffic, road and weather conditions.

References

Innovative Bicycle Treatments: An Informational Report - ITE Pedestrian and Bicycle Council

Portland's Blue Bike Lanes: Improved Safety through Enhanced Visibility – City of Portland, 1999

Evaluation of a Green Bike Lane Weaving Area in St. Petersburg, Florida – University of North Carolina, Highway Safety Research Center, 2008



Colored bicycle lane at location with high potential for conflict with motor vehicles

Buffered Bike Lanes

Description: Space between the bike lane and traffic lane, parking lane or both. Provides a more protected and comfortable space for cyclists than a conventional bike lane.

Design Guidelines

- Signage and dimensional guidelines are the same as for Class 2 bike lanes.
- Provide an additional two to four foot buffer or “shy zone” between the bike lane and traffic or parking lane.

Recommendations

- Add diagonal striping on the outer buffer adjacent to the traffic lanes every six feet.
- On-street parking remains adjacent to the curb.
- A travel lane may need to be eliminated or narrowed to accommodate the buffers.

References

City of Los Angeles Bicycle Plan Update, City of Los Angeles



Buffered bike lane - (Huntington Beach, CA)

Class 3 Bike Route Guidelines

Back-in/Head-out Diagonal Parking

Description

Back-in/head-out parking is considered safer than conventional head-in/back-out parking due to better visibility when leaving. This is particularly important on busy streets or where drivers may find their views blocked by large vehicles or the tinted windows of adjacent vehicles when trying to perform head-in/back-out angled parking.

Design Guidelines

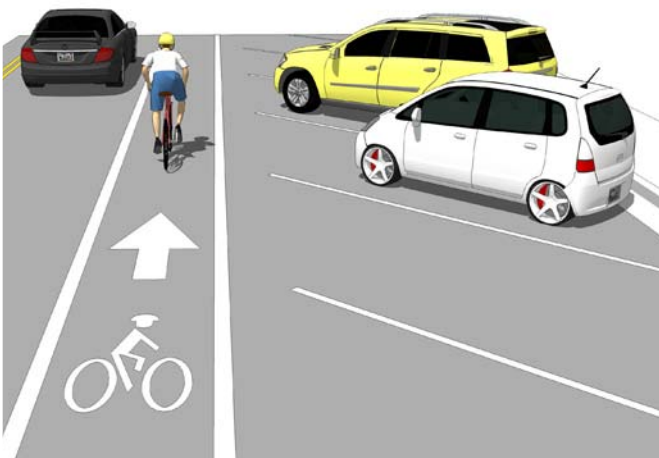
Based on existing dimensions from test sites and permanent facilities: 16 feet from curb edge to inner bike lane stripe and a five foot bike lane.

Recommendations

Test the facility on streets with existing head-in angled parking and moderate to high bicycle traffic. Additional signs to inform drivers how the back-in angled parking works are recommended. (Note: This design treatment is not currently present in any state or Federal design standard, but it is now a standard configuration in Seattle, WA.)

References

Back-in/Head-out Angle Parking, Nelson/Nygaard Consulting Associates, 2005 *City of Los Angeles Bicycle Plan Update*, City of Los Angeles



Back-in/head-out angled parking with bike lane

The following are typical guidelines for installing bike routes, including enhanced treatments. Other treatments not listed in these guidelines can be considered on a case-by-case basis when warranted.

Class 3 Bike Route

Signing

When designating a bicycle route, the placement and spacing of signs should be based on the *California Manual on Uniform Traffic Control Devices*, Part 9: Traffic Controls for Bicycle Facilities. For bike route signs to be functional, supplemental plaques can be placed beneath them when located along routes leading to high demand destinations (e.g. "To Downtown," "To Transit Center"). Since bicycle route continuity is important, directional changes should be signed with appropriate arrow sub plaques. Signing should not end at a barrier. Instead, information directing the cyclist around the barrier should be provided. If used, route signs and directional signs should be used frequently because they promote reasonably safe and efficient operations by keeping facility users informed of their location.

"BIKE ROUTE" - This sign is intended for use where no unique designation of routes is desired. However, when used alone, this sign conveys very little information. It can be used in connection with supplemental plaques giving destinations and distances. (See Section 1003-3 of the Caltrans *Highway Design Manual* and Part 9B-20 of the MUTCD for specific information on sub-plaque options.)

Roadways not designated for bicycle use usually do not require regulatory, guide or informational signing in excess of what is normally required for drivers. However, in certain situations additional signing may be advisable to advise both drivers and cyclists of the roadway's shared use status.

"BICYCLES MAY USE FULL LANE" - California Vehicle Code Section 21202 allows cyclists to ride in the center of a travel lane when that lane is too narrow to safely share with passing motor vehicles. The sign (R4-11) is intended to alert road users to this law and encourage cyclists to take the lane on streets with narrow lanes. This sign can be used on bicycle routes lacking a wide shoulder in conjunction with the shared roadway bicycle marking (sharrow), to improve bicyclist safety. This sign is recommended where the following roadway conditions occur:



Sign R4-11



Sign D11-1



Sign D1-1b (R)

Typical Class 3 Route signage (CAMUTCD)

- Shared lanes with relatively high posted travel speeds of 40 mph or greater
- Shared lanes in areas of limited sight distance
- Situations where shared lanes or demarcated shoulders or marked bike lanes end and bicycle and motor vehicle traffic must begin to share the travel lane
- Steep descending grades where bicycle traffic may be operating at higher speeds and requires additional maneuvering room to shy away from pavement edge conditions
- Steep ascending grades, especially where there is no paved shoulder, or the shared lane is not adequately wide and bicycle traffic may require additional maneuvering room to maintain balance at slow operating speeds
- High volume urban conditions, especially those with travel lanes less than the recommended width for lane sharing
- Other situations where it is determined to be advisable to alert drivers of the likely presence of bicycle traffic and to alert all traffic of the need to share available roadway space

Enhanced Class 3 Bike Route

Shared Lane Marking or “Sharrow” Design Criteria

The shared lane marking is an additional component of Class 3 routes, but not required. When used, it shall be as shown on the following page and in the photo below. At locations where parking is allowed adjacent to the travel lane, the center of the marking should be located a minimum of 11 feet from the curb face or edge of the road.



Shared lane marking



Green stripe w/shared lane marking (Green stripe not in CAMUTCD)

Design Considerations

Shared lane markings may be considered in the following situations:

- On roadways with posted speed limits of 35 mph or less (CAMUTCD)
- On constrained roadways too narrow to stripe bicycle lanes
- To delineate space within a wide outside lane where cyclists can be expected to ride
- On multi-lane roadways where cyclists can be expected to travel within the outside lane and drivers should be prepared to change lanes to pass cyclists
- On roadways where it is important to increase driver awareness of cyclists

- On roadways where cyclists frequently ride the wrong way
- On roadways where cyclists tend to ride too close to parked cars

A further Class 3 enhancement is a solid green lane used in conjunction with the shared lane marking. This enhancement is currently being used by the cities of Long Beach, Salt Lake City, New York City and Philadelphia. (Note: This design treatment is not currently present in any state or Federal design standard.)

Shared Lane Marking Guidelines

The following is the suggested pavement marking configuration for Class 3 bike routes from the CAMUTCD.

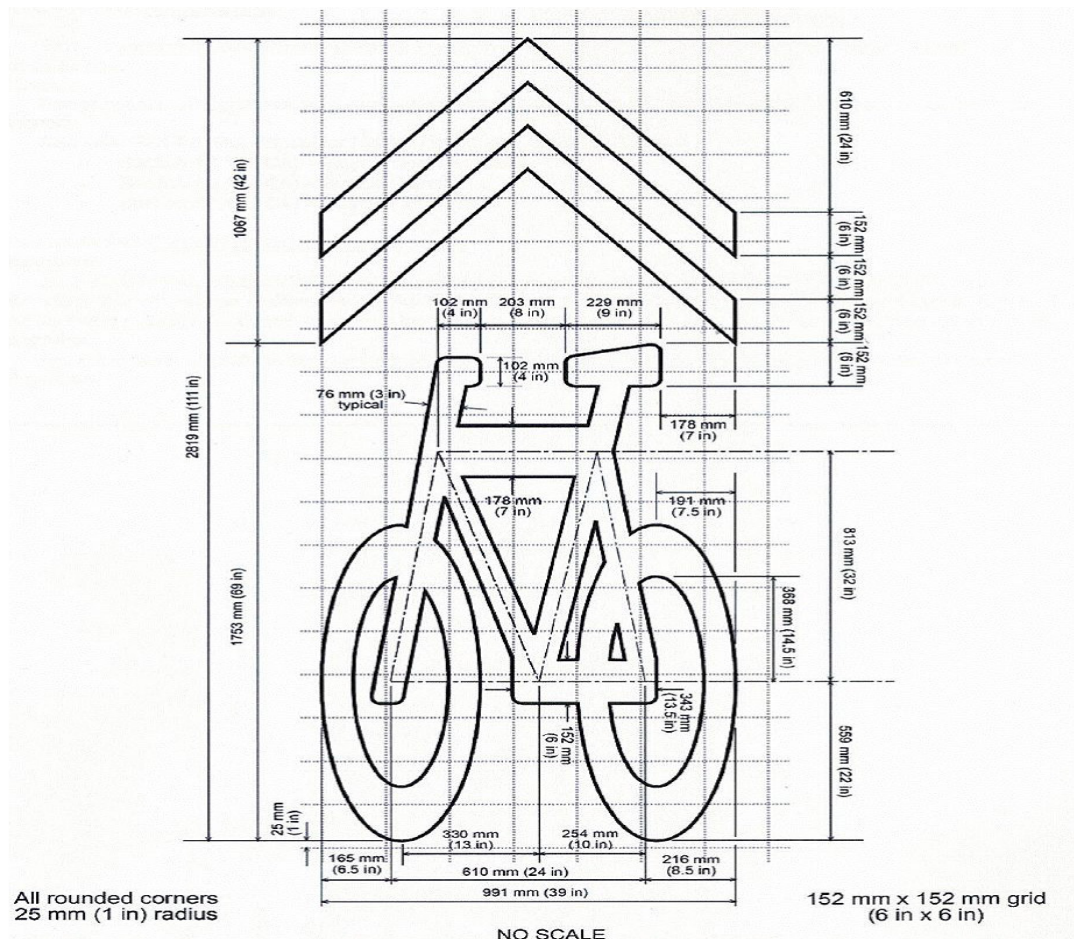


Figure 9C-104(CA): Shared roadway bicycle marking (CAMUTCD)

Final Design and Facility Selection

Class 2 facilities are usually more suitable in urban settings on roads with high traffic volumes and speeds. Class 3 facilities are often used in urban settings to guide cyclists along alternate or parallel routes that avoid major obstacles, or have more desirable traffic operational factors.

In rural settings, Class 2 facilities are not usually necessary to designate preferential use. On higher volume roadways, wide shoulders offer cyclists a safe and comfortable riding area. On low volume roadways, most cyclists prefer the appearance of a narrow, low speed country road.

The lane width table recommends the type of bikeway and pavement width for various traffic conditions. For locations where pavement widths do not meet the criteria listed in the table, the local municipal bicycle authority should be consulted to assist in the decision making process.

Where physical obstructions exist that can be removed in the future, the roadway facility should be designed to meet bikeway space allocation requirements and upgraded and designated when the physical constraint is remedied (e.g., bridge is replaced and improved to allow designated facility).

The final design should be coordinated with the bicycle coordinator for review and approval prior to construction. The following factors should be considered:

- Existing and projected traffic volumes and speeds
- Existence of parking (Can parking be restricted or removed to allow better sight distances? Although parallel parking is considered acceptable along streets with bike routes or adjacent to bike lanes, back-out angled parking has been found to conflict with bicycle traffic and should be avoided when planning bike facilities on a roadway. Angled parking next to bike lanes should be coordinated and further studied. Angled back-out parking means that vehicles park with their rear ends into the roadway and is impossible to determine where the parking lane ends and the bike lane would begin. Additionally, back-out diagonal parking requires a person leaving a parking space to back out into traffic, often without a good view of oncoming cyclists and vehicles. Back-in angled parking can be an option where vehicles back into the angled parking. Back-in angled parking provides better visibility when leaving and is particularly important on busy streets where drivers find their views block by large vehicles, or tinted windows on adjacent parked vehicle.
- Excessive intersection conflict points (Can intersection conflict points be reduced along roadways?)
- Turn lanes at intersections that can be designed to allow space for cyclists
- Sections with insufficient sight distance or roadway geometrics
- Traffic operations changed or “calmed” to allow space and increased safety for cyclists

Traffic Control Devices

As legitimate roadway users, cyclists are subject to essentially the same rights and responsibilities as drivers. For cyclists to properly obey traffic control devices, those devices must be selected and installed to take their needs into account. All traffic control devices should be placed so cyclists properly positioned on the road can observe them. This includes programmed visibility signal heads.

Traffic Signals and Detectors

Traffic-actuated signals should accommodate bicycle traffic. Detectors for traffic-activated signals should be sensitive to bicycles, should be located in the cyclist's expected path and stenciling should direct the cyclist to the point where they will be detected.

It is common for bicycles to be made of so little ferrous metals that they may not be easily detectable by some currently installed types of loop detectors. As a convenience for cyclists, the strongest loop detection point should be marked with a standard symbol. Since detectors can fail, added redundancy in the event of failure is recommended in the form of pedestrian push buttons at all signalized intersections. If possible, these buttons should be mounted in a location that permits their activation by a cyclist without having to dismount.

Where left turn lanes are provided and only protected left turns are allowed, bicycle-sensitive loop detectors should be installed in the left turn lane. Where moderate or heavy volumes of bicycle traffic exist, or are anticipated, bicycles should be considered in the timing of the traffic signal cycle, as well as in the selection and placement of the traffic detector device. In such cases, short clearance intervals should not be used where cyclists must cross multi lane streets. A speed of 10 mph and a perception/reaction time of 2.5 seconds can be used to check the clearance interval. Where necessary, such as for particularly wide roadways, an all red clearance interval can be used.

Protected left turns are preferred over unprotected left turns. In addition, traffic signal-controlled left turns are much safer for cyclists than left turns at which drivers and cyclists must simply yield. This is because motor vehicle drivers, when approaching an unprotected left turn situation or planning to turn left at a yield sign, tend to watch for other motor vehicles and may not see an approaching cyclist. More positive control of left turns gives cyclists an added margin of safety where they need it most.

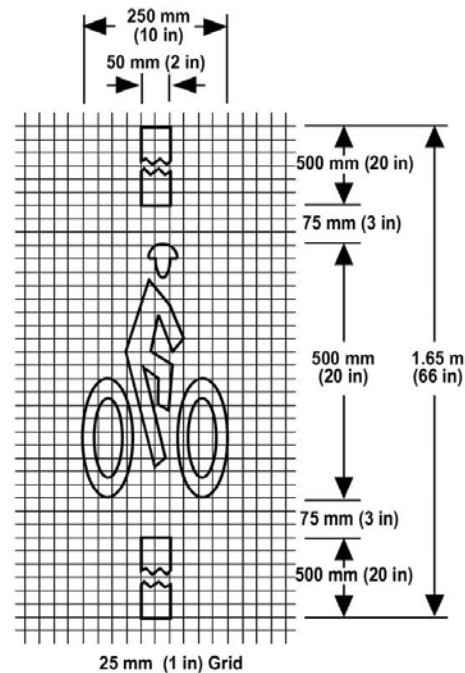


Figure 9G-7 (CAMUTCD) Bicycle Detector Symbol

Quadrupole Loop

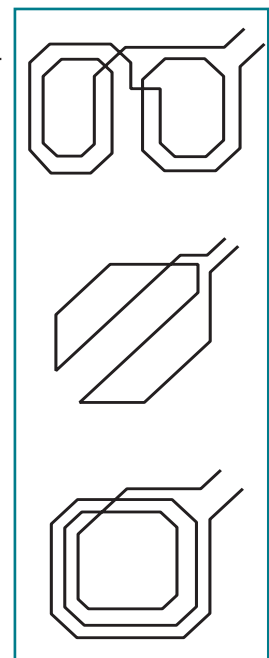
- Detects most strongly in center
- Sharp cut-off of sensitivity
- Used in bike lanes

Diagonal Quadrupole Loop

- Sensitive over whole area
- Sharp cut-off of sensitivity
- Used in shared lanes

Standard Loop

- Detects strongest over wires
- Gradual cut-off
- Used in advanced detection



Video Detection

Video detection can pick up a cyclist's presence at an intersection over a larger area. A video detection setup consists of a video detector, usually mounted on a riser or mainline pole and a computer with video image processing capability. Existing video detectors have a flexible detector layout allowing for fairly easy reprogramming of detection zones. Video detection technology has advanced to detect bikes with the same accuracy as loop detectors.

Some advantages to video detection include adjusting signal timing, once activated, to allow cyclists sufficient time to cross the intersection. This treatment enhances safety for this mode of transportation. Cameras can detect bicycles that do not contain iron, unlike some loop detectors, and in some cases can detect pedestrians fairly well. Video detection is also not affected by street repair work and can be used to help direct traffic during construction.

Bicycle Signals

Bicycle signals are typically used at intersections with heavy bicycle traffic in conjunction with high peak vehicle traffic volumes, high conflict intersections or at the connections of shared use bike lanes and busy roads. These signals separate conflicting movements between pedestrians, vehicles and cyclists. Bicycle signals also provide priority movement for cyclists at intersections and alternates rights of way between the different road users.

A bicycle signal is an electrically powered traffic control device that may only be used in combination with an existing traffic signal. Bicycle signals direct cyclists to take specific actions and may be used to improve an identified safety or operational problem involving bicycles.

Only green, yellow and red lighted bicycle symbols are to be used to implement bicycle movement at a signalized intersection. The application of bicycle signals shall be implemented only at locations that meet Department of Transportation bicycle signal warrants. Bicycle movement has its own signal phase.



Bicycle signals (Tucson, AZ)

Design Considerations

Guidance

Alternative means of handling conflicts between bicycles and motor vehicles should be considered first.

Two alternatives to be considered are:

- Striping to direct cyclists to a lane adjacent to a traffic lane, such as a bike lane to the left of a right-turn-only lane
- Redesigning the intersection to direct cyclists from an off-street path to a bicycle lane at a point removed from the signalized intersection

A bicycle signal must meet specified warrants before being considered for installation, according to the following formula or either of the other two criteria below:

Volume: When $W = B \times V$ and $W > 50,000$ and $B < 50$.

Where:

W is the volume warrant

B is the number of bicycles at the peak hour entering the intersection

V is the number of vehicles at the peak hour entering the intersection

(B and V shall use the same peak hour.)

- Collision: When two or more bicycle/vehicle collisions of types susceptible to correction by a bicycle signal have occurred over a 12 month period and the responsible public works official determines that a bicycle signal will reduce the number of collisions.
- Geometric: (a) Where a separate bicycle/multi-use path intersects a roadway. (b) At other locations to facilitate a bicycle movement not permitted for a motor vehicle.

Locating Bicycle Facilities on Roadways

The appropriateness of a bicycle facility is influenced by a number of factors classified into the following categories:

Land Use and Location Factors

These factors represent the most significant category affecting compatibility. Since bicycle trips are generally shorter than motor vehicle or public transit trips, there must be a manageable distance between origins and destinations, such as between residential areas and places of employment. There are certain key land uses especially likely to generate bicycle traffic if good bicycle facilities are available. These consist of, but are not limited to, transit centers, schools, employment centers with nearby residential areas, recreation areas and mixed use areas.

Physical Constraint Factors

These consist of roadway geometric or physical obstacles to bicycling difficult or costly to remedy. For example, a roadway may be appropriate because of location factors, but not appropriate because of the existence of physical constraints to bicycling such as a narrow bridge, insufficient right-of-way or intersections with restricted lane widths resulting from lane channelization. The feasibility of correcting these physical constraints must be weighed in designating bikeways.

Traffic Operations Factors

These include traffic volume, speed, the number of curb cuts or conflict points along the roadway, sight distance and bicycle-sensitive traffic control devices. Experienced cyclists will use roadways even if they have limiting traffic operational factors, but less confident cyclists will perceive such roadways as unsafe and intimidating. These roadway facilities should be designed or improved to accommodate cyclists. However, they are likely to be inappropriate for full designation as bikeways.

Other Safety Issues

Other safety issues such as maintenance and pavement repair are also important considerations in the designation of bikeways, but do not directly affect the planning aspects of appropriate facilities.

Class 3 Pavement Width

At a minimum, all roadway projects shall provide sufficient width of smoothly paved surface to permit the shared use of the roadway by bicycles and motor vehicles.

Considerations in the selection of pavement width include traffic volume, speed, sight distance, number of large vehicles (such as trucks) and grade. The dimensions given in the table for shared lanes are exclusive of the added width for parking, which is assumed to be eight feet. On shared lanes with parking, the lane width can be reduced if parking occurs only intermittently. On travel lanes where curbs are present, an additional one foot is necessary.

On very low volume roadways with average daily trips (ADTs) of less than 1,200, even relatively high speed roads pose little risk for cyclists since there will be high probability that an overtaking motor vehicle will be able to widely pass a bicycle. When an overtaking car is unable to immediately pass a bicycle, only a small delay for the driver is likely. Both cyclists and drivers jointly use these types of roadways in a safe manner and widening of these roads is not usually recommended. Costs of providing widening of these roads can seldom be justified based on either capacity or safety.

Similarly, moderately low volume roadways with ADTs between 1,200 and 2,000 generally are compatible for bicycle use and will have little need for widening. However, since there is a greater chance of two opposing cars meeting at the same time as they must pass a cyclist, providing some room at the outside of the outer travel lane is desirable on higher speed roadways. On low speed roadways, drivers should be willing to accept some minimal delay.

With ADTs from 2,000 to 10,000, the probability becomes substantially greater that a vehicle overtaking a bicycle may also meet another oncoming vehicle. As a result, on these roads, some room at the edge of the roadway should be provided for cyclists. This additional width should be two to three feet added to a typical 10 foot outer travel lane. At low speeds, such as below 25 mph, little separation is needed for both a cyclist and a driver to feel comfortable during a passing maneuver. With higher speeds, more room is needed.

At volumes greater than 10,000 ADTs, vehicle traffic in the curb lane becomes almost continuous, especially during peak periods. As a result, cyclists on these roadways require separate space to safely ride, such as a Class 2 facility. In addition, improvements to the roadway edge and the shoulder area will be valuable for drivers as well.

Caltrans guidelines for highways recommend that a full eight foot paved shoulder be provided for state highways. On highways having ADTs greater than 20,000 vehicles per day, or on which more than five percent of the traffic volume consists of trucks, every effort should be made to provide such a shoulder for the benefit of cyclists, to enhance the safety of motor vehicle movements and to provide "break down" space, as well as a Class 2 facility. Otherwise, the highway should probably not be designated as a bicycle facility.

Sight Distance

Roadways with adequate sight distance will allow a driver to see, recognize, decide on the proper maneuver and initiate actions to avoid a cyclist. Adequate decision sight distance is most important on high speed highways and narrow roadways where a driver would have to maneuver out of the travel lane to pass a cyclist.

The pavement widths given in the table are based on the assumption that adequate sight distance is available. In situations where there is not adequate sight distance, provision of additional width may be necessary.

Truck Traffic

Roadways with high volumes of trucks and large vehicles, such as recreational vehicles, need additional space to minimize cyclist/driver conflicts on roadways. Additional width allows trucks to overtake cyclists with less maneuvering and the cyclists will experience less lateral force from passing truck drafts. This additional width will also provide greater sight distance for following vehicles.

Although there is no established threshold, additional space should be considered when truck volumes exceed five percent of the traffic mix, or on roadways that serve campgrounds, or where a high level of tourist travel is expected using large recreational vehicles. Where truck volumes exceed 15 percent of the total traffic mix, widths shown on the table should be increased by one foot minimum.

Steep Grades

Steep grades influence overtaking of cyclists by drivers. Inexperienced cyclists climbing steep grades are often unsteady (wobbly) and may need additional width. Also, the difference in speed between a slow, climbing cyclist and a motor vehicle results in less time for the driver to react and maneuver around a cyclist. Motor vehicle slowing on a steep grade to pass a cyclist can result in a diminished level of service.

Unavoidable Obstacles

Short segments of roadways with multiple unavoidable obstacles that result in inadequate roadway width are acceptable on bicycle compatible roadways if mitigated with signing or striping. Typical examples include bridges with narrow widths and sections of roadway that cannot be widened without removing significant street trees. These conditions preferably should not exist for more than a quarter of a mile, or on high speed highways. Warning striping should be installed to shift traffic away from the obstacle and allow for a protected buffer for bicycle travel.

In situations where a specific obstacle such as a bridge abutment cannot be avoided, a pavement marking consisting of a single six inch white line starting 20 feet before and offset from the obstacle can also be used to alert cyclists that the travel lane width will soon narrow ahead. (See Section 1003.6 of the Caltrans *Highway Design Manual* for specific instructions.)

In either situation, where bicycle traffic is anticipated, a "SHARE THE ROAD" sign should be used to supplement the warning striping. On longer irrevocably narrow sections of roadway, edge striping should be employed to narrow the travel lane and apportion pavement space for a partial shoulder. In situations where even these measures may not provide adequate roadway space for cyclists, it is recommended that an alternate route be designated.

Pavement Design

Though wider tires are now very common and bicycle suspension systems are becoming increasingly prevalent, bicycles still require a riding surface without significant obstacles or pavement defects because they are much more susceptible to surface irregularities than are motor vehicles. Asphalt is preferred over concrete where shoulders are employed. The outside pavement area where bicycles normally operate should be free of longitudinal seams. Where transverse expansion joints are necessary on concrete, they should be saw cut to ensure a smooth transition. In areas where asphalt shoulders are added to existing pavement, or where pavement is widened, pavement should be saw cut to produce a tight longitudinal joint to minimize wear and expansion of the joint.

Raised Roadway Markers

Raised roadway markers such as reflectors or rumble strips should not be used on roadway edges where bicycles are most likely to operate because they create a surface irregularity that can be hazardous to bicycle stability. Painted stripes or flexible reflective tabs are preferred. In no case should strips of raised reflectors intended to warn drivers to reduce vehicle speeds prior to intersections be allowed to cross through the bicycle travel lane.

Pavement Painting and Striping

Although adding pavement legends to indicate a bike lane or path is recommended, the colorization of the bike lane pavement with paint to indicate non vehicular use is recommended in certain situations to further delineate bicycle facilities from the vehicular lane. Certain paint materials have greater degrees of glossiness that can contribute to the slippery nature of their surface. As an alternative to painting, dye treated colored asphalt or stained concrete overlays have equivalent friction levels and can be used if the selected colors do not interfere with the pavement striping legibility or conflict with MUTCD intentions.

Utilities

Because bicycles are much more sensitive to pavement irregularities than motor vehicles, utility covers should be adjusted as a normal function of any pavement resurfacing or construction operations. Failure to do so can result in the utility cover being sunken below the paving surface level, which creates a hazard experienced cyclists refer to as “black holes.” Also, it is common practice to excavate trenches for new utilities at road edges, the same location as bicycle facilities. When such trenching is completed, care should be given to replacing the full surface of the bicycle lane from the road edge to the vehicle travel lane instead of narrow strips that tend to settle or bubble, causing longitudinal obstructions. Replacement of the bike lane striping should also be required.

Drainage Facilities

Storm water drainage facilities and structures are usually located along the edge of roadways where they can create hazards for cyclists. Careful consideration should be given to the location and design of drainage facilities on roadways with bicycle facilities.

All drainage grate inlets pose some hazard to bicycle traffic. The greatest hazard comes from stream flow drainage grates that can trap the front wheel of a bicycle and cause the cyclist to lose steering control, or allow narrow bicycle wheels to drop into the grate. Another type of hazard may be caused by cyclists swerving into the lane of traffic to avoid a grate or cover. Riding across any wet metal surface increases the chances of a sudden slip and fall.

Only a “bicycle safe” drainage grate with acceptable hydraulic characteristics should be used. The inlet grate should be used in all normal applications and should be installed flush with the final pavement. Where additional drainage inlet capacity is required because of excessive gutter flow or grade (greater than two percent), double inlets should be considered. Depressed grates and stream flow grates should not be used except in unique or unusual situations that require their use and only outside the lane sharing area. Where necessary, depressed grates should only be installed on shoulders six feet wide or greater. Where projects offer the possibility for replacement of stream flow grates located in the lane sharing area, these grates should be replaced with the “bicycle safe” grate.

When roads or intersections are widened, new bicycle safe drainage grates should be installed at a proper location at the outside of the roadway. Existing grates and inlet boxes should be removed and the roadway reconstructed. Drainage grate extensions, the installation of steel or iron cover plates or other “quick fix” methods that allow for the retention of the subsurface drain inlet are unacceptable measures since they will create a safety hazard in the portion of the roadway where cyclists operate.

Manholes and covers should be located outside of the lane sharing area wherever possible. Utility fixtures located within the lane sharing area, or any travel lane used by bicycle traffic, should be eliminated or relocated. Where these fixtures cannot be avoided, the utility fixture cover should be made flush with the pavement surface.

Combination Curb and Gutter

These types of curbs reduce space available for cyclists. The width of the gutter pan should not be used when calculating the width of pavement necessary for shared use by cyclist. Caltrans includes the gutter as part of its calculations of bike lane widths and uses a larger minimum width when adjacent to vertical curbs and parking. See Figure 1003.2A of the Caltrans *Highway Design Manual Chapter 1000*. Although acceptable, this is not ideal. On steep grades, the gutter should be set back an additional one foot to allow space to avoid crashes caused by the longitudinal joint between the gutter pan and pavement. Where the combination curb and gutter is used, pavement width should be calculated by adding one foot from the curbed gutter.

Bridges

Bridges provide essential crossings over obstacles such as rivers, rail lines and high speed roadways, but they have been almost universally constructed for the expedience of motor vehicle traffic and often have features not desirable for cycling. Among these features are widths narrower than the approach roadways (which are especially troublesome when combined with relatively steep approach grades), low railings or parapets, high curbs and expansion joints that can cause steering problems.

Though sidewalks are generally not recommended for cycling, there are limited situations such as on long or narrow bridges where designation of the sidewalk as an alternate bikeway facility can be beneficial to cycling, especially when compared to riding in the narrow bridge roadway. This is only recommended where the appropriate curb cuts, ramps and signage can also be included. Using the bridge sidewalk as a bikeway facility is especially useful where pedestrian use is expected to be minimal. Appropriate signage directed to all potential users should be installed so that they will be aware of the shared use situation. Bridge railings or barrier curb parapets where bicycle use is anticipated should be a minimum of 4.5 feet high.

Short of wholesale replacement of existing narrow bridges over rail lines and highways, there are a few measures to substantially improve safety for cyclists. Signage warning drivers of both the presence of cyclists and the minimal bridge width should be installed at the bridge approaches. Warning stripe areas should be painted along high curbs to deter cyclists from riding too close to them, which can result in a pedal striking these high curbs, causing a crash. This situation is of particular concern since less experienced cyclists will probably want to stay as far to the right as possible to avoid passing motor vehicles traffic, even though riding far to the right increases the chances of hitting the high curb.

Though the first alternative mentioned above, bridge replacement, is the preferred alternative for bridges that are too narrow, it is the least likely to occur due to cost. A second alternative is to direct cyclists to alternate, safer routes, but this will not always be practical since highway and rail crossing points are usually limited in number and considerable distances apart. In any case, these other crossing points may well have similar width restrictions.

A third alternative is to build separate bridges for cyclist and pedestrian use. Where access warrants a workable solution, this could be a cost-effective long-term solution compared to rebuilding a motor vehicle bridge. This additional bridges could be built adjacent to the motor vehicle bridge, or be installed well away from it, depending upon where best to conveniently accommodate cyclists and pedestrians. An advantage to constructing the bridges away from motor vehicle bridges is that only one bridge would be needed since building bicycle/pedestrian bridges immediately adjacent to existing motor vehicle bridges would require constructing two spans, one on each side of the roadway, for optimum user safety.

If sidewalk widths are sufficient, directing cyclists to use the sidewalks and installing ramps at the bridge ends is a possible solution. In general, sidewalks are not recommended as a cycling venue, but in cases where narrow bridges are not expected to be rebuilt for an extended period of time, this may be a reasonable alternative. If possible, a railing should be installed between the roadway and the sidewalk.

Finally, it should be noted that all the other alternatives are inherently inferior to the first alternative of rebuilding narrow bridges in terms of safety and should only be considered where the first alternative cannot be implemented.

Intersections and Driveways

High speed, wide radius intersection designs with free rights turns, multiple right turn lanes and wide radius turns increase traffic throughput for motor vehicles by minimizing speed differentials between entering and exiting vehicles and through vehicles. However, these designs are dangerous for cyclists (and pedestrians) by design since they exacerbate speed differential problems faced by cyclists traveling along the right side of a roadway and encourage drivers to fail to yield the right-of-way to cyclists. As a result, Caltrans District 11 (San Diego County area) no longer allows such wide radius free right turns at interchanges.

Where they already exist, specific measures should be employed to ensure that the movement of cyclists along the roadway will be visible to drivers and to provide cyclists with a safe area to operate to the left of these wide radius right turn lanes. One method to accomplish this is to stripe a bicycle lane through the intersection, or even to paint a solid bike lane. Also, "BICYCLES MAY USE FULL LANE" signs should be posted in advance of the intersection to alert existing traffic. In general, however, curb radii should be limited to short distances, which helps to communicate to the driver that he or she must yield the right-of-way to cyclists and to pedestrians walking along the sidewalk or roadway edge approaching the intersection. Even so, wherever possible, such intersection conditions should be eliminated. Reconstruction of intersections to accomplish this is a legitimate use of bicycle program funds.

Sand, gravel and other debris in the cyclist's path present potential hazards. To minimize the possibility of debris from being drawn onto the pavement surface from unpaved intersecting streets and driveways, during new construction, reconstruction and resurfacing, all unimproved intersecting streets and driveways should be paved back to the right-of-way line or a distance of 10 feet. Where curb cuts permit access to roadways from abutting unpaved parking lots, a paved apron should be paved back to the right-of-way line, preferably 10 feet from the curb line. These practices will decrease the need for maintenance debris removal. The placement of the paved apron should be the responsibility of those requesting permits for access via curb cuts from driveways and parking lots onto the roadway system.

Access Control

Frequent access driveways, especially commercial access driveways, tend to convert the right lane of a roadway and its shoulder area into an extended auxiliary acceleration and deceleration lane. Frequent turning movements, merging movements and vehicle occupancy of the shoulder can severely limit the ability of cyclists to utilize the roadway and are the primary causes of motor vehicle-bicycle collisions. As a result, access control measures should be employed to minimize the number of entrances and exits onto roadways. For driveways having a wide curb radius, consideration should be given to marking a bicycle lane through the driveway intersection areas. As with other types of street intersections, driveways should be designed with sufficiently tight curb radii to clearly communicate to drivers that they must fully stop and then yield the right-of-way to cyclists and pedestrians on the roadway.

Traffic Calming

There exist roadway conditions in practically all communities where controlling traffic movements and reducing motor vehicle speeds is a worthwhile way to create a safer and less stressful environment for the benefit of non-motorized users such as pedestrians and cyclists. These controlling measures are referred to as traffic calming. These measures are also intended to mitigate vehicular traffic impacts such as noise, crashes and air pollution, but the primary link between traffic calming and bicycle planning is the relationship between motor vehicle speed and the severity of crashes. Studies have shown that instituting traffic calming techniques significantly decreases the number of pedestrian and cyclist fatalities in crashes involving motor vehicles, as well as the level of injuries and air pollution, without decreasing traffic volume.

Stop Signs/Yield Signs

The installation of stop signs is a common traffic calming device intended to discourage vehicular through traffic by making the route slower for drivers. However, stop signs are not speed control devices, but rather right-of-way control devices. They do not slow the moving speed of motor vehicles and compliance by cyclists is very low. Requiring motor vehicles to stop excessively also contributes to air pollution. Cyclists are even more inconvenienced by stop signs than drivers because unnecessary stopping requires them to repeatedly re-establish forward momentum. The use of stop signs as a traffic management tool is not generally recommended unless a bicycle route must intersect streets with high motor vehicle traffic volumes. Controlled intersections generally facilitate bicycle use and improve safety while stop signs tend to facilitate bicycle movement across streets with heavy motor vehicular traffic. An alternative to stop signs may be to use yield signs or other traffic calming devices as methods to increase driver awareness of crossing cyclists.

Speed Humps

Bicycle-friendly speed humps (and speed lumps, the same as humps, but with cutouts for emergency vehicle access) address two design specifics:

- Sinusoidal profile – to eliminate pavement lip
- Not extending the speed hump/lump into the bike lane



Recommended sinusoidal speed hump profile



Not recommended parabolic speed hump profile

Speed humps on bikeways should be designed to slow motor vehicles while minimizing the disruption to cyclists. Cyclists feel the lip of the speed hump, the edge of the paving where the speed hump meets the street as an abrupt jolt. While the overall height of the speed hump has comparatively little impact on cyclists, drivers are less impacted by an abrupt lip because of a vehicle's greater shock absorbency.

Bicycle-friendly speed humps eliminate this lip by providing a smooth transition from the street to the speed hump. Such speed humps still have the intended effect of slowing motor vehicles because the height of the speed hump remains the same. More specifically, bicycle-friendly speed humps have a sinusoidal profile to avoid the abrupt lip created by speed humps with parabolic profiles. The installation of speed humps on bikeways should seek to minimize this lip by providing a smooth pavement transition.

Typical speed humps extend to the edge of concrete gutter while bicycle-friendly speed humps extend only to the edge of the bike lane. However, more drivers can be expected to drive around speed humps when they extend only to the edge of the bike lane. The need to extend speed humps to the edge of the bike lane or the edge of the concrete gutter should consider the overall need for traffic calming and the associated impacts on cyclists.

Standard advance warning signs and markers must be installed as well.

Permeable Pavement

Traditional impervious surfaces such as asphalt and concrete can be damaging to the local environment. Stormwater runoff collects dirt and debris and even oil from the asphalt itself and washes them into the streams, lakes and oceans. Stormwater runoff is the leading source of non point-source pollutants entering our waterways. This stormwater runoff does not get treated, but instead is directly transported into the local water system.

An alternative to an impervious surface for bike paths is a porous pavement such as pervious concrete or asphalt. Pervious pavement assists water filtration into the soil by capturing rainwater in a network of voids and allowing it to percolate into the underlying soil. This material is a carefully controlled mix of water and cementing material used to create a paste that forms a thick coating around aggregate particles. A pervious pavement mixture contains little or no sand that would otherwise fill voids. Using this paste to coat and bind the aggregate particles together creates a system of highly permeable, interconnected voids that drains quickly by allowing rainwater to seep into the ground. Porous pavement is instrumental in recharging groundwater, reducing stormwater runoff and meeting U.S. Environmental Protection Agency (EPA) stormwater regulations.

By capturing the first flow of rainfall and allowing it to percolate into the ground, soil chemistry and biology can then filter the polluted water naturally, allowing stormwater retention areas to be reduced or eliminated. In some cases, pervious pavements can double as water retention structures, reducing or eliminating the need for traditional stormwater management systems such as retention ponds and sewer tie-ins. Furthermore, by collecting rainfall and allowing it to infiltrate, groundwater and aquifer recharge is increased, peak water flow through drainage channels is reduced and flooding is minimized. In fact, EPA named pervious pavements as a best management practice (BMP) for stormwater pollution prevention because they allow surface runoff to percolate into the soil.

Maintenance Priorities

Bikeway maintenance is easily overlooked. The paving and surface maintenance schedule of bicycle facilities should be increased to the levels of arterial roads to ensure a safe, comfortable surface for bicycling.

The “sweeping” effect of passing motor vehicle traffic readily pushes debris such as litter and broken glass toward the roadway edges where it can accumulate within an adjoining bicycle facility. Since the potential for loss of control can exist due to a blowout caused by broken glass, or through swerving to avoid other debris, proper maintenance is directly related to safety. For this reason, street sweeping must be a priority on roadways with bike facilities, especially in the curb lanes and along the curbs themselves. The police department could assist by requiring towing companies to fully clean up crash scene debris, or face a fine. This would prevent glass and debris from being left in place after a motor vehicle crash, or simply swept to the curb or shoulder area.

A suggested minimum monthly sweeping schedule is recommended for heavily used Class 1 and 2 facilities and twice a year where use is light. Class 3 facilities should be swept at least twice a year.

Bikeway Reconstruction

Since roadways with designated bicycle facilities carry the largest volumes of users, their reconstruction should be of particular concern. Unfortunately, bicycle facilities are often installed piecemeal and users can find themselves facing construction detours and poor integration of facilities where facilities begin and end.

Bicycles facilities also sometimes seem to “disappear” after roadway construction occurs. This can happen incrementally as paving repairs are made over time and are not followed by proper bikeway re-striping. When combined with poor surface reconstruction following long periods out of service due to road work, this can result in the eventual loss of affected bikeway facilities and decrease the number of cyclists regularly using the facilities.

Adjacent construction projects that require the demolition and rebuilding of roadway surfaces can cause problems in maintaining and restoring bikeway function. Construction activities controlled through the issuance of permits, especially driveway, drainage, utility, or street opening permits, can have an important effect on the quality of a roadway surface where cyclists operate. Such construction can create hazards such as mismatched pavement heights, rough surfaces or longitudinal gaps in adjoining pavements.

Permit conditions should ensure that pavement foundation and surface treatments are restored to their pre-construction conditions, that no vertical irregularities will result and that no longitudinal cracks will develop. Stricter specifications, standards and inspections designed to prevent these problems should be developed, as well as more effective control of construction activities wherever bikeways must be temporarily demolished. A five year bond should be held to assure correction of any deterioration that may occur as a result of faulty roadway surface reconstruction.

Spot widening associated with new access driveways frequently results in the relocation of drainage grates. Any such relocation should be designed to permanently close the old drainage structure and restore the roadway surface. New drainage structures should be selected and located to comply with drainage provisions established in these guidelines.

Bicycle Parking Facilities

Marginal Improvements and Retrofitting Existing Roadways

There may be instances or locations where it is not feasible to fully implement guidelines pertaining to the provision of adequate pavement space for shared use due to environmental constraints or unavoidable obstacles. In such cases, warning signs and/or pavement striping must be employed to alert cyclists and drivers of the obstruction, alert drivers and cyclist of the need to share available pavement space, identify alternate routes (if they exist), or otherwise mitigate the obstruction.

On stretches of roadway where it is not possible to provide recommended shoulder or lane widths to accommodate shared use, bicycle traffic conditions can be improved by:

- Striping wider outside lanes and narrower interior lanes
- Providing a limited paved shoulder area by striping a narrow travel lane. This tends to slow motor vehicle operating speeds and establish a space (with attendant psychological benefits) for cyclists.

Where narrow bridges create a constriction, striping should be used to shift traffic away from the parapet and provide space for bicycle traffic.

Other possible strategies include:

- Elimination of parking or restricting it to one side of the roadway
- Reduction of travel lanes from two in each direction to one in each direction, plus a center turn lane and shoulders
- Reduction of number of travel lanes in each direction and inclusion or establishment of paved shoulders

Whenever possible, the racks should be placed within 50 feet of building entrances where cyclists would naturally transition to pedestrian mode. The rack placement would ideally allow for visual monitoring by people within the building and/or people entering the building. The placement of the racks should minimize conflicts with both pedestrians and motorized traffic. All bicycle parking should be on paving and located a minimum of two feet from a parallel wall, and four feet from a perpendicular wall (as measured to the closest center of the rack).

The following paragraphs and graphics focus on outdoor installations using racks intended to accommodate conventional, upright, single-rider bicycles and a solid, U-shaped lock, or a cable lock, or both.

Rack Element

The rack element is the part of the bike rack that supports one bicycle. It should support the bicycle by its frame in two places, prevent the front wheel from tipping over, allow the frame and one or both wheels to be secured and support bicycles with unconventional frames.

“Inverted-U” and similar type racks are most recommended because each element can support two bicycles. Commonly used “wave” type racks are not recommended because they support the bicycle at only one point. Also, cyclists often park their bikes parallel with such racks, instead of perpendicular as intended, which reduces the rack capacity by half.

The rack element must resist being cut or detached using common hand tools, especially those that can be concealed in a backpack. Such tools include bolt cutters, pipe cutters, wrenches and pry bars. Square tubing is highly recommended.

Rack

The rack itself is one or more rack elements joined on a common base or arranged in a regular array and fastened to a common mounting surface.

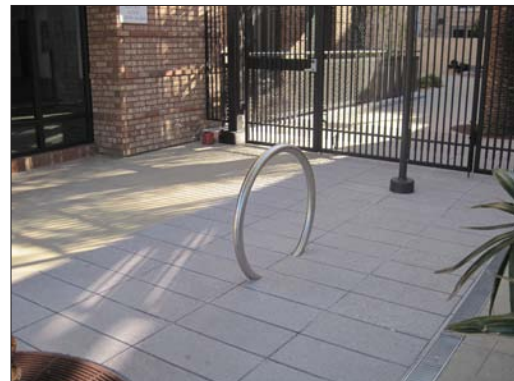
The rack elements may be attached to a single framework or remain single elements mounted in close proximity. They should not be easily detachable from the rack framework or easily removed from the mounting surface. The rack should be anchored so that it cannot be stolen with the bikes attached, such as with vandal-resistant fasteners.

The rack should provide easy, independent bike access. Typical inverted-U rack elements mounted in a row should be placed on 30" centers. Normally, the handlebar and seat heights will allow two bicycles to line up side by side in opposite directions. If it is too inconvenient and time-consuming to squeeze the bicycles into the space and attach a lock, cyclists will look for alternative places to park or use one rack element per bicycle and reduce the projected parking capacity by half.

See Page 44 for specific bicycle rack type recommendations.



Custom bicycle rack (Oceanside, CA)



Custom bicycle rack (San Diego, CA)

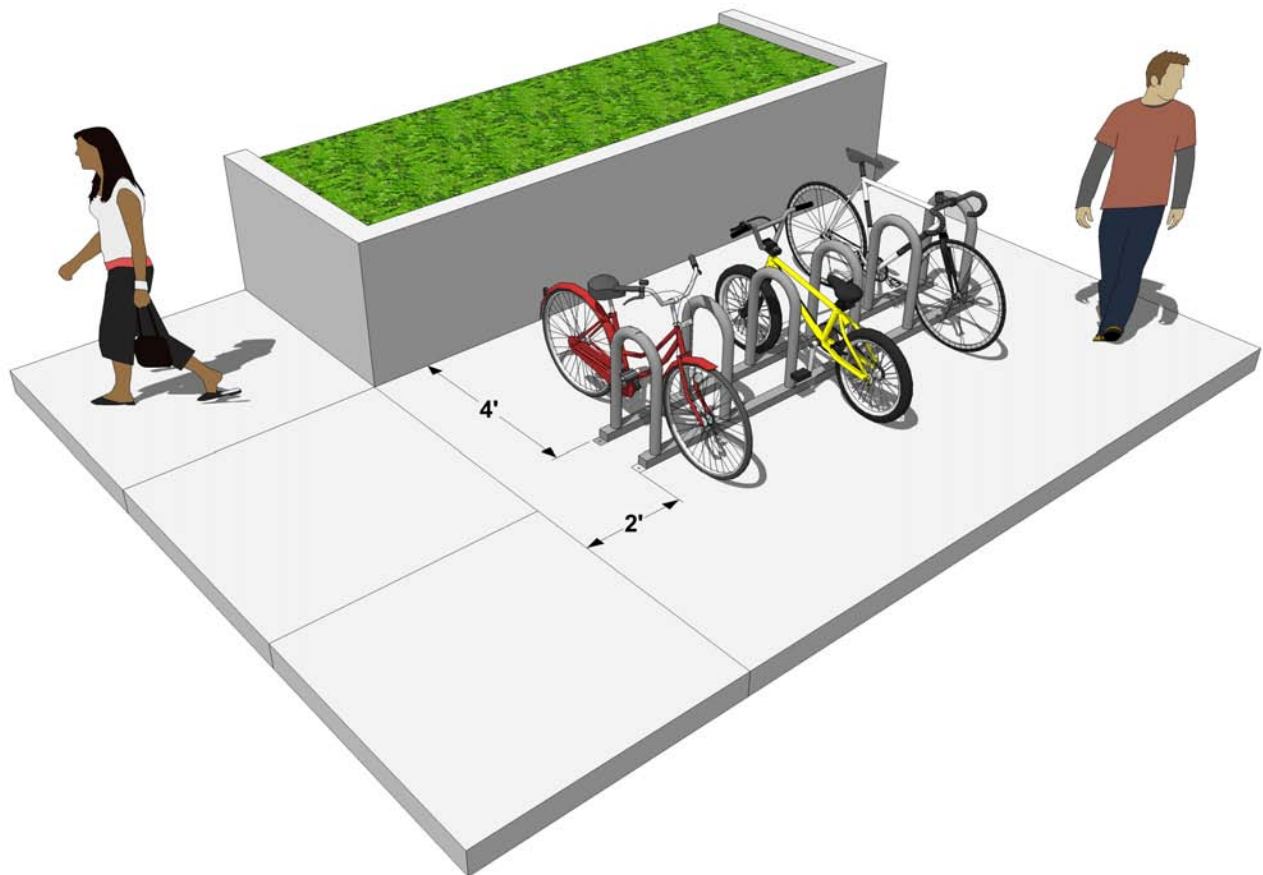


Bike corral (Fort Collins, CO)

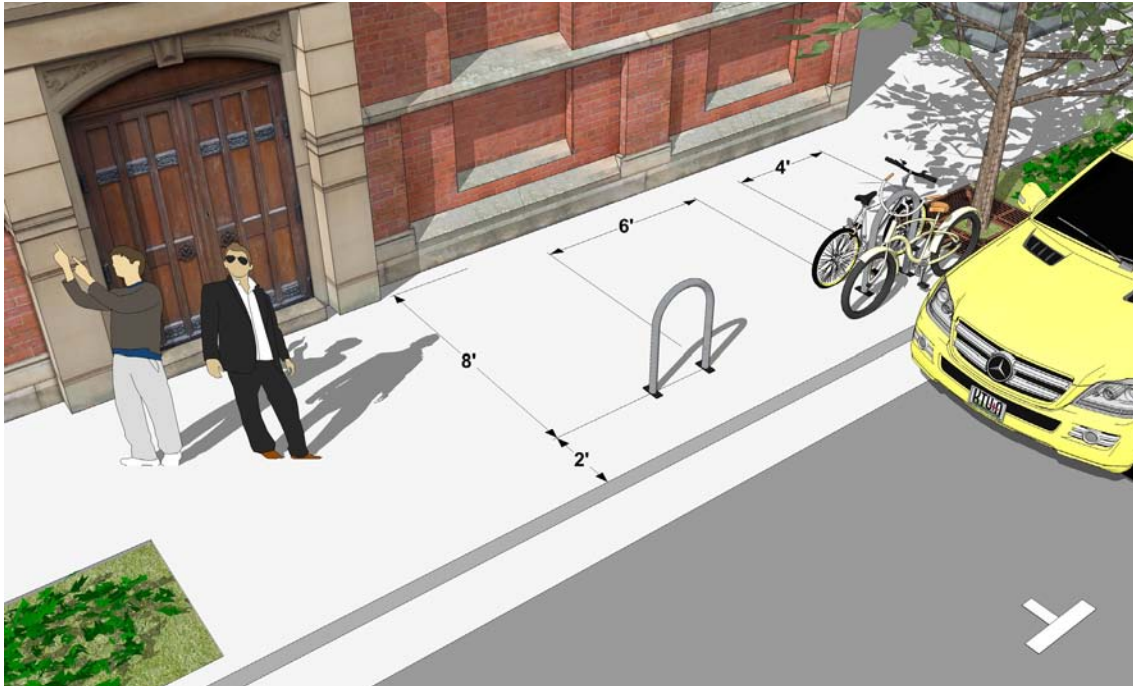
Rack Area

The rack area is a bicycle parking lot where multiple racks are separated by aisles. The distance between aisles is measured from tip to tip of bicycle tires across the space between racks. The minimum separation between aisles should be 48 inches, which provides enough space for one person to walk one bicycle. In high traffic areas where many users park or retrieve bicycles at the same time, such as at college campuses, the recommended aisle width is 72 inches. The depth of each row of parked bicycles should also be 72 inches.

Large rack areas in high turnover areas should have more than one entrance. If possible, the rack area should be protected from the elements. Even though cyclists are exposed to sun, rain and snow while en route, covering the rack area keeps cyclists more comfortable while parking, locking their bicycles and loading or unloading cargo. A covering will also help keep bicycles dry, especially the saddles.



Bicycle rack dimensions for installations adjacent to walls



Bicycle rack dimensions for installations parallel to curb



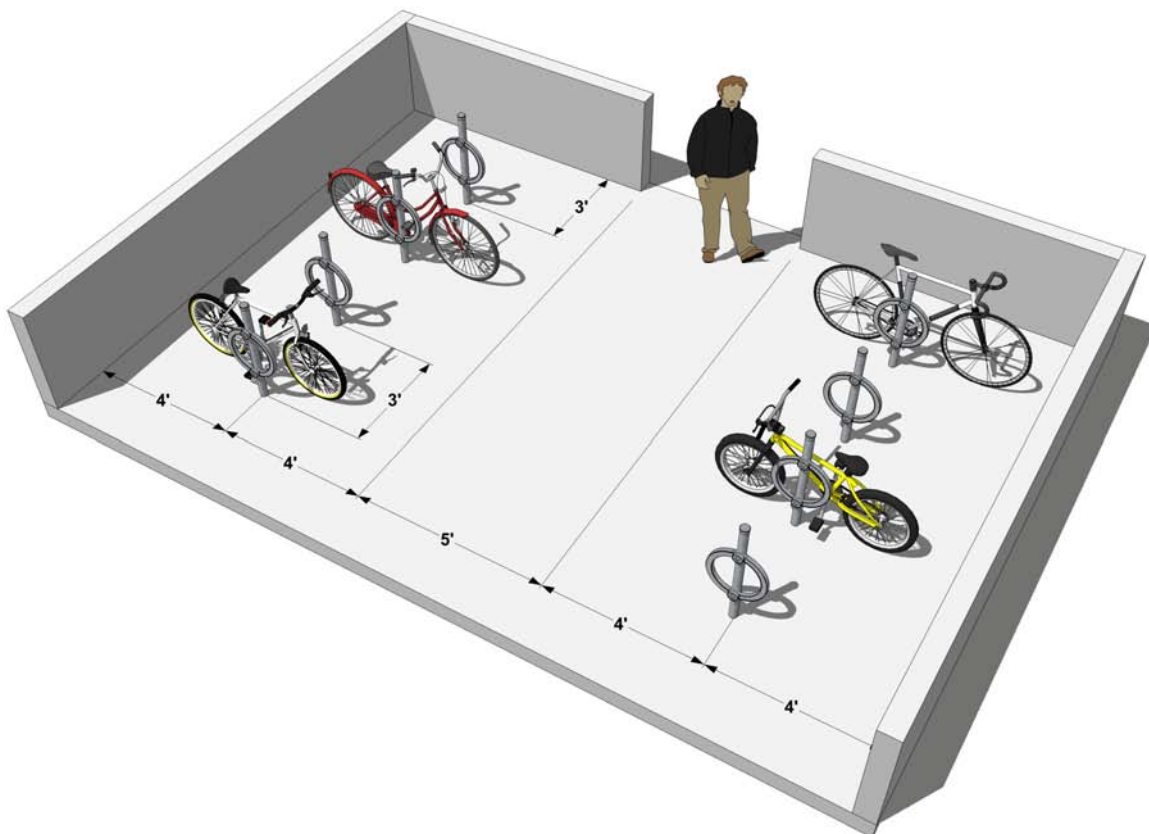
Bicycle rack dimensions for installations perpendicular to curb

Rack Area Site

The rack area site is the relationship of a rack area to the building entrance or approach. In general, smaller, conveniently located rack areas should serve multiple buildings, rather than a larger combined, distant one. Racks far from the entrance or perceived to be where bicycles will be vulnerable to vandalism will not receive much use.

Rack area location in relationship to the building it serves is very important. The best location is immediately adjacent to the entrance it serves, but racks should not be placed where they can block the entrance or inhibit pedestrian flow. The rack area should be located along a major building approach line and clearly visible from the approach.

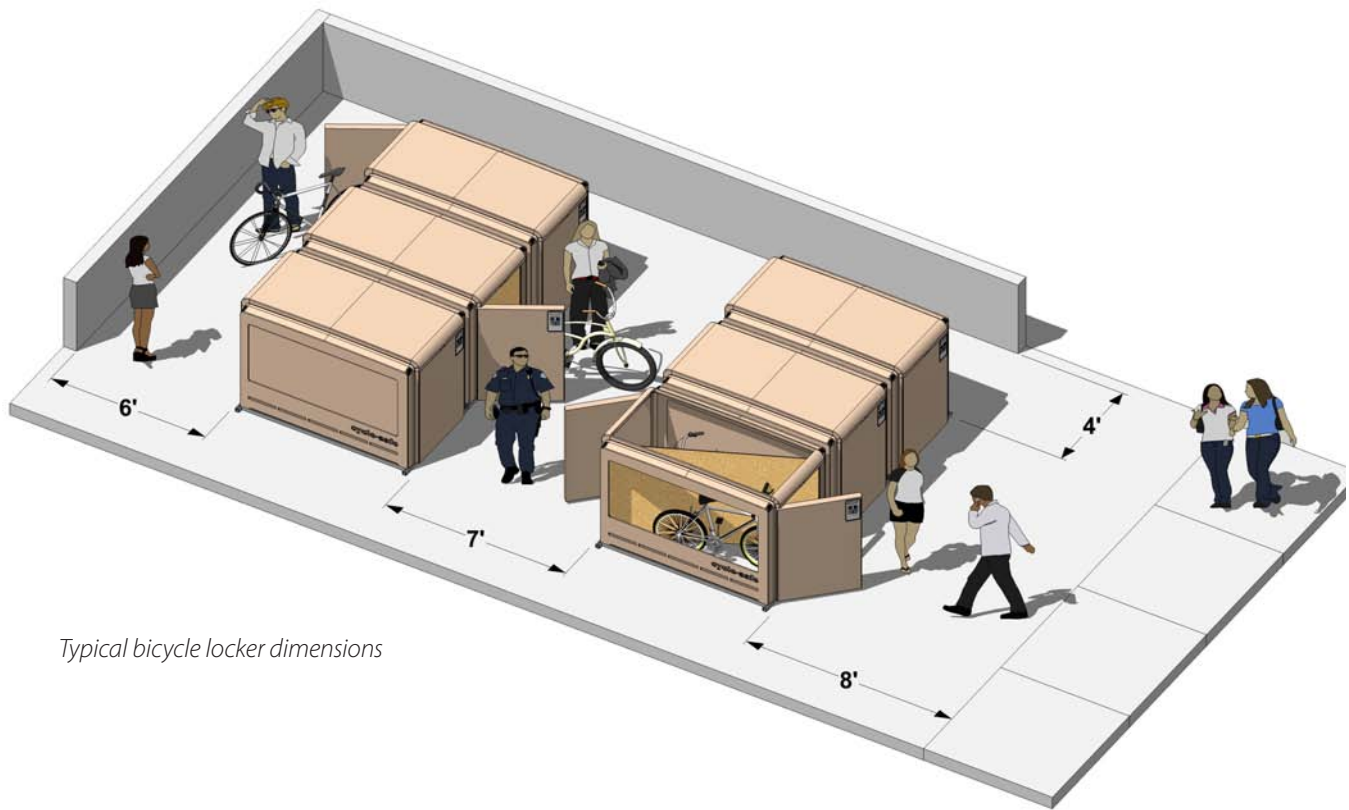
The rack area should be no more than a 30 second walk (120 feet) from the entrance it serves and should preferably be within 50 feet. A rack area should be as close or closer than the nearest car parking space, be clearly visible from the entrance it serves and be near each actively used entrance. In some cases, an appropriate location may be within the adjacent right-of-way as a bike corral, as shown in the graphic on the facing page.



Bicycle rack dimensions for installations to serve large areas



Bike corral dimensions - Converts one car parking space into 8-10 bike spaces



Typical bicycle locker dimensions

Long-term Parking

Bicycle parking facilities intended for long-term parking must protect against theft of the entire bicycle and its components and accessories. Three common ways of providing secure long-term bicycle parking are:

- Fully enclosed lockers accessible only by the user, either coin-operated, or by electronic, on-demand locks operated by “smartcards” equipped with touch-sensitive imbedded RFID chips.
- A continuously monitored facility that provides at least medium-term type bicycle parking facilities generally available at no charge.
- Restricted access facilities in which short-term type bicycle racks are provided and access is restricted only to the owners of the bicycles stored there.

Perhaps the easiest retrofit is the bicycle locker. Generally, they are as strong as the locks on their doors and can secure individual bikes with their panniers, computers, lights, etc., left in place. Some bike locker designs can be stacked to double the parking density. Weather protection is another benefit. Bike lockers tend to be used most for long-term bicycle commuter parking in areas without continuous oversight. On the downside, if lockers have coin-operated locks, they can be a target of theft and may attract various unintended uses. This can be mitigated by installing lockers with mesh sides to allow periodic inspection.

Priority Project Costs

The following are detailed cost estimates for the five selected priority projects described in Chapter 5.

Note that Project #1, which combines facilities along Hopkins Lane with a connection north of the Geisel Library has been sub-divided into two separate estimates.

This is also the case with Project #3, which combines the Library Walk bicycle bypass (Grove Path) and facilities on Peterson Hill.

Also, Project #2 (Voigt Crosswalk at Warren College) contains two options, one with a pedestrian crossing and speed humps, (Option A) and one with a traffic signal (Option B).

Top 5 Priority Projects Costs

UCSD Bicycle and Pedestrian Master Planning Study Cost Estimate - For Planning Purposes Only

Hopkins Lane

Item	Description	Qty.	Unit	Unit Cost	Total Cost
1	Remove asphalt	2,400	SF	\$ 3.0	\$ 7,200
2	Remove concrete curb and gutter	650	LF	\$ 5.0	\$ 3,250
3	Excavation	90	CY	\$ 60.0	\$ 5,400
4	Remove existing light fixtures	3	EA	\$ 500.0	\$ 1,500
5	Retaining wall	200	LF	\$ 80.0	\$ 16,000
6	Curb and gutter	650	LF	\$ 21.0	\$ 13,650
7	Concrete sidewalk	7,200	SF	\$ 5.0	\$ 36,000
8	Accessible ramp	5	EA	\$ 1,500.0	\$ 7,500
9	Striping	1,000	LF	\$ 0.5	\$ 500
10	Stencils	7	EA	\$ 200.0	\$ 1,400
11	Light fixtures	12	EA	\$ 2,000.0	\$ 24,000
12	Traffic control and mobilization (10%)	1	LS	\$ 12,000	\$ 12,000
13	Design of improvements (10%)	1	LS	\$ 12,000	\$ 12,000
Subtotal					\$ 140,400
Contingency (20%)					\$ 28,080
TOTAL					\$ 168,480

Connection North of Library

Item	Description	Qty.	Unit	Unit Cost	Total Cost
1	Remove asphalt	4,530	SF	\$ 3.0	\$ 13,590
2	Clearing and grubbing	1	LS	\$ 5,000.0	\$ 5,000
3	Excavation	60	CY	\$ 60.0	\$ 3,600
4	Hot mix asphalt	170	TON	\$ 110.0	\$ 18,700
5	Aggregate base	180	CY	\$ 120.0	\$ 21,600
6	Decomposed granite	400	SF	\$ 2.5	\$ 1,000
7	Light fixtures	8	EA	\$ 2,000.0	\$ 16,000
8	Mobilization (10%)	1	LS	\$ 8,000	\$ 8,000
9	Design of improvements (10%)	1	LS	\$ 8,000	\$ 8,000
Subtotal					\$ 95,490
Contingency (20%)					\$ 19,100
TOTAL					\$ 114,590

Notes and assumptions:

1. This construction cost estimate is preliminary based on aerial graphics and is for planning purposes only.
2. Costs do not include drainage improvements or utility relocation.

UCSD Bicycle and Pedestrian Master Planning Study
Cost Estimate - For Planning Purposes Only

Voigt Crosswalk at Warren College - Option A

Item	Description	Qty.	Unit	Unit Cost	Total Cost
1	Remove asphalt	1,440	SF	\$ 3.0	\$ 4,320
2	Remove existing signage and flashing beacon	4	EA	\$ 150.0	\$ 600
3	Remove sidewalk	350	SF	\$ 2.0	\$ 700
4	Remove pavement marking	400	SF	\$ 1.5	\$ 600
5	Hot mix asphalt (pavement underneath existing speed table)	35	TON	\$ 110.0	\$ 3,850
6	Hot mix asphalt (speed humps)	16	TON	\$ 110.0	\$ 1,760
7	Accessible ramp	2	EA	\$ 1,500.0	\$ 3,000
8	Cobblestone/landscaping	1	LS	\$ 2,000.0	\$ 2,000
9	Striping (4" painted)	200	LF	\$ 0.5	\$ 100
10	Striping (12" painted)	240	LF	\$ 2.0	\$ 480
11	Signage	6	EA	\$ 150.0	\$ 900
12	<i>Rapid Rectangular Flashing Beacon w/Remote Detection (optional)</i>	2	EA	\$ 15,000.0	\$ 30,000
13	Traffic control and mobilization - without optional RRFB (10%)	1	LS	\$ 2,000	\$ 2,000
14	Design of Improvements - without optional RRFB (10%)	1	LS	\$ 2,000	\$ 2,000
15	<i>Traffic control and mobilization - with optional RRFB (10%)</i>	1	LS	\$ 5,000	\$ 5,000
16	<i>Design of improvements - with optional RRFB (10%)</i>	1	LS	\$ 5,000	\$ 5,000
Subtotal - without optional RRFB					\$ 22,310
Subtotal - with optional RRFB					\$ 62,310
Contingency - without optional RRFB (20%)					\$ 4,460
Contingency - with optional RRFB (20%)					\$ 12,460
TOTAL - without optional RRFB					\$ 26,770
TOTAL - with optional RRFB					\$ 74,770

Notes and assumptions:

1. This construction cost estimate is preliminary based on aerial graphics and is for planning purposes only.
2. Costs do not include drainage improvements or utility relocation.

Top 5 Priority Projects Costs

UCSD Bicycle and Pedestrian Master Planning Study Cost Estimate - For Planning Purposes Only

Voigt Crosswalk at Warren College - Option B

Item	Description	Qty.	Unit	Unit Cost	Total Cost
1	Remove asphalt	1,440	SF	\$ 3.0	\$ 4,320
2	Remove existing signage and flashing beacon	4	EA	\$ 150.0	\$ 600
3	Remove sidewalk	350	SF	\$ 2.0	\$ 700
4	Remove pavement marking	400	SF	\$ 1.5	\$ 600
5	Hot mix asphalt (pavement underneath existing speed table)	35	TON	\$ 110.0	\$ 3,850
6	Accessible ramp	2	EA	\$ 1,500.0	\$ 3,000
7	Cobblestone/landscaping	1	LS	\$ 2,000.0	\$ 2,000
8	Striping (4" painted)	200	LF	\$ 0.5	\$ 100
9	Striping (12" painted)	130	LF	\$ 2.0	\$ 260
10	Signage	2	EA	\$ 150.0	\$ 300
11	Traffic signal	1	EA	\$ 120,000.0	\$ 120,000
12	Traffic control and mobilization (10%)	1	LS	\$ 14,000	\$ 14,000
13	Design of improvements (10%)	1	LS	\$ 14,000	\$ 14,000
Subtotal					\$ 163,730
Contingency (20%)					\$ 32,750
TOTAL - with optional RRFB					\$ 196,480

Notes and assumptions:

1. This construction cost estimate is preliminary based on aerial graphics and is for planning purposes only.
2. Costs do not include drainage improvements or utility relocation.

UCSD Bicycle and Pedestrian Master Planning Study
Cost Estimate - For Planning Purposes Only

Grove Path

Item	Description	Qty.	Unit	Unit Cost	Total Cost
1	Remove asphalt	1,200	SF	\$ 3.0	\$ 3,600
2	Remove concrete curb and gutter (existing median)	130	LF	\$ 5.0	\$ 650
3	Excavation	10	CY	\$ 60.0	\$ 600
4	Curb and gutter (new median)	500	LF	\$ 21.0	\$ 10,500
5	Hot mix asphalt	38	TON	\$ 110.0	\$ 4,180
6	Aggregate base	40	CY	\$ 120.0	\$ 4,800
7	Landscaping	1	LS	\$ 10,000.0	\$ 10,000
8	Accessible ramp	1	EA	\$ 1,500.0	\$ 1,500
9	Stencils	12	EA	\$ 200.0	\$ 2,400
10	Signage	10	EA	\$ 150.0	\$ 1,500
11	Traffic control and mobilization (10%)	1	LS	\$ 4,000	\$ 4,000
12	Design of improvements (10%)	1	LS	\$ 4,000	\$ 4,000
Subtotal					\$ 47,730
Contingency (20%)					\$ 9,550
TOTAL					\$ 57,280

Peterson Hill

Item	Description	Qty.	Unit	Unit Cost	Total Cost
1	Remove concrete path	900	SF	\$ 2.0	\$ 1,800
2	Excavation	50	CY	\$ 60.0	\$ 3,000
3	Concrete stairs (includes AB and formwork)	65	CY	\$ 160.0	\$ 10,400
4	Tubular handrailing	90	LF	\$ 50.0	\$ 4,500
5	Landscaping	1	LS	\$ 5,000.0	\$ 5,000
6	Stencils	3	EA	\$ 200.0	\$ 600
7	Mobilization (10%)	1	LS	\$ 2,000	\$ 2,000
8	Design of improvements (10%)	1	LS	\$ 2,000	\$ 2,000
Subtotal					\$ 29,300
Contingency (20%)					\$ 5,860
TOTAL					\$ 35,160

Notes and assumptions:

1. This construction cost estimate is preliminary based on aerial graphics and is for planning purposes only.

Top 5 Priority Projects Costs

UCSD Bicycle and Pedestrian Master Planning Study Cost Estimate - For Planning Purposes Only

I-5 Bike Path

Item	Description	Qty.	Unit	Unit Cost	Total Cost
1	Clearing and grubbing	1	LS	\$ 20,000.0	\$ 20,000
2	Excavation (import borrow)	1,100	CY	\$ 60.0	\$ 66,000
3	Retaining wall	1,150	LF	\$ 80.0	\$ 92,000
4	Hot mix asphalt	640	TON	\$ 110.0	\$ 70,400
5	Aggregate base	660	CY	\$ 120.0	\$ 79,200
6	Accessible ramp	2	EA	\$ 1,500.0	\$ 3,000
7	Concrete stairs (includes AB and formwork)	35	CY	\$ 160.0	\$ 5,600
8	Striping (12" painted)	750	LF	\$ 2.0	\$ 1,500
9	Mobilization (10%)	1	LS	\$ 34,000	\$ 34,000
10	Design of improvements (10%)	1	LS	\$ 34,000	\$ 34,000
Subtotal					\$ 405,700
Contingency (20%)					\$ 81,140
TOTAL					\$ 486,840

Notes and assumptions:

1. This construction cost estimate is preliminary based on aerial graphics and is for planning purposes only.
2. Costs do not include drainage improvements or utility relocation.
3. Costs assume Voigt Drive bridge replacement (with bike path underneath and Gilman Drive realignment)
4. Costs assume Gilman Drive bridge construction and Gilman Drive underpass construction

Gilman Drive Bike Lanes

Item	Description	Qty.	Unit	Unit Cost	Total Cost
1	Remove concrete curb and gutter	4,720	LF	\$ 5.0	\$ 23,600
2	Excavation	870	CY	\$ 60.0	\$ 52,200
3	Remove pavement marking	8,100	SF	\$ 1.5	\$ 12,150
4	Curb and gutter	4,720	LF	\$ 21.0	\$ 99,120
5	Hot mix asphalt (for bike lane)	630	TON	\$ 110.0	\$ 69,300
6	Aggregate base (for bike lane)	760	CY	\$ 120.0	\$ 91,200
7	Slurry seal	160	TON	\$ 500.0	\$ 80,000
8	Roadway restripe (4" painted stipes, crosswalks, legends)	2,700	LF	\$ 40.0	\$ 108,000
9	Signage	18	EA	\$ 150.0	\$ 2,700
10	Traffic control and mobilization (10%)	1	LS	\$ 54,000	\$ 54,000
11	Design of improvements (10%)	1	LS	\$ 54,000	\$ 54,000
Subtotal					\$ 646,270
Contingency (20%)					\$ 129,250
TOTAL					\$ 775,520

Notes and assumptions:

1. This construction cost estimate is preliminary based on aerial graphics and is for planning purposes only.
2. Costs do not include drainage improvements, utility relocation, new traffic signals or traffic signal modifications.