Best Practices for Bicycle Master Planning and Design

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BICYCLE MASTER PLAN BEST PRACTICES

This document presents best practices for bicycle master plans for consideration and potential adoption by the Collaborative. These best practices were gleaned from bicycle plans recognized as being exemplary and from cities and/or counties that were recognized as being highly bikeable. First, the required elements of a bicycle master plan in the State of California are presented. Next, best practice bicycle master plan content is presented in the form of a typical bicycle plan outline. A special section addressing the current state-of-the-practice with regard to bicycle level of service measures is presented.

The very first step in creating a Bicycle Master Plan is the formation of a Bicycle Advisory Committee to guide the creation of the document and to review ongoing changes made to the Plan. The Bicycle Advisory Committee may be composed of members nominated by Councilmembers or other policymakers, or members of the public may be invited to submit applications for membership.

I. Required Plan Content

Caltrans composed a list of requirements contained in the Streets and Highways Code Section 891.2. Fulfilling these requirements ensures eligibility for Caltrans Bicycle Transportation Account funds. The Bicycle Transportation Account (BTA) provides state funds for city and county projects that improve safety and convenience for bicycle commuters. If the bicycle plan does not follow the exact outline of the Caltrans list of mandatory bicycle plan elements, it is helpful to include in an appendix a guide to where the mandatory elements can be found in the bicycle plan document.

Why create a Bicycle Master Plan?

Most cities, counties, and regions create Bicycle Master Plans for four key reasons:

- To **recognize** bicycling as a form of transportation.
- To improve **safety** for existing bicyclists.
- To **encourage** bicycling.
- To qualify for **funding**.

To be eligible for BTA funds, a city[1] or county must prepare and adopt a Bicycle Transportation Plan (BTP) that contains, as a minimum, the following, as noted in the Streets and Highways Code, Section 891.2:

a) The estimated number of existing bicycle commuters in the plan area and the estimated increase in the number of bicycle commuters resulting from implementation of the plan.
b) A map and description of existing and proposed land use and settlement patterns which shall include, but not be limited to, locations of residential neighborhoods, schools, shopping centers, public buildings, and major employment centers.
c) A map and description of existing and proposed bikeways.
d) A map and description of existing and proposed end-of-trip bicycle parking facilities. These shall include, but not be limited to, parking at schools, shopping centers, public buildings, and major employment centers.
e) A map and description of existing and proposed bicycle transport and parking facilities for connections with and use of other transportation modes. These shall include, but not be limited to, parking facilities at transit stops, rail and transit terminals, ferry docks and landings, park and ride lots, and provisions for transporting bicyclists and bicycles on transit or rail vehicles or ferry vessels.

[1] If a city plans to use a countywide BTP to establish their eligibility for BTA funds, the countywide BTP must include a discussion of the Items a. – k. in Streets and Highways Code Section 891.2 for that city, in addition to the discussions of these items for the unincorporated areas in the county.

f) A map and description of existing and proposed facilities for changing and storing clothes and equipment. These shall include, but not be limited to, locker, restroom, and shower facilities near bicycle parking facilities.
g) A description of bicycle safety and education programs conducted in the area included within the plan, efforts by the law enforcement agency having primary traffic law enforcement responsibility in the area to enforce provisions of the Vehicle Code pertaining to bicycle operation, and the resulting effect on accidents involving bicyclists.
h) A description of the extent of citizen and community involvement in development of the plan, including, but not limited to, letters of support.
i) A description of how the bicycle transportation plan has been coordinated and is consistent with other local or regional transportation, air quality, or energy conservation plans, including, but not limited to, programs that provide incentives for bicycle commuting.
j) A description of the projects proposed in the plan and a listing of their priorities for implementation.
k) A description of past expenditures for bicycle facilities and future financial needs for projects that improve safety and convenience for bicycle commuters in the plan area.

II. Sample Bicycle Plan Outline and Community Outreach Strategy

Each section below contains the purpose, content and pertinent examples from exemplary plans. **Required elements are in italics.**

A. Community Outreach Strategies

When embarking on a citywide or countywide bicycle plan, there are several ways to approach community outreach. An effective outreach strategy is the key to a successful plan and successful project implementation once the plan is adopted. At a minimum, outreach should occur on two levels: individual stakeholders and advocates should have an opportunity for continual, direct input and the community at-large should have an opportunity to have input at key decision points.

The Three-Meeting Process: General Public Outreach

This describes the process for gathering input from the general public. It represents the minimum approach to outreach.

1st Meeting: An interactive meeting with location maps and pens available for meeting participants to identify potential projects, barriers, and wish lists.

2nd Meeting: Presentation of the draft Recommended Bicycle Network. Stakeholders review and revise the network as necessary. Present criteria for prioritization.

3rd Meeting: Presentation of the final, prioritized Recommended Bikeway Network.

Stakeholder Input

Often, one of the most effective ways to engage community members and activists is through the formation of a community advisory committee or a technical advisory committee in development of the plan. The members of this committee may be appointed by policymakers, or the community may be invited to submit applications or letters of interest to the staff members involved in writing the plan. The members of the committee could also include other agency staff with particular expertise (a representative from Parks and Recreation or the Police Department, for example). The committee establishes a regular meeting schedule, which may also serve as the meeting time for the larger community meetings.

Area-Wide Community Input

A critical challenge when dealing with area-wide issues that concern one user group, such as bicyclists, is generating enough interest from a broad cross-section of the community to get input. There are several strategies to overcome this challenge. One strategy is to hold a series of meetings in different districts. Another especially effective strategy is to attend regularly-scheduled meetings of neighborhood or business groups and present information about plan formation to these smaller, established groups. Additionally, sometimes established community groups will host a joint meeting to discuss the plan alone. Another, less effective means is to issue surveys to bicyclists along a particular route. This strategy by its nature offers input from bicyclists-only, rather than the broader population. However, it is sometimes the only way to reach bicyclists unlikely to be exposed to outreach in other ways (cyclists in non-English-speaking communities, for instance). Meeting notification should

B. Introduction

The introduction is an appropriate location for providing background on the bicycle planning process in the community. A description of the community can be provided to give context for the bicycle plan. Also, a description of the extent of citizen and community involvement in development of the plan, including, but not limited to, letters of support could be included in this section.

C. Existing Conditions

Purpose

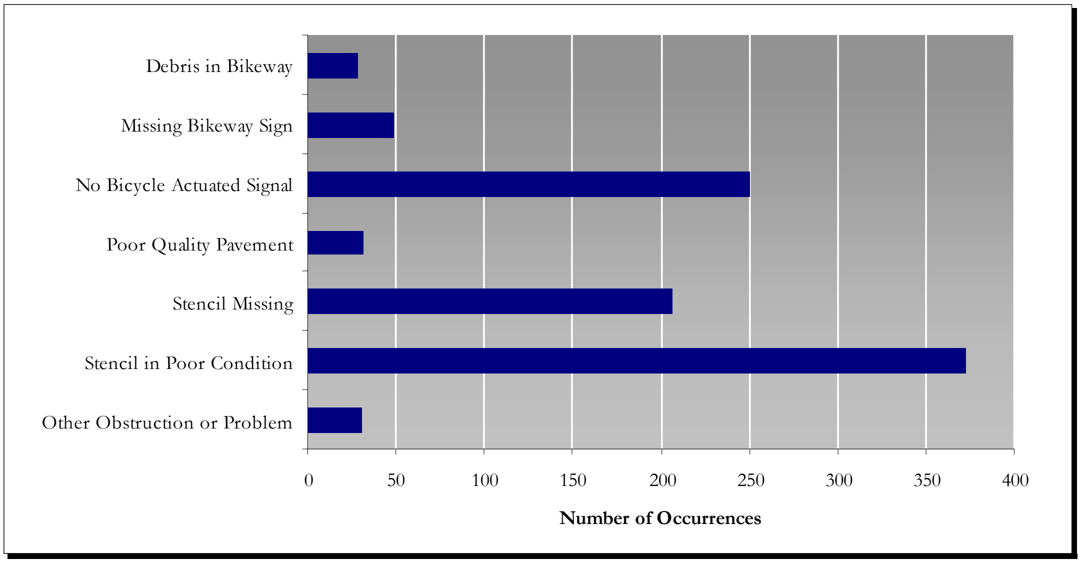
The purpose of this section is to present a comprehensive picture of the existing bicycle facilities to help guide policymaking and the selection and prioritization of future bicycle improvements. Typically the existing conditions data comes from four key sources: a survey of existing street conditions, the Journey to Work data from the most recent Census, bicycle collision data, and community outreach.

Content

- *The number of existing bicycle commuters in the plan area*
- *A map and description of existing bikeways, end-of-trip bicycle parking facilities, intermodal connections and parking facilities, and facilities for changing and storing clothes and equipment.*
- *A map and description of existing land use patterns (Highlight major bicycle trip generators and attractors)*
- Available bicycle count data.
- Current bicycle collision data
- *Expenditures for the last five years for bicycle facilities*
- Bicycle Level of Service Analysis
- Needs analysis

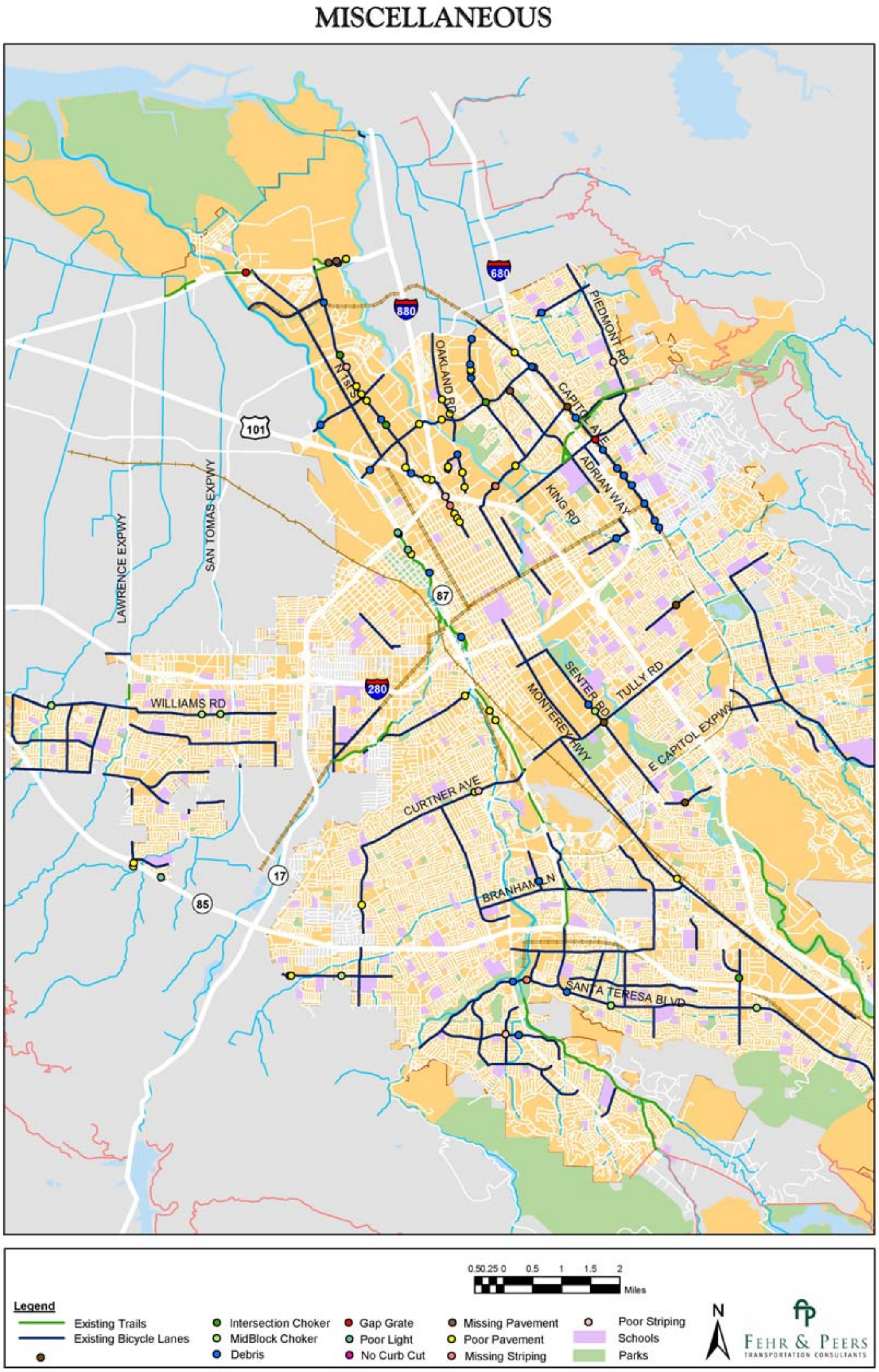
As part of the Bicycle Master Plan update, a detailed survey on all existing bicycle lanes and routes can be performed. The purpose of the survey is to verify the presence of bicycle facilities and identify locations where maintenance is required or improvements needed. The City of San José performed such an audit at the beginning of their Bicycle Master Plan Update. The survey recorded over 950 locations where improvement needs exist.

Figure 1: Bicycle Facility Audit Results



The most common deficiencies were missing or poorly-maintained bicycle lane markings and signals lacking bicycle detection capabilities. Improved maintenance of existing facilities and signal retrofits would be needed to address these deficiencies. Implementing such measures could be costly. Alternatively, stencils and loop detectors can be added as part of normal maintenance rather than recommending a separate, stand-alone program to address the deficiency. The map on the following page is one of a series that illustrates the deficiency locations.

Figure 2: City of San José Deficiency Map



The map below is from the City of Santa Clara's Bicycle Master Plan. It illustrates the basic required elements, including activity centers and existing bikeways.

Figure 3: Sample Existing Facilities Map

D. Policies and Objectives

Purpose

Existing and proposed policies and objectives help guide the creation of the remainder of the bicycle plan and other future bicycle planning activities. The policies and objectives also clearly communicate to citizens, government agencies, and developers the desired role of bicycle transportation in the city and/or county. Another element of this section is benchmarks. Benchmarking assists agencies in measuring the effectiveness of their plans and helps in policy creation. It is essential when measuring successful implementation of any bicycle or pedestrian master plan.

Content

- *A description of how the bicycle transportation plan has been coordinated and is consistent with other local or regional transportation, air quality, or energy conservation plans, including, but not limited to, programs that provide incentives for bicycle commuting.*
- Existing and new bicycle policies and objectives

Sample Goals:

- **Provide a safe, efficient bicycle network** that improves bicycle access and mobility throughout the city and/or county by removing obstacles, implementing bicycle facilities, and enforcing laws related to bicycle travel.
- **Create a policy framework and action program** to enhance bicycling as a viable transportation choice, particularly for commutes and errands under five miles.
- **Implement a citywide and/or countywide network of bikeways** connecting activity centers, schools, employment districts, and neighborhoods that also integrates regional routes.

Accommodating Bicycle and Pedestrian Travel: A Recommended Approach is a policy statement adopted by the United States Department of Transportation. USDOT hopes that public agencies, professional associations, advocacy groups, and others adopt this approach as a way of committing themselves to integrating bicycling and walking into the transportation mainstream.
The Design Guidance incorporates three key principles:

- A policy statement that **bicycling and walking facilities will be incorporated into all transportation projects** unless exceptional circumstances exist;
- An approach to achieving this policy that has already worked in State and local agencies; and
- A series of action items that a public agency, professional association, or advocacy group can take to achieve the overriding goal of improving conditions for bicycling and walking.

-Joint Statement on Accommodating Bicycle and Pedestrian Travel, USDOT

Sample Benchmarks:

- **Double the number of bicycle commuters** from 1.3% of all employed residents to 2.6% of all employed residents per U.S. Census data by 2022
- Implement 35% of all recommended facility improvements within the first five years
- Implement 65% of all recommended facility improvements within ten years, focusing primarily on gaps in the network
- By 2022, **reduce the number of collisions per capita** involving cyclists by 10%
- Provide three to five events per year promoting bicycling within the first five years

Photo by Lorenzo Lopez

- Ensure that at least 50% of all school-age children receive bicycle safety education within the first ten years of the plan
- Ensure that at least 50% of all schools have implemented Safe Routes to School Improvements (either adopting a map or implementing specific improvements where appropriate)

E. Bicycle Facility Design Guidelines

Purpose
This section of the bicycle plan (sometimes created as a separate design guidelines document or included in the appendix) is intended to identify and communicate the design elements important to improving bicycle safety and bicycle comfort level. Arming designers, engineers, developers, and others with these guidelines will help ensure that new and improved bicycle facilities reflect the policies, goals and objectives of this plan, and consequently maximize safety and bicycle comfort. The subsequent sections of the bicycle plan then identify where, to what degree and it what order these guidelines will be implemented throughout the planning area.

Content
The following is a non-exhaustive list of bicycle design elements commonly presented in bicycle master plans or in separate bicycle design guidelines documents:

- Bike lanes
- Signage and markings
- Shared roadway
- Treatments at intersections
- Shared-use paths
- Traffic signals
- Drainage grates and utility covers
- Railroad crossings
- Lighting
- Traffic calming devices
- Bicycle Parking

F. Recommended Bicycle Network

Purpose

This section defines the desired bicycle network based on the bicycle policies and objectives established in the first section of the plan and opportunities for improvement in the bicycle network identified in the second section of the plan.

At the outset of the Plan, stakeholders including local bicyclists, merchants, transit agencies, school districts, law enforcement, and agency staff should have the opportunity for input into the Plan in order to identify barriers to bicycling, opportunities for new facilities, and wish lists identifying particularly challenging facilities. Often, gathering input on a Bicycle Master Plan is difficult. One strategy for meeting this challenge is to identify a smaller group of stakeholders who meet regularly throughout the creation of the Plan.

Content

- Key objectives of the bicycle network
- Criteria for bicycle route selection and proposed level of improvement
- Definition of different types of bicycle facilities
- *A map and description of proposed bikeways*
- List of bikeway improvements to existing bicycle facilities identified by needs assessment (eg. Faded paint on roadway markers, missing signs, defective bicycle signal actuation devices, etc.)

G. Support Facilities and Intermodal Connections

Purpose

Support facilities at or near the destination of a bicycle trip (including on transit vehicles or at transit stations) can play a large role in making bicycling an attractive transportation alternative. This is because support facilities provide a measure of security for bicycles that makes trip-linking possible.

Content

- *Map and description of existing and proposed end-of-trip bicycle parking facilities, and clothes changing and storage facilities at major destinations such as schools, shopping centers, public buildings, major employment centers, and transit stations.*
- Policies and guidelines for the provision of future end-of-trip bicycle parking, and clothes changing and storage facilities.
- Policies and guidelines supporting the transport of bicycles on transit vehicles.

H. Education and Enforcement

Purpose

One of the main goals of a bicycle plan is to provide facilities that help improve bicycle safety. However, safer facilities alone cannot ensure that accidents will not occur. As with motor vehicles, education and enforcement play a large role in making bicycle transportation safer. Since there are no mandatory education or operator licensing requirements for bicycles, it is of even greater importance to identify existing and proposed bicycle education and enforcement programs in the bicycle plan and highlight their impact on bicycle safety.

Content

- Identify and describe current education programs for each targeted group (eg. "youth bicyclists, "adult bicyclists", and motorists), including those provided by bicycle advocacy and user groups and the effectiveness of these programs.
- Identify improvements to existing or new government sponsored educational programs. Maximize the reach of these programs through relationships with advocacy and user groups.
- Identify existing or proposed enforcement programs that will help increase awareness amongst motorists and bicyclists of the laws governing their roadway interaction, and help address safety issues identified in the accident analysis.

Two cities with good education and enforcement programs are the cities of Sunnyvale, CA and San José, CA. Elements of their programs are described below. This is by no means an exhaustive list of education and enforcement tools, but it describes some sample measures.

Sample Programs: Sunnyvale

Education Programs

Bicycle and Pedestrian Advisory Committee Activities

The City's Bicycle and Pedestrian Advisory Committee provides safety tips online. It also coordinates the distribution of a utility bill stuffer annually. For the past two years, the focus of the utility bill stuffer content has been tips on sharing the road with cyclists. Next year's focus will likely be pedestrian safety.

School Programs

The City's Parks and Recreation Department offers after-school Driver Training classes for teens that include sections on bicycle and pedestrian safety. Periodically, they offer a bicycle maintenance and safety class for middle school students, but this is infrequent.

Neighborhood Resource Officers give annual safety lectures, including traffic safety, to elementary students at all of the elementary schools in the City. They also periodically conduct a Bicycle Rodeo for the students.

Bicycle Licensing

The Department of Public Safety (DPS) coordinates a bicycle licensing program. When a bicyclist applies for a license, DPS officers inspect the bicycles and distribute education materials.

Enforcement Programs

Bicycle and Pedestrian Infractions

While the Police Department does not have any special policies regarding bicycle, pedestrian, or motorist violations, they do conduct a program targeting child bicycle violations approximately every 4 months. Underage bicyclists are usually cited into a Bicycle Safety class taught by Neighborhood Resource Officers. Severe staffing shortages have curtailed this program in recent months.

Red Light Running

The City currently has "rat-boxes" at a number of high-incidence red-light running locations. The City participates in a County-wide red light running program that features special events, outreach, projects, etc. For example, Sunnyvale will be hosting a Special Enforcement Detail next month. Traffic Officers from neighboring cities will work in Sunnyvale for several hours to enforce Pedestrian and Rat Box red light violations.

Collision Reporting Training

All Traffic officers attend Advanced Traffic Investigations School or Reconstruction school. Those officers are available for special call back for Major Injury crashes. Officers and administrative personnel are trained in the use of the Crossroads database, as it relates to their specific job functions.

<u>Sample Programs: San José</u>

San José also has several programs aimed at improving bicycle safety. Street Smarts is an educational program designed to make streets safer for drivers, bicyclists, and pedestrians. San José also has a traffic calming program to implement measures reducing vehicle speeds in neighborhoods.

School safety is a major focus within San Jose – the City designates a full-time school safety coordinator to enhance safety and access to schools. Some elements of the School Safety Program were formerly operated by non-profit organization known as Safe Moves, but budgetary constraints have recently eliminated funding for outside assistance. The City has been proactive in developing an internal school safety curriculum, as part of the “One Voice” effort, that will utilize the City’s existing resources and combine them under a single program. The new bicycle and pedestrian safety curriculum will include safety presentations at about half of San José’s schools each year, emphasizing safe routes to schools and the use of bicycle helmets. Training classes and bicycle rodeos will also be offered. The installation of bicycle parking will be another element to the program, as many schools lack adequate parking facilities.

The City’s Bicycle & Pedestrian Program offers the public free Bicycling Skills Courses. Based on the League of American Bicyclists national BikeEd curriculum, these courses empower citizens to bicycle with greater skills, confidence and comfort. Additional resources are needed to expand the program.

The San José Police Department’s School Safety Unit currently gives safety presentations at city schools. These presentations are given to any school that requests it, and a total of about 80 presentations are given each year. Bicycle topics covered include proper helmet use, bicycling laws, bicycle maintenance, and intersection safety. A “Bike Robot” is used to present many of the tips. This program will be combined with existing City efforts under the “One Voice” program as described above.

I. Implementation: Capital Improvement Program

Purpose

The capital improvement program (CIP) is one of the most important elements of a bicycle plan. It helps guide implementation of the bicycle plan.

Content

- A consolidated list of all proposed bicycle improvement projects
- The priority or phasing for the implementation of each improvement
- The cost of each project and a cost per year for all projects to be implemented in the first five to ten years
- The anticipated source(s) of funding for each project

The CIP may have a detailed prioritization for each project, including a cost per project and overall cost per year for every project in the Plan. However, given the fact that the CIP will likely change and should be treated as a dynamic portion of the plan, an agency may choose to provide detailed project costs and annual costs for the first five to ten years, with an overall needs assessment and general phasing for the remaining projects.

A CIP should be coordinated with other jurisdictions to ensure that overlapping projects are prioritized and coordinated.

Examples

Each project listed in the CIP should be assigned an implementation phase or a priority. This enables those implementing the plan in the future, in the face of funding and/or labor constraints which may make it infeasible to implement the entire bicycle plan, to select projects that will provide communities with maximum benefits.

Each agency typically develops its own methodology for prioritizing and phasing projects. When selecting a prioritization methodology consideration should be given to the time and resources available for the process and the quantity of proposed bicycle improvements. If time or resources are scarce and/or there are a small number of proposed improvements, a more simple qualitative methodology can be used to prioritize the improvements. Larger cities with a more sizeable list of improvements and greater available planning resources may choose to utilize a more complex, quantitative methodology that prioritizes projects based on a scoring system.

Regardless of the type of methodology chosen, the prioritization should reflect which projects will best satisfy the goals and objectives set forth in the bicycle plan, and in other planning documents such as the circulation element of the general plan, and county or regional bicycle planning documents. Factors which could be considered when utilizing either a quantitative or qualitative prioritization method include characteristics of the transportation network such as[2]:

- Rider stress
- Collision history
- Average daily traffic volumes
- Gap Closure
- Cost/Funding
- Connectivity
- Implementation complexity

An explanation of how each factor may be applied and weighted is below. This is one example of how to evaluate and prioritize projects, but it is not the only method.

[2] These factors were used in the City of Sunnyvale and City of Santa Clara bicycle CIP's

Rider Stress

Three considerations are evaluated to analyze rider stress. These considerations take into account the need to reduce rider stress as well as the proposed project's ability to create comfortable passage throughout the city or county. The three considerations were:

- Existing separation distance between traveling automobiles and bicycles
- Speed limit for automobiles sharing the roadway
- Parking configuration and turnover along the roadway

The overall rating for this criterion is based on the average score for all three considerations. The descriptions for how the considerations that make up the Rider Stress Criteria are presented below.

Existing Separation Distance Between Traveling Automobiles and Bicycles
The goal of this consideration is to give preference to roadway segments where current rider stress is high due to the lack of separation distance between bicycles and automobiles. Improved bicycle facilities will decrease rider stress on the segment. Separation distance is dependent on the type of parking configuration present on the existing roadway segment. The following definitions may be used to identify separation distance from the roadway:

Rank	**Existing Bicycle Space Plus Travel Lane Width, No Existing On-Street Parking (Lane Stripe to Curb Face)**	**Existing Bicycle Space Plus Travel Lane Width, Existing On-Street Parking (Lane Stripe to Curb Face)**
Poor Separation Distance	Less than 14 feet	Less than 23 feet
Moderate Separation Distance	14-16 feet	23-24 feet
Adequate Separation Distance	More than 17 feet	More than 25 feet

Segments having poor separation distance are given a high rating (3 points). A medium rating (2 points) is given to segments where moderate separation distance exists. A low rating (1 point) is given to segments where there is adequate existing separation distance.

Speed Limit for Automobiles Sharing the Roadway
The purpose of this consideration is to give preference to roadway segments where current rider stress is high due to the high-speed automotive travel on the roadway. Improved bicycle facilities on these roadways will decrease rider stress on the segment. If the speed limit for automobiles sharing the roadway is between 0 to 25 miles per hour (MPH), then the segment is given 0 points for this consideration. A low rating (1 point) is given to segments where the speed limit is 25 to 35 MPH. Roadways where the speed limit is between 35 to 40 MPH are given a medium rating (2 point). Segments with speed limits greater than 40 MPH receive a high rating (3 points).

Parking Configuration and Turnover Along the Roadway
The goal of this consideration is to measure the safety and comfort level associated with each segment's existing parking configuration and parking turnover. Rider friendly parking configurations and turnover receive low ratings. The parking turnover shall be determined by examining the zoning present along each roadway segment. Typically, low parking turnover exists in residential districts and high parking turnover exists in business districts. Proposed segments that do not allow on-street parking or parallel parking along segments that have low

parking turnover receive no rating (0 points). Parallel parking along segments that have high turnover receive a low score (1 point). Diagonal or perpendicular parking that has low parking turnover receive a medium rating (2 point). Segments with diagonal or perpendicular parking with high turnover receive a high rating (3 points).

Collision History

The purpose of this criterion is to identify current roadway facilities with high bicycle accident frequency. The more frequent the accident occurrence, the greater the need for improved bicycle facilities. Roadway segments with high bicycle accident rates will benefit from bicycle facility improvements and receive high ratings.

Average Daily Traffic Volumes

This consideration gives preference to roadway segments where current bicycle travel is discouraged due to high volumes of vehicle traffic. Improved bicycle facilities on these roadways will increase bicyclists' sense of safety and encourage bicycle travel along these roadways. Average daily traffic volumes (ADT) are reviewed to determine which roadways have high daily vehicle volumes. Roadway segments with an ADT of 25,000 vehicles or greater receive a high rating (3 points). A medium rating (2 points) is given to segments with ADT ranging from 10,000 to 25,000 vehicles. Roadways with an ADT between 2,000 and 10,000 vehicles are given a low rating (1 point). All other segments were given 0 points for this consideration.

Gap Closure

Priority is given to proposed bicycle facilities that would provide a link between two existing bicycle facilities. A proposed bicycle project receives a high rating (3.0) if one of the following conditions are met:

- Connects to existing bikeways at both ends
- Bridges a gap in an existing bikeway
- Serves as a collector of other bikeways or residential streets
- Creates a cross-city or cross-county bikeway
- Connects to an existing bikeway at one end and the city or county limit at the other end

A proposed bicycle project receives a medium rating (2.0) if more than one of the following conditions are met:

- Does not qualify for a high rating
- Provides an access link for another bikeway
- Connects to a county-wide bicycle route

A proposed bicycle project receives a low rating (1.0) if more than one of the following conditions are met:

- Does not qualify for high or medium rating
- Connects to an existing bikeway on one end and a proposed bikeway on the other end
- Connects to a proposed bikeway on one end and the city or county limit at the other end
- Connects to proposed bikeways on both ends

A proposed bicycle project receives 0 points if it does not qualify for a high, medium, or low rating.

Cost/Funding

The bicycle improvement projects are evaluated based on the preliminary cost estimates and on the project's ability to compete for outside funding. Project competitiveness is accounted for by making estimates of local contributions toward improvements. For example, if a project has an estimated cost of $100,000, but the project is expected to compete well for federal and/or state funding, only the expected local match will be considered a cost to the city or county. In this example, if the local match is expected to be 15 percent of the total cost, $15,000 would represent the cost (cost to the agency) of the project. High priority will be given to the improvements that are most cost efficient under this criterion (i.e., lowest cost per mile).

Total project costs and expected city or county contributions are developed for all project corridors. Contributions per mile were normalized over a 3-point scale. Proposed projects receive a high rating if their contribution costs were expected to be low on a per mile basis. This tended to favor projects that only involve signing and striping without modifying hard-scape features or acquiring right-of-way. Projects that are expected to have a high contribution cost per mile, such as major widening projects, receive a low rating.

Connectivity

Priority for development of proposed bicycle improvements is based on the number of local and regional activity centers on or near the proposed facility. Activity centers include regional and local parks, shopping centers, schools, large employment centers, and multi-modal connections.

A bike facility is considered to be serving an activity center if it is located within a quarter mile ride of the center. The total number of activity centers served by each project (measured in activity centers per mile of the proposed project) is summed. For the purposes of this effort, a regional activity center is given an equivalency factor of 1.5 compared to local activity center (1.0). The numbers for all projects are normalized over a 3-point scale. A rating of 3.0 is the highest rating, indicating that the facility serves more than the average number of activity centers. 0 points indicated that the facility does not serve any activity centers.

Complexity

The complexity criteria are evaluated using the following considerations:

- Right-of-way (ROW) availability
- The number of agencies involved in development of the segment
- Expected community reactions

The overall complexity score is based on the average of the three considerations listed above.

ROW Availability
Availability of right-of-way can be a key issue in the feasibility, timing and cost of a project. As such, it is assessed as a condition of the complexity criteria. The ratings for this consideration are as follows:

- High rating (3 points) – ROW suitable and available
- Medium rating (2 points) – ROW suitable and could easily be acquired
- Low rating (1 point) – ROW suitable but acquisition may be difficult
- 0 points – ROW not suitable or available

Agency Involvement
Interaction between agencies is often difficult and hard to facilitate. Therefore, the number of agencies involved with each roadway segment is evaluated as a consideration for the complexity criteria. The ratings for this consideration are as follows:

- High rating (3 points) – Only involved agency is the jurisdiction itself
- Medium rating (2 points) – Two involved agencies
- Low rating (1 point) – Three involved agencies
- 0 points – More than three involved agencies and the estimated cost of the project is expected to exceed $150,000.

Expected Community Reaction
This consideration attempted to quantify the expected community reaction for each proposed bicycle segment. The expected community reaction is based on the proposed bicycle improvement project and the proposed roadway modifications required by the improvement. For example, some bicycle improvements require simple re-striping of the existing roadway and do not affect through vehicular traffic or roadway parking capacities. Other bicycle improvements that require removal of travel lanes and/or parking facilities are expected to have a lower degree of community support. The ranking system for this consideration is as follows:

- High rating (3 points) – no parking or vehicular travel lanes will be affected
- Medium rating (2 points) – small number of parking spaces affected or parking in very low demand areas affected; minor geometry or travel lane removal required, e.g. low demand right-turn lanes at intersections.
- Low rating (1 point) – significant parking removal; travel lane removal

Ranking Procedure
Each criterion is assigned a weighting factor based on the importance of the criteria. This allowed more desirable criteria, like Rider Stress and Cost/Funding, to influence the segment's ranking more so than less desirable criteria. A sample weighting is below:

0.30 for Rider Stress
0.10 for Collision History
0.05 for Average Daily Vehicle Volumes
0.10 for Gap Closure
0.20 for Cost/Funding
0.15 for Connectivity
0.10 for Complexity

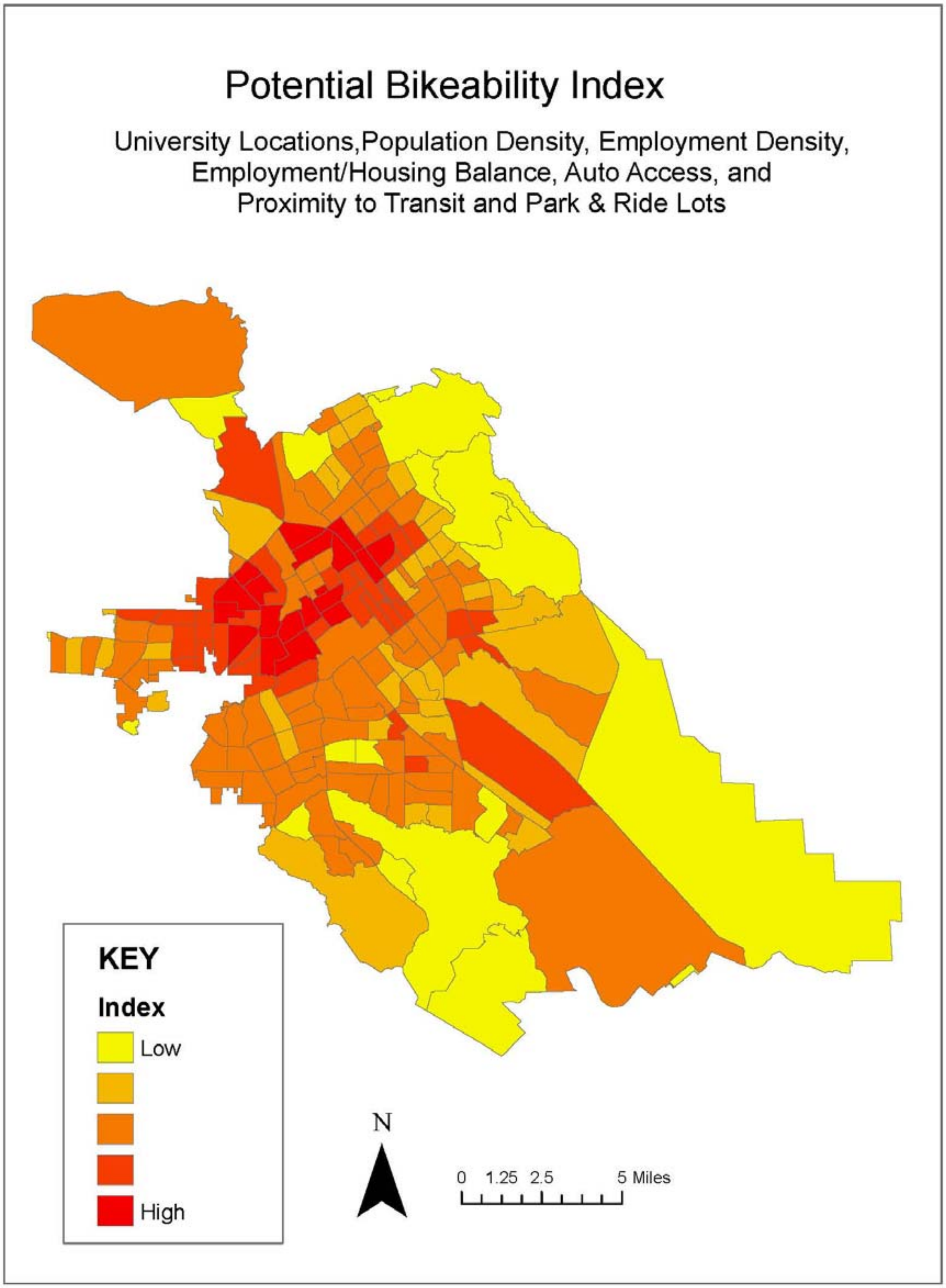
<u>Other Factors</u>
Also, consideration is often given to characteristics of the land uses adjacent to the bicycle network and how they can influence the decision to bicycle or walk. The following factors were identified by the EPA in development of a Smart Growth Index, for identifying locations that have the greatest potential to serve a large number of cyclists[3]:

- Proximity to a University
- Population density
- Employment density
- Mix of land uses
- Zero vehicle households
- Proximity to transit

The map on the following page displays a map of the City of San José showing the combination of these factors.

[3] This methodology was utilized in the City of San Jose Bicycle Plan.

Figure 4: Land Use Factors and Bikeability



Geographic equity is another important consideration in the prioritization process. It may be difficult to receive support for a plan that neglects bicycle improvements in certain portions of the city or county.

Since it is often most cost effective to implement bicycle improvements in conjunction with other roadway improvements or maintenance activities, the implementation schedule of bicycle improvement is often ultimately dictated by the implementation of other maintenance and roadway improvement activities.

The following table shows an excerpt from a capital improvement program worksheet.

Figure 5: Sample Capital Improvement Program

Street	Segment	Class	2003		2004		2005		2006		2007	
			City	*Outside*	*City*	*Outside*	*City*	*Outside*	*City*	*Outside*	*City*	*Outside*
Lick Mill Road	Tasman to Montague Expwy	II	$8,000	$32,000								
Benton Street	Dunford to Lawrence Expwy	II	$2,400	$9,600								
	Lawrence to San Tomas Expwy	II/III			$19,400	$77,600						
	San Tomas to El Camino	II					$15,000	$60,000				
Granada/Flora Vista	Pomeroy to Benton	III			$7,000							
Las Palmas	Homestead to Warburton	III			$14,500							
The Alameda/Park		III					$11,000					
Alviso	De La Cruz to Market	III					$7,000					
Great America	Moffett to Augustine	II	$16,300	$65,200	$16,300	$65,200			$16,200	$64,800	$16,200	$64,800
Old Mtn View/Alviso	Calabazas to Great America	III					$7,000					
Homestead Road	Lafayette to North Winchester	II/III	$6,600	$26,400								
	North Winchester to Lawrence	II/III							$13,400	$53,600	$13,400	$53,600
Lincoln	Warburton to Homestead	III									$10,000	
Washington	Homestead to Poplar	III					$8,000		$8,000			
Warburton	Monroe to Lawrence	III	$20,000									
Woodhams	Homestead to Stevens Creek	III							$7,000		$7,000	
Total Costs			*$53,300*	*$133,200*	*$57,200*	*$142,800*	*$48,000*	*$60,000*	*$44,600*	*$118,400*	*$46,600*	*$118,400*

III. Bicycle Level-of-Service Calculations

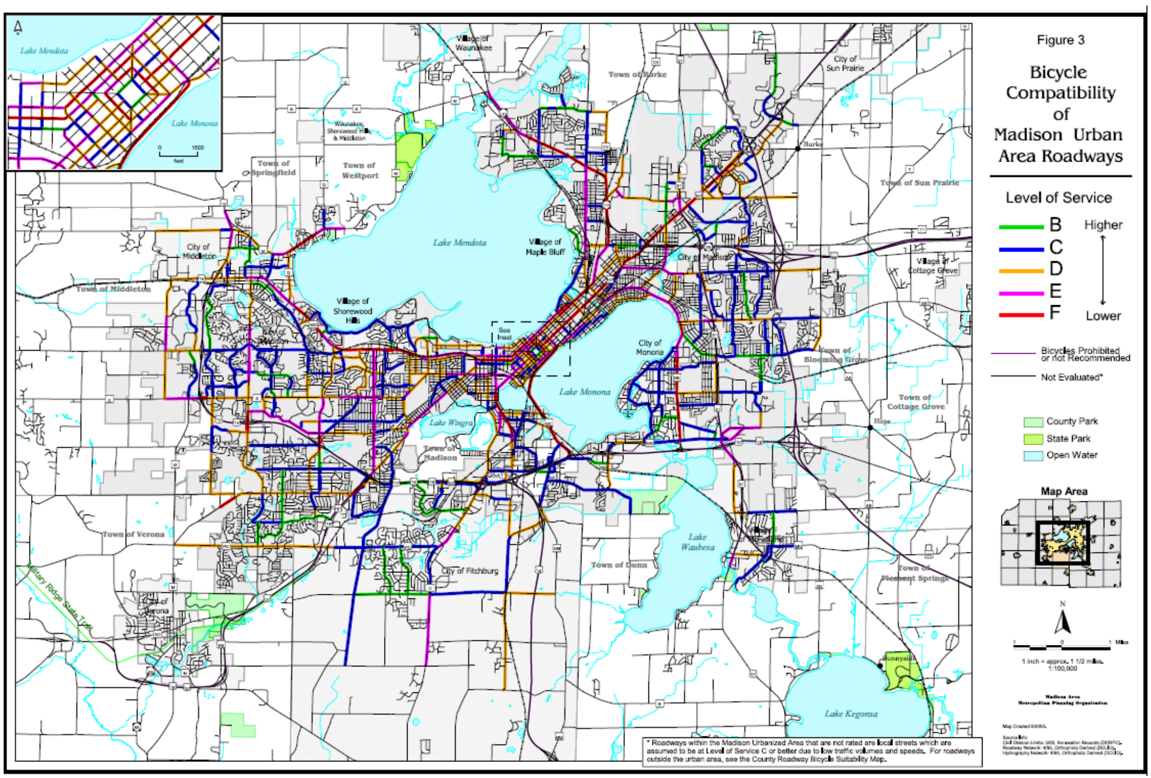
Though most planning agencies do not utilize a bicycle level of service to measure conditions, a number of methodologies have been conceived:

- The highway capacity manual has established level of service criteria for exclusive and shared bicycle paths based on the frequency of interference events and level of service for delay at intersections.
- The Bicycle Level of Service (BLOS) model, published by Bruce W. Landis in Transportation Research Record 1578 in the paper "Real-Time Human Perceptions: Toward a Bicycle Level of Service", measures the relative comfort of bicyclists given the conditions of a particular street segment.
- The Bicycle Compatibility Index (BCI) published by Alex Sorton in Transportation Research Record 1438 in the paper "Bicycle Stress Level as a Tool to Evaluate Urban and Suburban Bicycle Compatibility" also measures the relative comfort of a bicyclist given the conditions of a street segment. More information on the BCI can be found here: http://www.hsrc.unc.edu/research/pedbike/98095/

The latter models are similar in that they measure variables in the street cross section that affect bicycling, such as amount of motor vehicle traffic, traffic speed, the amount of separation between the cyclist and moving traffic, the percentage of heavy vehicles, presence of on-street parking, and the condition of the pavement surface.

Below, an excerpt from the City of Madison Bicycle Master Plan shows the use of the BCI methodology in evaluating the quality of bicycle facilities.

Figure 6: Sample Bicycle Compatibility Map



Sacramento Transportation & Air Quality COLLABORATIVE

IV. Transportation Impact Analyses

Transportation impact studies, whether as stand-alone documents or chapters in an environmental document, are intended to disclose information to assist decision makers and the public in the project review process. The National Environmental Policy Act (NEPA), the Federal law governing environmental analysis, and the California Environmental Quality Act (CEQA)[4] have many differences, such as the level of specificity of alternatives analysis, but both require a full disclosure of transportation impacts, not just vehicular traffic impacts.

The term transportation captures a wide range of potential impacts and modes. To adequately assess impacts to the transportation system, transportation analyses should evaluate impacts to vehicles, transit, bicycle and pedestrian systems. Another suggested element of transportation analyses is a review of on-site circulation and access that also considers all modes. In jurisdictions that define neighborhood livability, land use compatibility, transportation demand management and/or quality of life objectives, analysis may be even broader.

Many locations lack policies related specifically to pedestrian, bicycle, and transit circulation. Some even lack policies related to vehicular level of service. Even where such policy guidance is lacking, it is important to provide a comprehensive evaluation of transportation impacts. The significance criteria below represent a minimum standard for assessing a broad set of transportation impacts. They are generally organized around the themes of identifying impacts that disrupt existing operations; interfere with plans for the future; conflict with adopted policies; and/or create new demand beyond that anticipated in existing planning documents.

Significance Criteria for Bicycles

Bicycle impacts are considered significant if:

1. A project disrupts existing bicycle facilities.

    Note: Particular attention should be paid to on-street bicycle facilities on roadways with project-proposed driveways.

2. A project interferes with planned bicycle facilities. This includes failure to dedicate right-of-way for planned on- and off-street bicycle facilities included in an adopted Bicycle Master Plan or to contribute toward construction of planned bicycle facilities along the project's frontages.

3. A project conflicts or creates inconsistencies with adopted bicycle system plans, guidelines, policies or standards.

[4] CEQA guidelines are presented in Appendix A.

Site Access & Internal Circulation

Project site plans and proposed off-site improvements, including mitigation, should be reviewed for consistency with local design standards, parking codes, and other adopted guidelines. Where no local policies express alternative significance criteria, project impacts should be considered significant if:

1. A project fails to provide a sufficient quantity of on-site parking for bicycles.

   Notes: Bicycle parking should be required of non-residential projects at a ratio of at least one bicycle parking space for each 20 vehicle parking stalls; should be well located, preferably in a well lighted and visible area; and should be functional and provide sufficient security to allow bicycle owners to lock both tires and the frame. Bicycle parking impacts can only be considered significant where local jurisdictions have adopted policies related to bicycle parking. Where such policies do not exist, impacts related to bicycle parking are considered less than significant, and improvements are considered recommendations rather than mitigation.

   In addition to requiring a set number of bicycle parking spaces, consideration should be given for the type of bicycle parking. Class I facilities, which allow the locking of both wheels and the frame of the bicycle, should be required in areas where bicycles will be parked for long durations (such as employment sites) and where bicycle parking is not highly visible (such as in parking structures). Class II facilities, the most common of which is the inverted U rack, are appropriate for high turn-over areas (such as on a commercial street) and should interspersed for optimal convenience to destinations.

BICYCLE FACILITY DESIGN BEST PRACTICES

This section includes discussion of best practices for the selection and design of bicycle facilities. Bikeway planning and design in California typically relies on the guidelines and design standards established by Caltrans as documented in "Chapter 1000: Bikeway Planning and Design" of the *Highway Design Manual* (5th Edition, California Department of Transportation, January 2001). Chapter 1000 follows standards developed by the American Association of State Highway and Transportation Officials (AASHTO) and the Federal Highway Administration (FHWA), and identifies specific design standards for various conditions and bikeway-to-roadway relationships. These standards provide a good framework for future implementation, but may not always be feasible given specific constraints. Bikeway design and planning standards are continually changing and expanding. However, local jurisdictions, interested in minimizing their liability, typically adopt the Caltrans or AASHTO standards as a minimum.

Also, the design of bicycle facilities should be in compliance with laws governing the operation of bicycles:

- California Vehicle Code Sections 21200-21212
- California Streets and Highway Code 890-894.2
- Local codes and ordinances governing bicycle transportation

There are numerous other sources for bicycle design guidelines, some of which focus on innovative designs. These innovations may provide solutions which improve the safety and/or comfort of bicyclists in unique situations not addressed in the standard bicycle design manuals.

I. Bicycle Facility Type and Location

Deciding where to locate bicycle facilities and what type of facility is appropriate at each location is one of the first steps in the bicycle facility planning and design process. The location and type of facility selected is usually determined by the bicycle transportation needs that facility will serve and the characteristics of the right-of-way and adjoining land uses.

A. Selecting the Location of Bikeways

The recommended bikeway network is not meant to accommodate every bicyclist and bicycle trip. Once completed, this network will furnish safer and more direct travel paths for a majority of bicyclists within the planning area. A bikeway network consists of routes that are designed to be the primary system for bicyclists traveling through the city or county. It is important to recognize that, by law, bicyclists are allowed on all streets and roads regardless of whether they are a part of the bikeway network. The bikeway network is a tool that allows agencies to focus and prioritize implementation efforts where they will provide the greatest community benefit. Streets or corridors selected for inclusion in the network should be targeted for specific improvements, such as the installation of bicycle lanes or wide curb lanes.

The following is a list of factors that should be considered when selecting the location of bicycle facilities:

SKILL LEVEL OF USERS	Consideration should be given to the skills and preferences of the types of bicyclists who will use the facility. Facilities near schools, parks and residential neighborhoods are likely to attract a higher percentage of basic and child bicyclists than advanced bicyclists. These facilities should not be located on busy arterial or other streets that would be dangerous to children.
MOTOR VEHICLE PARKING	The turnover and density of on-street parking can affect bicyclist safety (e.g., opening car doors and cars leaving parallel parking spaces). Diagonal and perpendicular parking arrangements are not compatible with bicycle facilities because of restricted sight distance and the related potential for bicycle-motor vehicle conflicts. They should be avoided wherever possible.
BARRIERS	In some areas, there are physical barriers to bicycle travel caused by topographical features, such as rivers, railroads, freeways or other impediments. In such cases, providing a facility to overcome a barrier can create new opportunities for bicycling.
CRASH REDUCTION	The reduction or prevention of bicycle crashes (i.e., bicycle/motor vehicle, bicycle/bicycle, bicycle/pedestrian and single bicycle crashes) is important. Therefore, the potential for reducing crash problems through the location or re-location of a facility should be assessed. Plans for constructing new bicycle facilities should be reviewed to identify and resolve potential safety issues.
DIRECTNESS	Particularly for utilitarian bicycle trips, facilities should connect traffic generators and should be located along a direct line of travel that is convenient for users.
ACCESSIBILITY	In locating a bicycle facility, consideration should be given to the provision for frequent and convenient bicycle access, especially in residential areas. Adequate access for emergency, maintenance and service vehicles should also be considered. Other major traffic generators such as educational facilities, office buildings, shopping areas, parks and museums should also be considered when evaluating bicycle accessibility.
AESTHETICS	Scenery is an important consideration along a facility, particularly for a facility that will serve a primarily recreational purpose. Trees can also provide cooler riding conditions in summer and can provide a windbreak.
PERSONAL SAFETY/SECURITY	The potential for criminal acts against bicyclists, especially along isolated shared use paths, and the possibility of theft or vandalism at parking locations, should be considered.

STOPS	Bicyclists have a strong inherent desire to maintain momentum. If bicyclists are required to make frequent stops, they may avoid the route or disregard traffic control devices.
CONFLICTS	Different types of facilities introduce different types of conflicts. Facilities on the roadway can result in conflicts between bicyclists and motorists. Shared use paths can involve conflicts between bicyclists, horseback riders, skaters, runners and pedestrians on the facility. Conflicts between bicyclists and motorists may also occur at highway and driveway intersections.
PAVEMENT SURFACE QUALITY	Bikeways should be free of bumps, holes and other surface irregularities if they are to attract and satisfy the needs of bicyclists. Utility covers and drainage grates should be at grade and, if possible, outside the expected path of travel. Railroad crossings should be improved as necessary to provide for safe bicycle crossings.
TRUCK AND BUS TRAFFIC	Because of their width, high–speed trucks, buses, motor homes and trailers can cause special problems for bicyclists. Where bus stops are located along a bicycle route, conflicts with bus loading and unloading and pavement deterioration, such as asphalt pavement shoving, may also be problems.
TRAFFIC VOLUMES AND SPEEDS	For facilities on roadways, motor vehicle traffic volumes and speeds must be considered along with the roadway width. Commuting bicyclists frequently use arterial streets because they minimize delay and offer continuity for long trips. If adequate width for all vehicles is available on the more heavily traveled streets, it can be more desirable to improve such streets than adjacent streets. When this is not possible, a nearby parallel street may be improved for bicyclists, if stops are minimal and other route conditions are adequate. When such a parallel facility is improved, care must be taken that motor vehicle traffic is not diverted. While inexperienced bicyclists prefer more lightly-traveled streets, it should be remembered that preferred routes may change over time as skill levels change.
BRIDGES	Bridges can serve an important function by providing bicycle access across barriers. However, some bridge features restrict bicycle access and/or create unfavorable conditions for bicyclists. The most common of these are curb-to-curb widths that are narrower than the approach roadways (especially where combined with relatively steep grades), open grated metal decks found on many spans, low railings or parapets, and certain types of expansion joints such as finger-type joints, that can cause steering difficulties.

INTERSECTION CONDITIONS	A high proportion of bicycle crashes occur at intersections. Facilities should be selected so as to minimize the number of crossings, or intersections should be improved to reduce crossing conflicts. At-grade intersections on high-volume (or high-speed) roadways and mid-block crossings should be analyzed with bicyclists' needs in mind to determine the most appropriate crossing design treatments.
COSTS/FUNDING	Facility selection normally will involve a cost analysis of alternatives. Funding availability can limit the alternatives; however, it is very important that a lack of funds not result in a poorly designed or constructed facility. The decision to implement a bikeway plan should be made with a conscious, long-term commitment to a proper level of maintenance. When funding is limited, emphasis should be given to low-cost improvements such as bicycle parking, removal of barriers and obstructions to bicycle travel, and roadway improvements. Facility selection should seek to maximize user benefits per dollar funded.
STATE AND LOCAL LAWS AND ORDINANCES	Bicycle programs must reflect state and local laws and ordinances. Bicycle facilities must not encourage or require bicyclists to operate in a manner that is inconsistent with these laws and ordinances.

Source: AASHTO Guide for the Development of Bicycle Facilities

B. Selecting the Type of Bicycle Facility

The designation of bikeways as Class I, II and III does not constitute a hierarchy of bikeways; one is not better than the other. Each class of bikeway has its appropriate application.

In selecting the proper facility, an overriding concern is to assure that the proposed facility will not encourage or require bicyclists or motorists to operate in a manner that is inconsistent with the rules of the road. Managing driver and bicyclist expectations is the key to safety.

Here, the different types of bicycle facilities are listed in order of the resources required to implement them. For each type of facility, guidelines from the Caltrans Highway Design Manual, indicating where each facility type is appropriate are presented:

- <u>Shared Bikeway (No designation)</u>: Much bicycle travel occurs on streets and highways without bikeway designations. There are many reasons a street may remain as an undesignated shared bikeway. The primary reason is that a street may be fully adequate for safe and efficient bicycle travel and signing and striping for bicycle use may be unnecessary, such as on a lower volume, low speed residential street. The minimum standards for a street's bicycle friendliness, including well-maintained pavement, bicycle friendly drainage grates, and adequate street sweeping, should still be a part of this description.

- <u>Class III Bikeway (Bike Route)</u>: Bike routes are shared facilities which serve either to designate preferred routes through high demand corridors or to provide continuity to other bicycle facilities (usually Class II bikeways). As with bike lanes, designation of bike routes should indicate to bicyclists that there are particular advantages to using these routes as compared with alternative routes. This means that responsible agencies have taken actions to assure that these routes are suitable as shared routes and will be maintained in a manner consistent with the needs of bicyclists. Class III routes are not generally appropriate on high volume, high speed streets. The two main advantages associated with designating a Class III route are to provide wayfinding through the use of signage and to raise the visibility of cyclists. They may also link two segments of Class II Bicycle Lanes. When used in this way, it is advantageous to provide additional pavement stencils, such as the new bike-and-chevron, adopted to the California supplement of the Manual on Uniform Traffic Control Devices in August, 2004 (see Figure 5). Normally, bike routes are shared with motor vehicles. The use of sidewalks as Class III bikeways is strongly discouraged.

- <u>Class II Bikeway (Bike Lane)</u>: Bike lanes are established along streets in corridors where there is significant bicycle demand, and where there are distinct needs that can be served by them. The purpose should be to improve conditions for bicyclists in the corridors. Bike lanes are intended to delineate the right of way assigned to bicyclists and motorists and to provide for more predictable movements by each. But a more important reason for constructing bike lanes is to better accommodate bicyclists through corridors where insufficient room exists for safe bicycling on existing streets. This can be accomplished by reducing the number of lanes, or prohibiting parking on given streets in order to delineate bike lanes. In addition, other things can be done on bike lane streets to improve the situation for bicyclists, that might not be possible on all streets (e.g., improvements to the surface) augmented sweeping programs, special signal facilities, etc.). Generally, stripes alone will not measurably enhance bicycling. If bicycle travel is to be controlled by delineation, special efforts should be made to assure that high levels of service are provided with these lanes.
- <u>Class I Bikeway (Bike Path)</u>: Generally, bike paths should be used to serve corridors not served by streets and highways or where wide right of way exists, permitting such facilities to be constructed away from the influence of parallel streets. Bike paths should offer opportunities not provided by the road system. They can either provide a recreational opportunity, or in some instances, can serve as direct high-speed commute routes if cross flow by motor vehicles and pedestrian conflicts can be minimized. The most common applications are along rivers, ocean fronts, canals, utility right of way, and abandoned railroad right of way, within college campuses, or within and between parks. There may also be situations where such facilities can be provided as part of planned developments. Another common application of Class I facilities is to close gaps to bicycle travel caused by construction of freeways or because of the existence of natural barriers (rivers, mountains, etc.). Special attention should be paid to interfaces between the trail and the street system, such as installing special bicycle signals or delineating crossing locations with pavement markings or speed tables.

In addition to the general guidelines listed above, there are other recommended methodologies for selecting the appropriate type of facility.

FHWA Selecting Roadway Design Treatments to Accommodate Bicycles

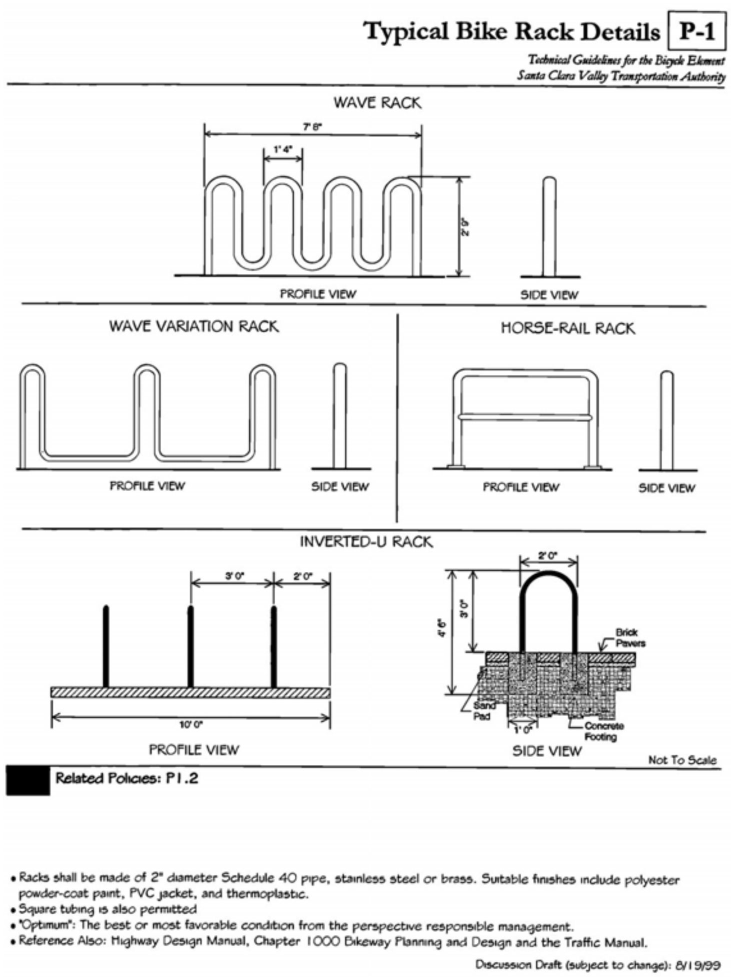
This prescribes a process that utilizes five criteria to determine recommended bicycle facilities: traffic volume; average motor vehicle operating speed; traffic mix of automobiles, trucks, buses, and/or recreational vehicles; on-street parking; and sight distance. Values for these criteria were determined and tables were developed for urban and rural roadway sections for two groups of design users.

C. Bicycle Parking

There are different types of support facilities just as there are different levels of route facilities. Support facilities fall into one of three main categories:

- Short-term Bicycle Parking: *Bicycle Racks* are low-cost devices that provide a location to secure a bicycle. Bicyclists should be able to lock both their frame and wheels, and the rack should be compatible with any type of bicycle lock. The bicycle rack should be secured to the ground in a highly-visible location where there is good surveillance. Short-term bicycle parking is commonly used for short trips, when cyclists are planning to leave their bicycles for a few hours.
- Long-term Bicycle Parking: *Bicycle Lockers* are covered storage units that can be locked individually, providing secure parking for one bicycle. *Bicycle Stations* are secure areas with limited-access doors. Occasionally, they are attended, and they may offer services such as repair, rentals, or sales. Each of these means is designed to provide complete enclosure of a bicycle, therefore providing bicyclists with a high level of security so that they feel comfortable leaving their bicycles for long periods of time. They are appropriate for employees of large buildings and at transit stations.
- Shower and Locker Facilities: *Lockers* provide a secure place for bicyclists to store their helmets or other riding gear. *Showers* are important for bicycle commuters with a rigorous commute or formal office attire.

Figure 7: Bicycle Rack Details[5]



[5] The wave, or ribbon rack is specifically not recommended by the Association of Pedestrian and Bicycle Professionals.

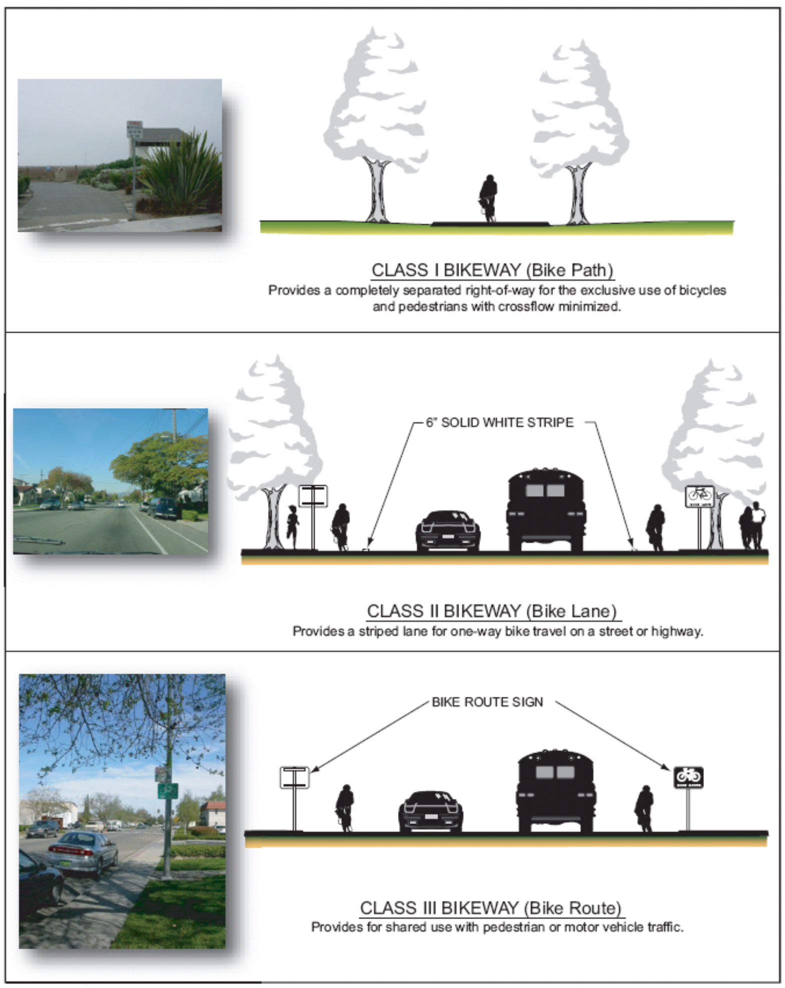
II. Design Elements – Street Layout

Though selecting the appropriate bicycle facility and location plays a large role in creating a comfortable, safe, and usable bicycle network, the detailed design elements of the bicycle facility are also of great importance. Below, best practices on design elements or references to other sources are presented. Standard or basic design elements are first presented, followed by innovative treatments.

A. Basics

The most basic element of bicycle facility design is determining how to accommodate the desired bicycle facility in the given right-of-way. The Caltrans Highway Design Manual and AASHTO Guide for the Development of Bicycle Facilities are the best starting point for street layout guidelines. The diagram below shows a basic layout for the three different types of bicycle facilities.

Figure 8: Basic Bikeway Illustrations

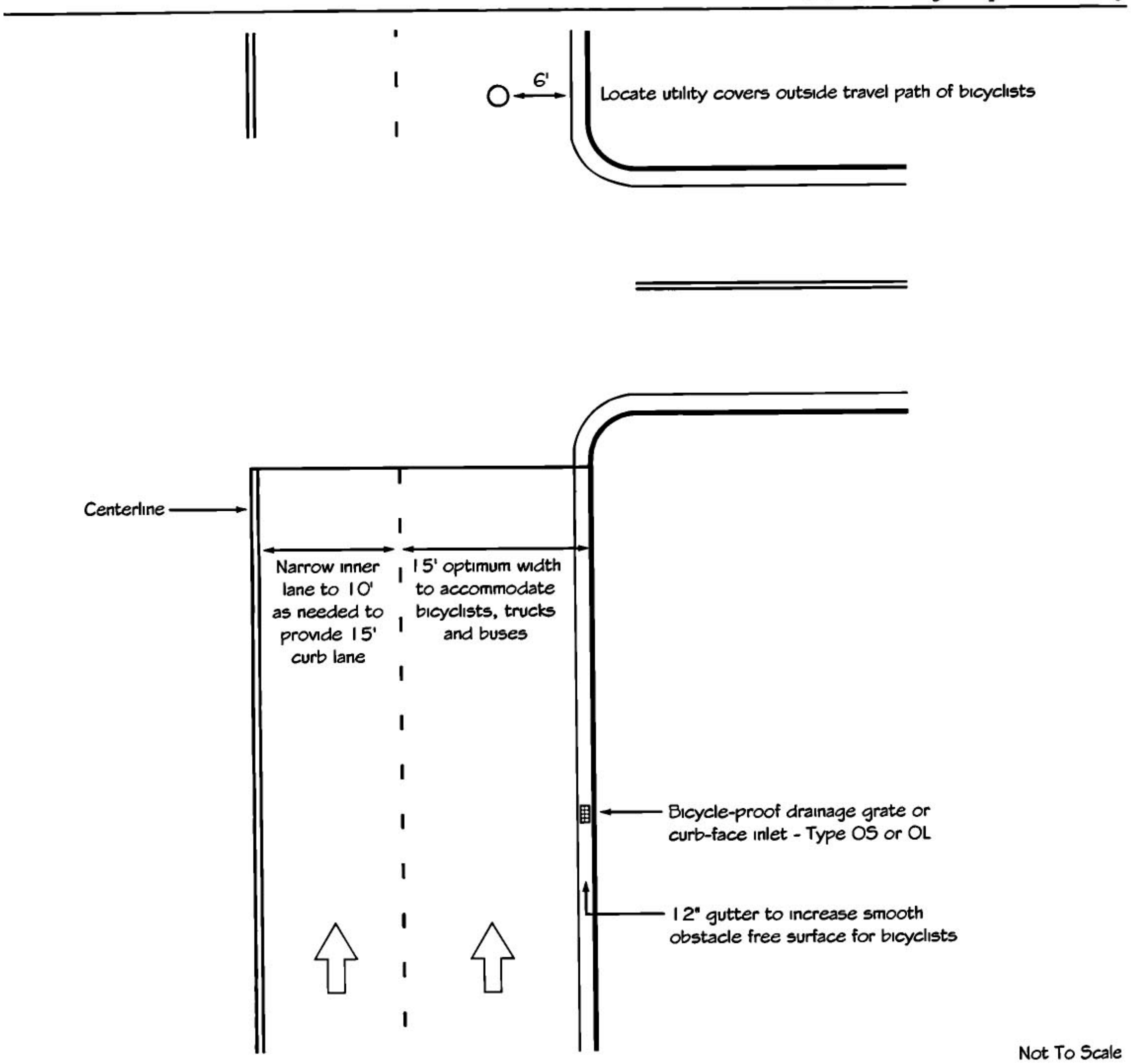


Beginning with Class III Bicycle Routes, the figure below presents the basic design details necessary to accommodate bicyclists.

Figure 9: Bicycle Route Design Details

Class 3C: Wide Curb Lanes | **8**

Technical Guidelines for the Bicycle Element
Santa Clara Valley Transportation Authority



Related Policies: D1.5, D2.1, D2.2, D4.3.1, D4.3.2

- "Optimum": The best or most favorable condition from the perspective of responsible management.
- Reference Also: Highway Design Manual, Chapter 1000 Bikeway Planning and Design and the Traffic Manual.

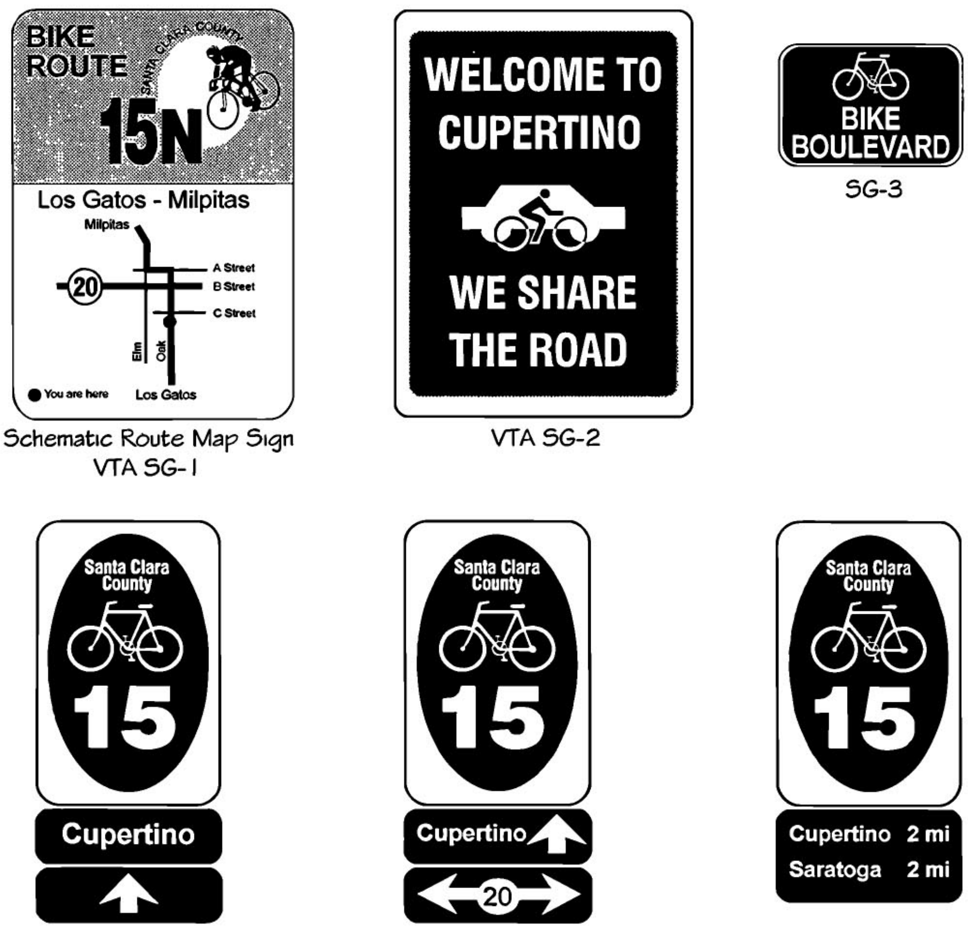
Discussion Draft (subject to change): 8/19/99

There are several alternatives for signing Class III Bicycle Routes.

Figure 10: Bicycle Route Signing

Bikeway Guide Signs **21C**

Technical Guidelines for the Bicycle Element
Santa Clara Valley Transportation Authority



Schematic Route Map Sign
VTA SG-1

VTA SG-2

SG-3

Route sign with destination
Caltrans SG-45
with supplementary placards

Route sign with route crossing
Caltrans SG-45
with supplementary placards

Route sign with distance
Caltrans SG-45
with supplementary placards

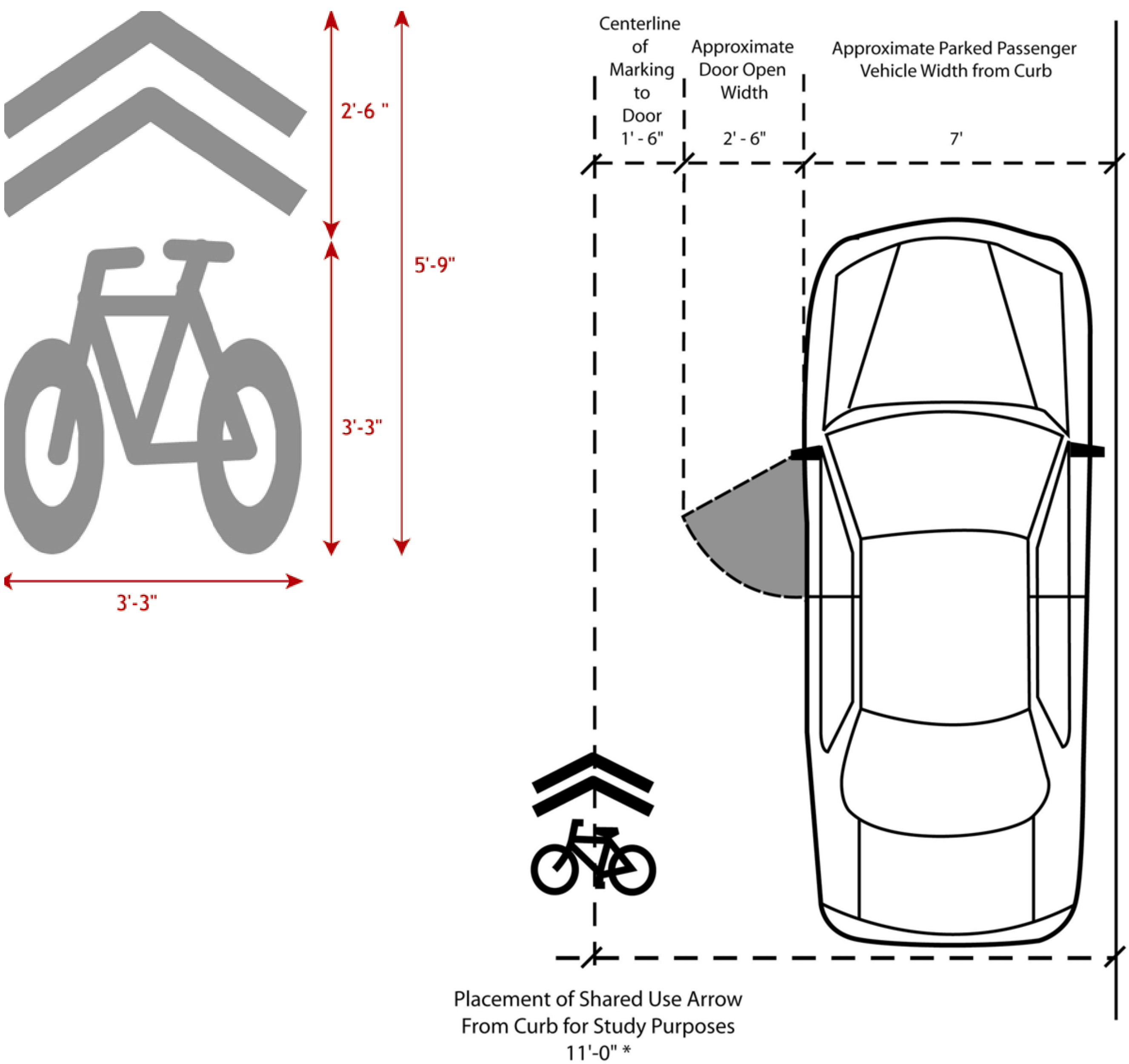
Related Policies: D5.1.3

- White lettering on green background.
- See also Traffic Manual, Chapter 4.
- Reference Also: Highway Design Manual, Chapter 1000 Bikeway Planning and Design and the Traffic Manual.

Discussion Draft (subject to change): 6/22/99

When using a Class III treatment on a narrow lane, especially close to parked cars, the following symbol has been shown to reduce wrong-way riding, riding on the sidewalk, and riding in the door zone. The figure is taken from *San Francisco's Shared Lane Pavement Markings*, February 2004. The study concluded that the symbol below had a positive impact on motorist and cyclist behavior, positions, and safety. In particular, the symbols significantly reduced wrong-way riding and riding on the sidewalk. Cyclists surveyed preferred this symbol to the "sharrow," another popular pavement stencil used in shared lanes.

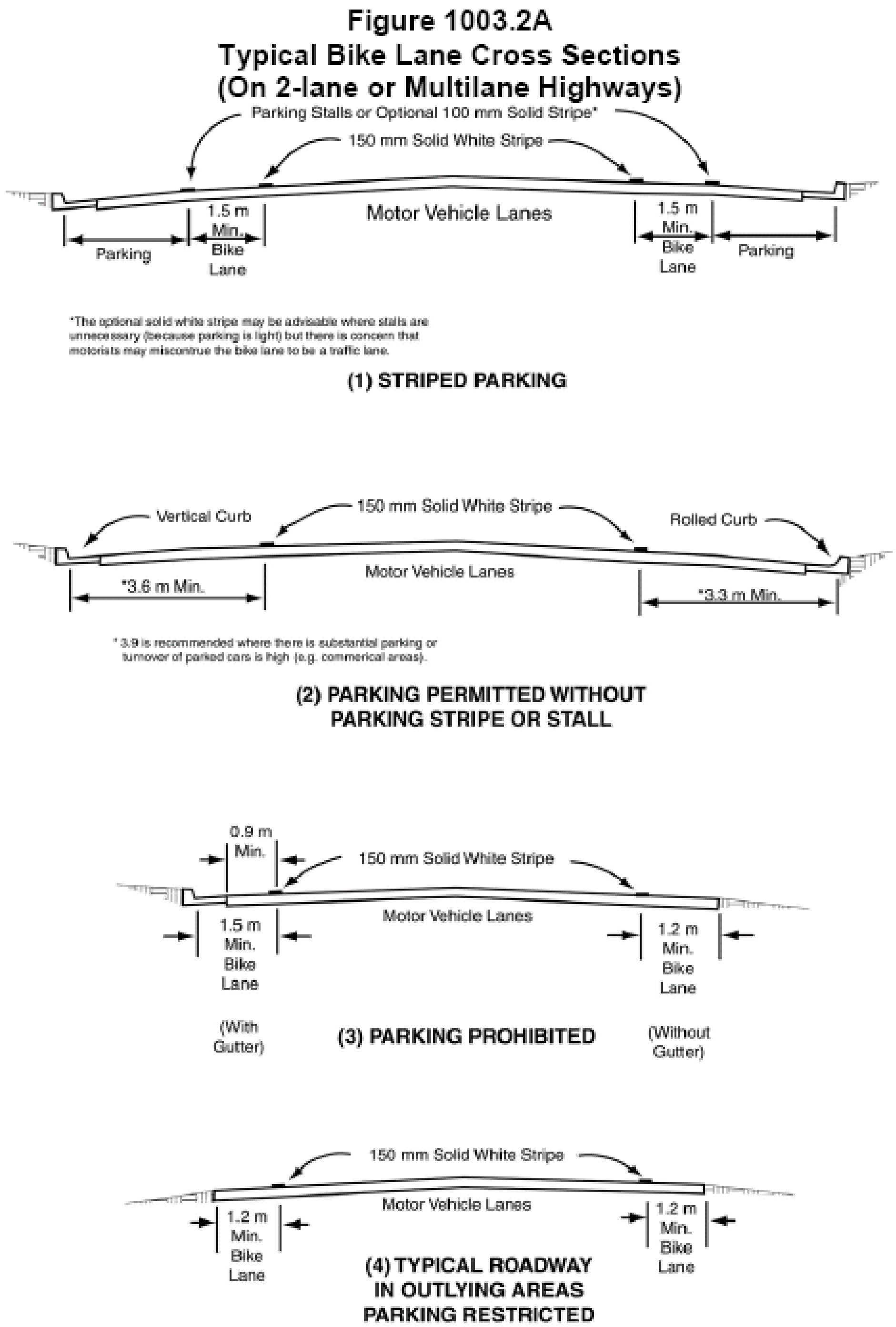
Figure 11: Bike and Chevron



* Selection of this placement is based on the following:
-- Average car door opens to 9'6" from curb (per DPT field observations),
-- average width of bicycles 2'
-- 6" clearance from door to bicycle handlebar is desired minimum shy distance

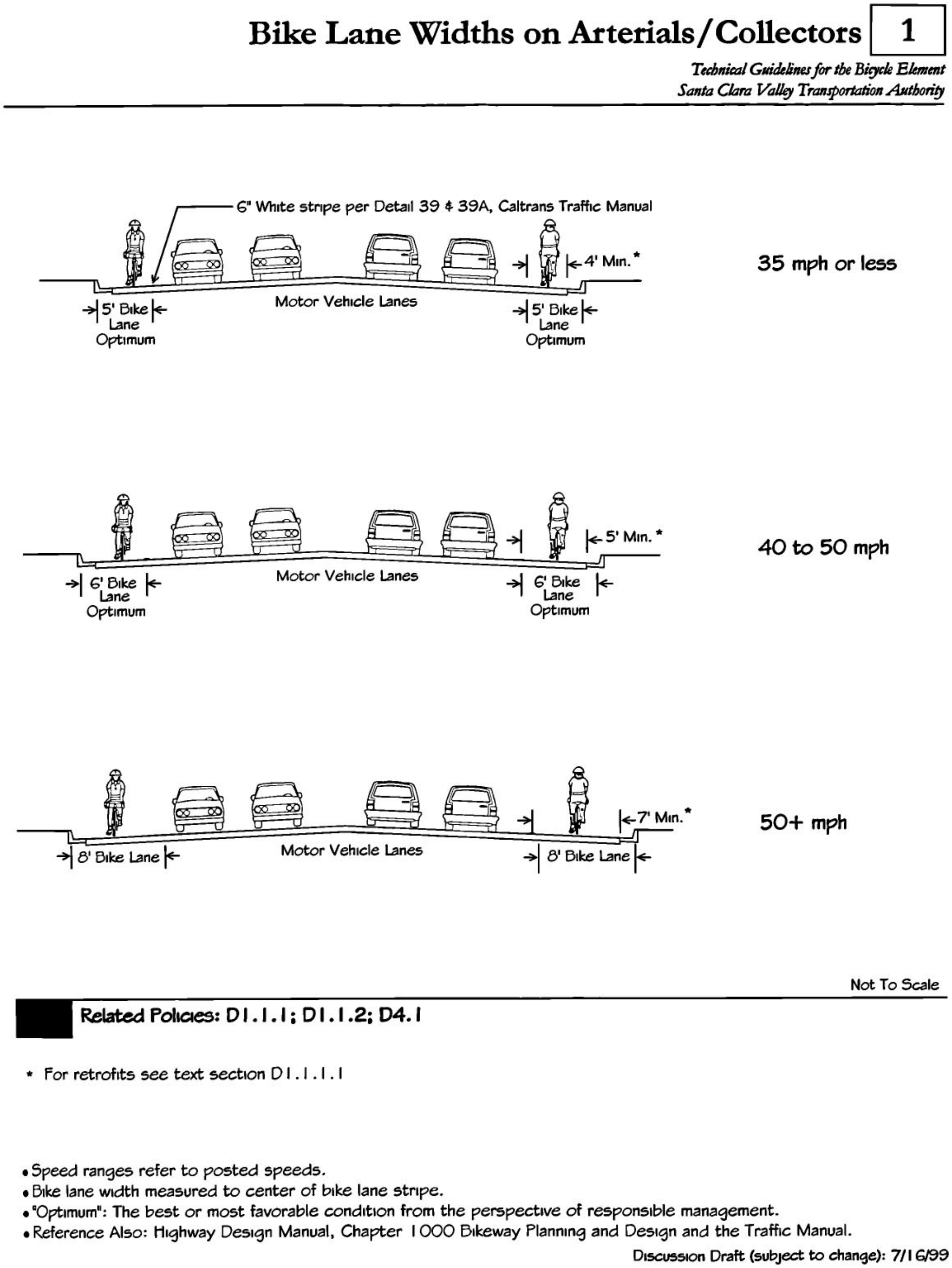
Here is a sample street layout for Class II Bicycle Lane facilities:

<u>Figure 12: Minimum/Standard Class II Bicycle Lane Design</u>



Bicycle lanes should be sized according to the type of facility they serve. Below is an example of sizing bikeways based on adjacent roadway speed. Generally the greater the speed, the greater the separation from traffic to avoid sidewinds from passing motorists.

Figure 13: Sizing Bicycle Lanes

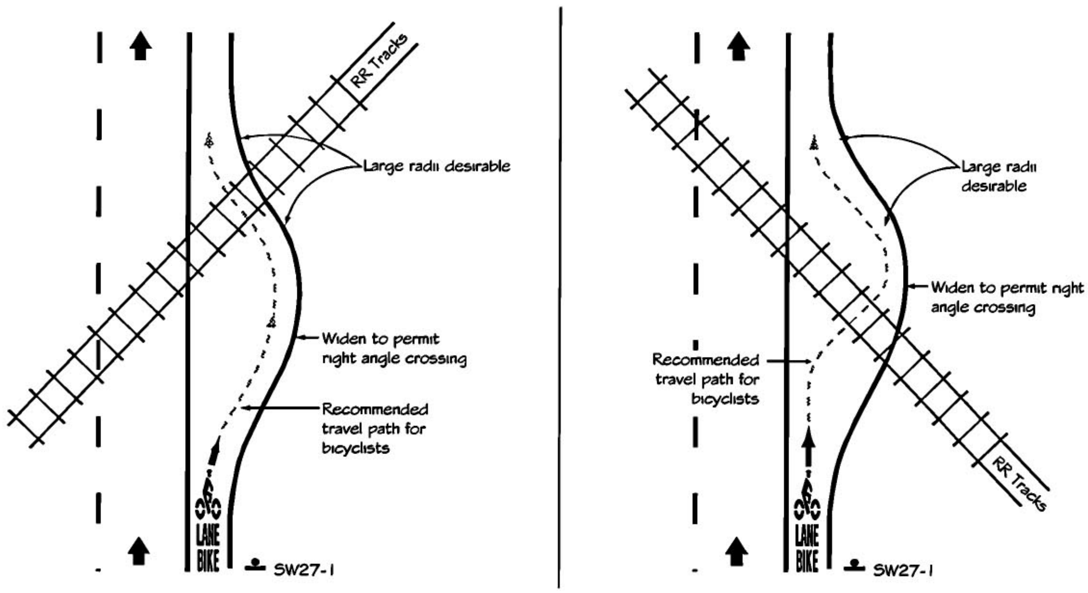


Railroad tracks can pose a slipping hazard to cyclists, especially in wet weather. Additionally, poorly maintained tracks can trap bicycle wheels and cause crashes.

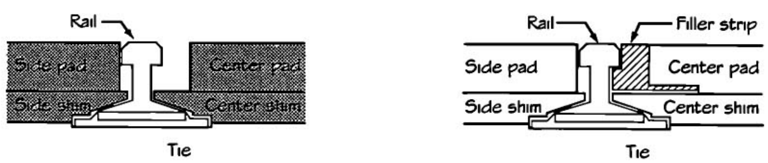
Figure 14: Accommodating Bicyclists at Railroad Tracks

Railroad Tracks-Details 19

Technical Guidelines for the Bicycle Element
Santa Clara Valley Transportation Authority



ROADWAY WITH BIKE LANE OR SHOULDER



Cross section of rubberized railroad crossing for rough perpendicular crossings

Cross section of rubberized railroad crossing with flangeway filler strip for low-speed skewed crossings

Not To Scale

Related Policies: D4.3.3

SOURCE: Caltrans "Highway Design Manual", North Carolina DOT "Bicycle Facilities Planning and Design Guidelines".

- Flangeway filler strips are not acceptable for high-speed rail lines, as the filler will not compress fast enough and the train may derail.
- "Optimum": The best or most favorable condition from the perspective of responsible management.
- Reference Also: Highway Design Manual, Chapter 1000 Bikeway Planning and Design and the Traffic Manual.

Discussion Draft (subject to change): 8/19/99

Below is a sample layout of a Class I Bicycle Path from the Caltrans Highway Design Manual.

Figure 15: Standard Bicycle Path Design

Figure 1003.1A

Two-Way Bike Path on Separate Right of Way

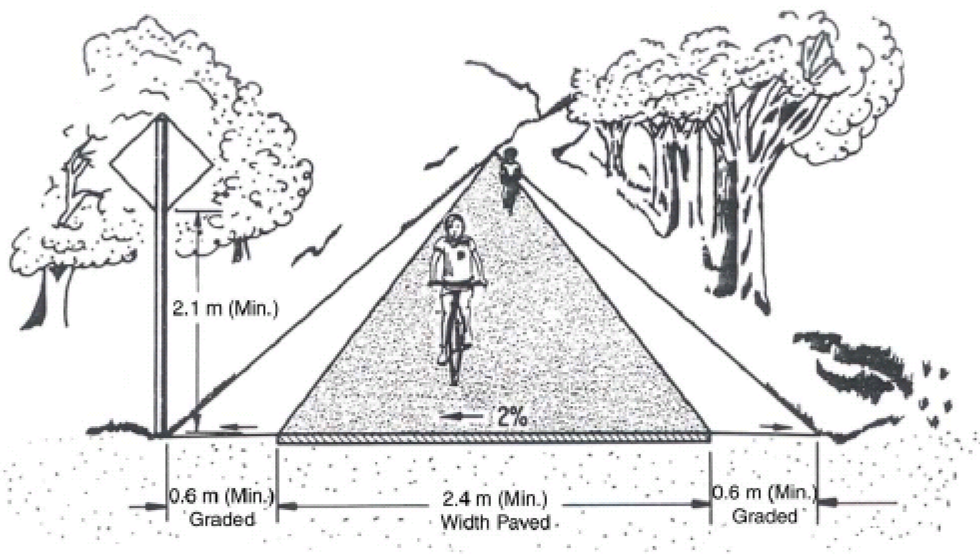
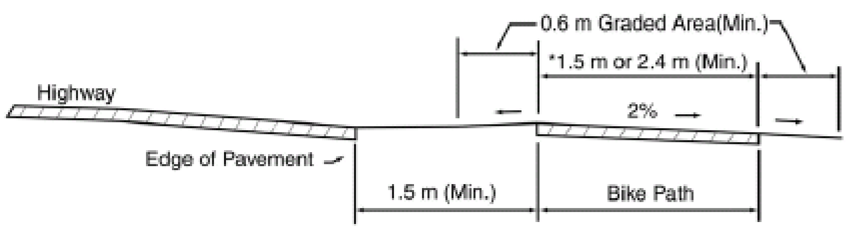


Figure 1003.1A

Typical Cross Section of Bike Path Along Highway



NOTE: See Index 1003.1(5)

*One - Way: 1.5 m Minimum Width
Two - Way: 2.4 m Minimum Width

B. Signal Timing

Clearance time collisions are a significant proportion of collisions involving bicyclists at signalized intersections. The combination of green, yellow and all-red phases must be calculated so that cyclists can clear the intersection in both of the following instances: (1) when beginning from a stopped position at the start of the green phase; and (2) when entering an intersection at speed at the end of the green phase.

The total length of the signal phase (green plus yellow plus all red) should be at least as long as it takes a bicyclist to travel the length of the intersection. This amount of total time should be calculated using the following formula:

$$g + y + r_{clear} \geq t_{cross} + t_{lost}$$

Where

g = green signal time (sec)
y = yellow signal time (sec)
r = all-red signal time (sec)
t_{lost} = bicyclist start up time (sec) reacting to the green and accelerating;
= zero for bicyclist approaching intersection on green
t_{cross} = bicyclist full-speed intersection crossing time (ft/sec)

and $t_{cross} = (w + l)/v$

w = intersection width (feet)
l = bicycle length (feet)
v = bicycle speed (feet/second) = 10 ft/sec (16 mph) assuming an average adult bicyclist

Generally, the following assumptions should be used in calculating green time

y = 3 to 4 seconds (depending on intersection width and speeds)

r = 1 to 2 seconds (depending on intersection width and speeds)

t_{lost} = 5 seconds

l = 6 feet

v = 12 feet/sec (8mph) = 2nd percentile speed for adults (i.e. 98% of adults ride at least this fast)

For example, at a 55 foot wide intersection with yellow time of three seconds and all-red time of one second, the required green time would be

$t_{cross} = (w + l)/v = (55+6)/12 = 5$ seconds

so that $g + y + r_{clear} \geq t_{cross} + t_{lost}$ becomes

$g + 3 + 1 \geq 5 + 5$ and $g \geq 6$

In this example, the green time must be at least six seconds for bicyclists to adequately clear the intersection from a complete stop.

Where other signal timing issues call for shorter green times, the calculated green time may be reduced a maximum of one second. This allows the bicycle's front wheel to reach the middle of the furthest lane, rather than the whole bicycle to clear the entire intersection.

C. Innovations

The following innovations appear in *Innovative Bicycle Treatments, An Informational Report,* published by the Institute of Transportation Engineers. Each one responds to problems that are typical in cities wishing to retrofit existing streets for bicycle lanes. They should be employed using good engineering judgement. Each of these devices has been used somewhere in California or in the United States, although most of them do not appear in state or national standards.

Contra-flow Bike Lane

A contra-flow bicycle lane allows bicyclists to travel the opposite direction of motor vehicle traffic on a one-way street. There are several design options that can be used depending on the existing conditions: lanes with no physical separation; lanes with separation only at intersections, or separation only mid-block; lanes with complete separation (including lanes located between parallel parking and the sidewalk). Factors that should be considered during design include vehicle and bicycle turning movements, vehicle and bicycle ADT, available street width, existence of on-street parking and rate of turnover, and transit routes. Contra-flow lanes are most often marked with a double yellow line. If parked cars are involved, it is important to provide enough room between the parked cars and the bike lane for a "door zone," so parked car doors are not opened into the bike lane.

For a contra-flow lane to function well, these special features should be incorporated into the design:

- The contra-flow lane must be placed on the correct side of the street, to the driver's left
- Any intersecting alleys, major driveways and streets must have signs indicating to motorists that they should expect two-way bicycle traffic
- Existing traffic signals should be modified for bicyclists, with loop detectors or push buttons. The push buttons must be placed so they can be easily reached by bicyclists

Evaluation Studies:
TRL Report 358: Further Developments in the Design of Contra-flow Cycling Schemes
ITE Journal, February 1986, Pg. 46

Sample Sites:

- Cambridge, MA
- Eugene, OR
- Madison, WI
- Chicago, IL
- Berkeley, CA

S
Source: Diane Bishop, City of Eugene, Oregon

Left-side Bicycle Lane on One-way Street

The purpose of this design is to reduce conflicts with parked cars, buses and right-turning vehicles. For use on one-way streets with high bus volumes in the right-most lane and/or high volumes of right-turns from the subject street. This treatment is safer if there is no parking on the left side of the street. The treatment may reduce the danger of parked car driver-side doors opening into the bike lane and help avoid the leap frog effect, where buses pass bikes between stops and bikes pass buses at stops. However, it may be difficult for bicycles to move back to the right side when the bike lane ends or reverts to a right-side bike lane.

A left-side bike lane with on-street parking, in Minneapolis, Minnesota.
Source: Donald Pflaum, City of Minneapolis, Minnesota

Bicycle Boulevard

Bicycle boulevards provide an alternative to bicycling on arterial roads. The best locations are on residential streets parallel to a nearby arterial, on a route with high or potentially high bicycle traffic. Bicycle boulevards are generally too narrow to install a bicycle lane. Direct, cross-town routes are preferable.

The defining feature of bicycle boulevards is that they prioritize bicycle traffic through the use of various treatments:

- Through motor vehicle traffic is discouraged by periodically diverting it off the street.
- Remaining traffic is slowed to approximately the same speed as bicyclists.
- Stop signs and signals on the bicycle boulevard are limited to the greatest extent possible, except where they aid bicyclists in crossing busy streets.

The development of a bicycle boulevard may include the alteration of intersection controls, the installation of signage, stencils, or other treatments that facilitate bicycling. Bicycle boulevards are most effective when several treatments are used in combination. Bryant Street in Palo Alto, California uses traffic circles, stop signs on streets that cross the bicycle boulevard and other devices to give cyclists the right of way, while Berkeley, California's bike boulevards utilize identity and directional signage, and pavement stencils to make it known to all road users that bicyclists are permitted to use the full traffic lane, and to guide them to their destination.

Directional Signage and pavement stencil on the bike boulevard in Berkeley, California.
Source: Jumana Nabti

Colored Bicycle Lanes in High-Conflict Zones

Colored bicycle lanes increase the visibility of cyclists by explicitly defining cyclist right-of-way. They may also remind motorists that they are crossing a bike lane and to take extra caution in high-conflict zones. Colored lanes are useful at hazardous intersections and other locations, especially where motorists fail to yield right-of-way to bicyclists. The City of Portland has experimented using them at freeway exit ramps, entrance ramps, and right-turn lanes. Short sections of the bike lane are colored at high-risk locations, where motorists are permitted or required to merge into or cross the bike lane. In Portland, Oregon, these bike lane locations were previously marked with white dashed lines. The City of San Francisco is considering experimenting and studying the use of these lanes for possible inclusion in the California supplement of the MUTCD.

Evaluation Studies:

- "Portland's Blue Bike Lanes: Improved Safety through Enhanced Visibility," City of Portland, 1999.
- "Evaluation of the Blue Bike Lane Treatment used in Bicycle-Motor Vehicle Conflicts Areas in Portland, Oregon." U.S. Department of Transportation, Federal Highway Administration. Publication Number FHWA-RD-00-150, August 2000.

Sample Sites:

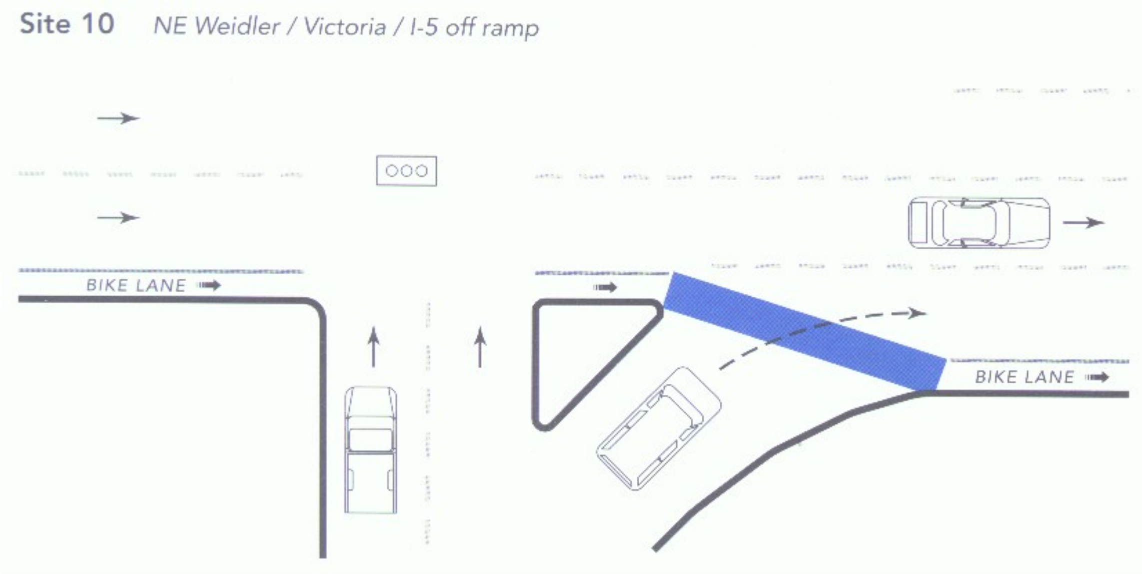
Portland, OR: S.E. Madison between Sixth and Grand, the east end of the Broadway Bridge, the east end of the Hawthorne Bridge, N.E. Weidler at Victoria, N.E. Broadway at Williams, Beaverton-Hillsdale Highway at Bertha, S.E. Seventh at Morrison, S.W. Terwilliger at I-5, S.W. Mulnomah at Garden Home Road

Cambridge, MA: Huron Avenue at Fresh Pond Parkway, Sparks Street at Huron Avenue, Massachusetts Avenue at Prospect Street, Broadway at Hampshire

Montreal, QC, Canada: Avenue Christophe-Colomb/Rue Sauve

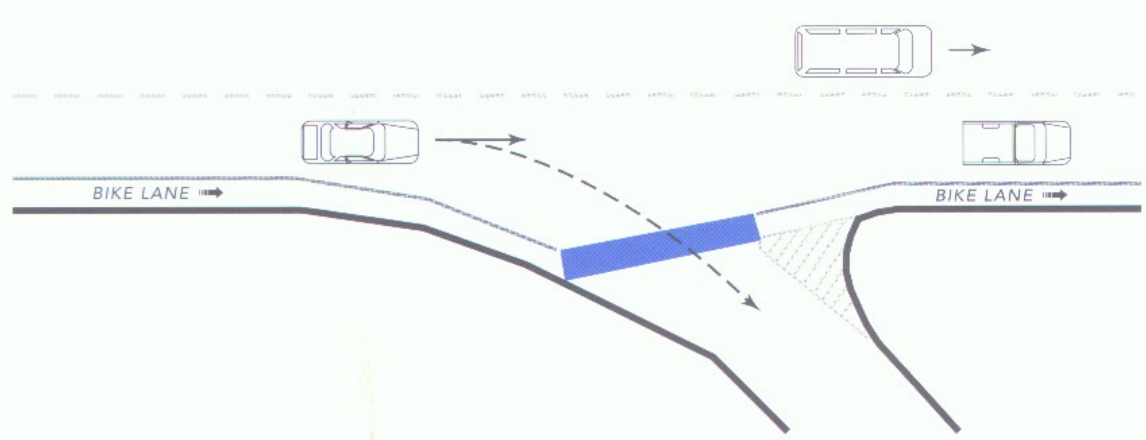
Petaluma, CA: 1-block stretch of red bicycle lane near downtown

Diagram of a colored bike lane at an on-ramp as used in Portland, Oregon.

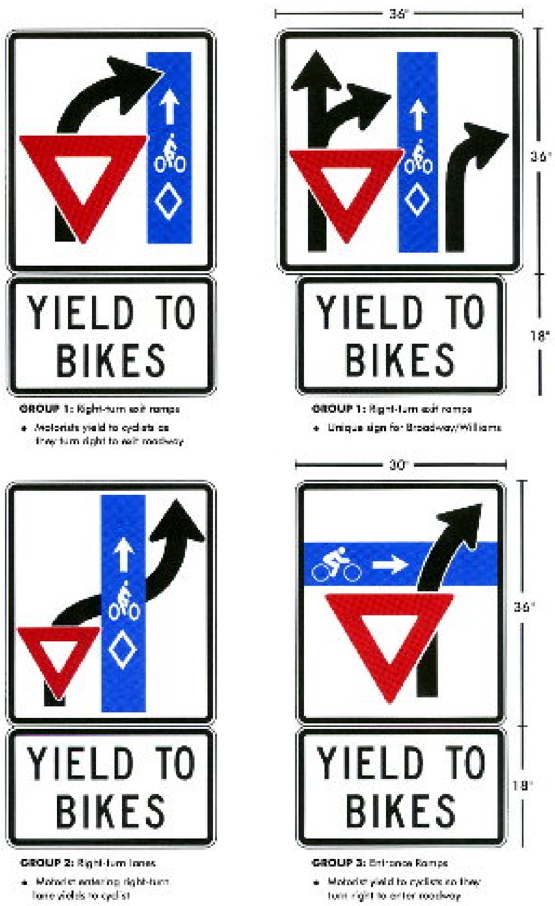


Source: City of Portland

Figure 2-13D: Diagram of colored bike lane at an off-ramp, as used in Portland, Oregon.



Source: City of Portland



Blue bike lane in Cambridge, Massachusetts.
Source: Jumana Nabti

Signage used at blue bike lane locations in
Portland, Oregon
Source: City of Portland

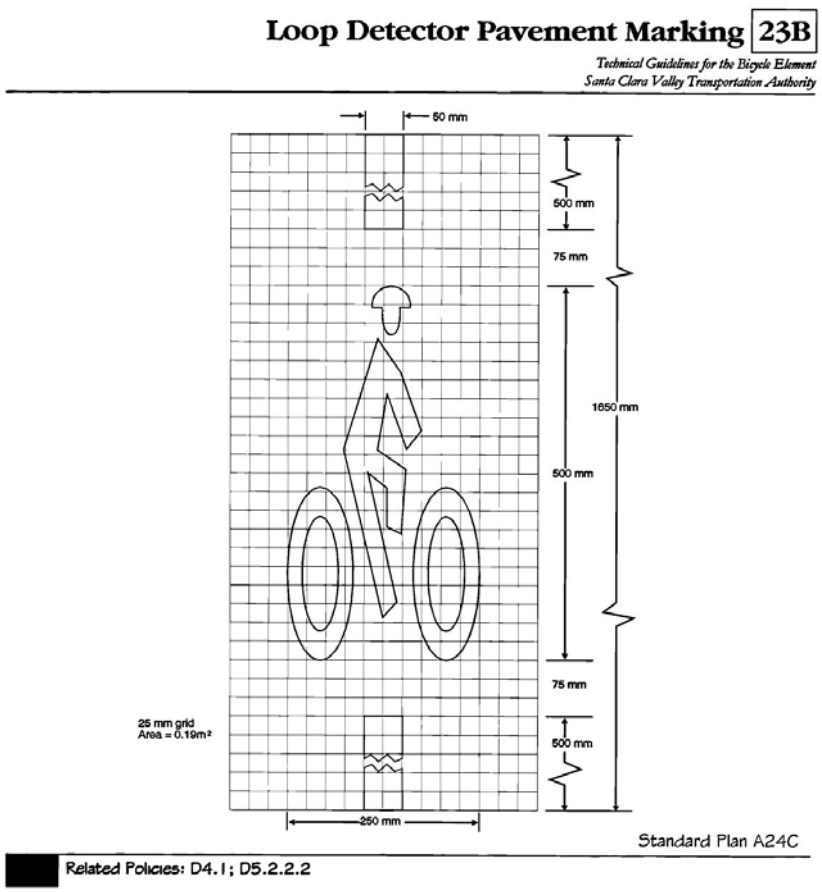
III. Design Elements - Intersection Treatments

The largest numbers of bicycle/auto accidents occur at intersections. Therefore following proper design guidelines and exploring other innovative treatments at intersections can yield significant safety benefits for bicyclists.

A. Basics

Bicycle Detection
Caltrans provides recommended intersection treatments in Chapter 1000 of the Highway Design Manual including bike lane "pockets" and loop detectors. Bicycle loop detectors should be installed on the roadway system at all actuated signals. Critical for bicyclists on any street are loop detectors at actuated signals. As a practice, all loop detectors should detect cyclists, and all signals should designate their location with the stencil below.

Figure 16: Bicycle Loop Detector Stencil



• Reference Also: Highway Design Manual, Chapter 1000 Bikeway Planning and Design and the Traffic Manual.
Discussion Draft (subject to change): 4/26/99

OLLABORATIVE

Class II Bicycle Lanes at Intersections

This figure presents typical striping and lane configurations for bike lanes and loop detectors at a multi-lane intersection

Figure 17A: Bicycle Lanes at Multi-Lane Intersections

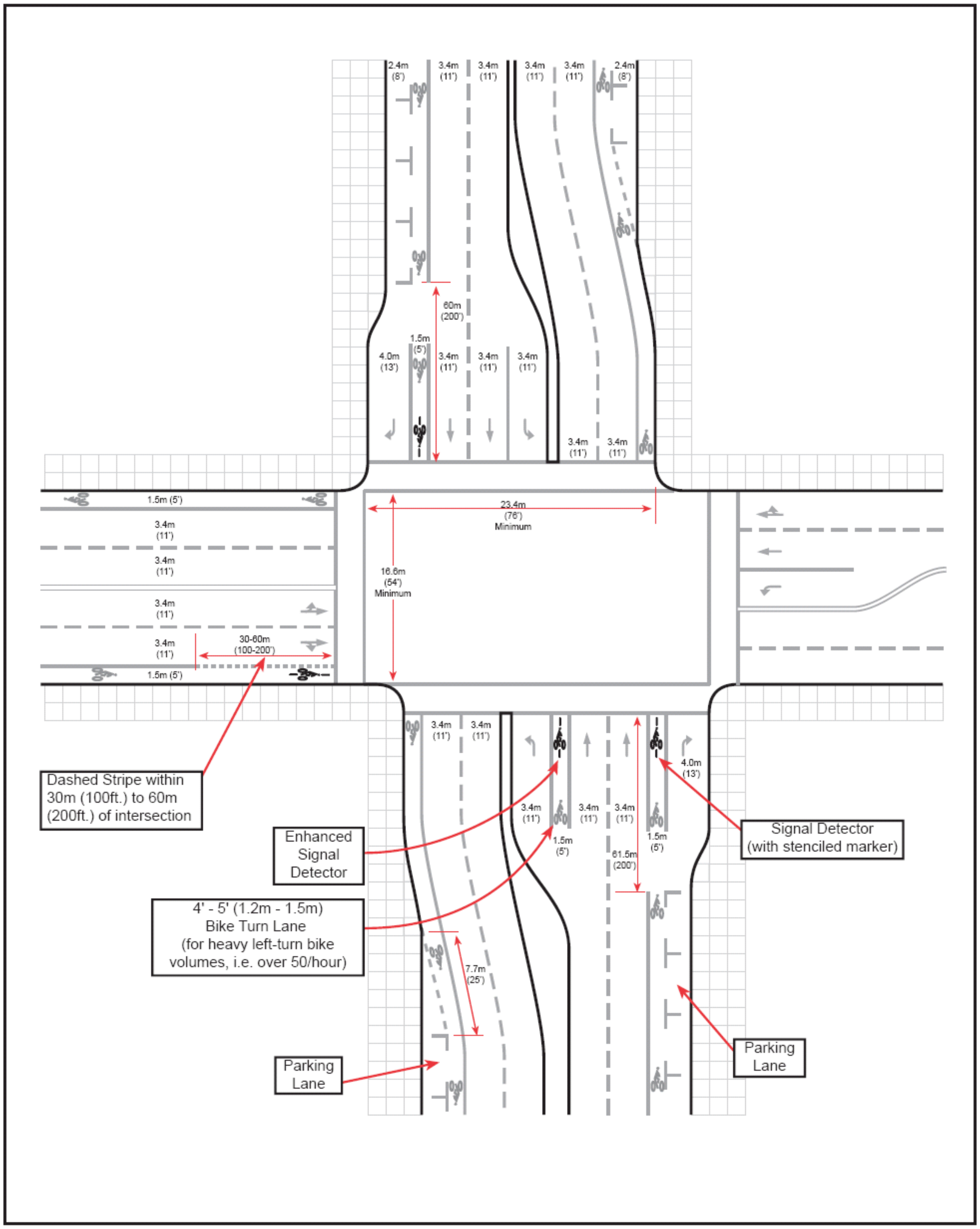
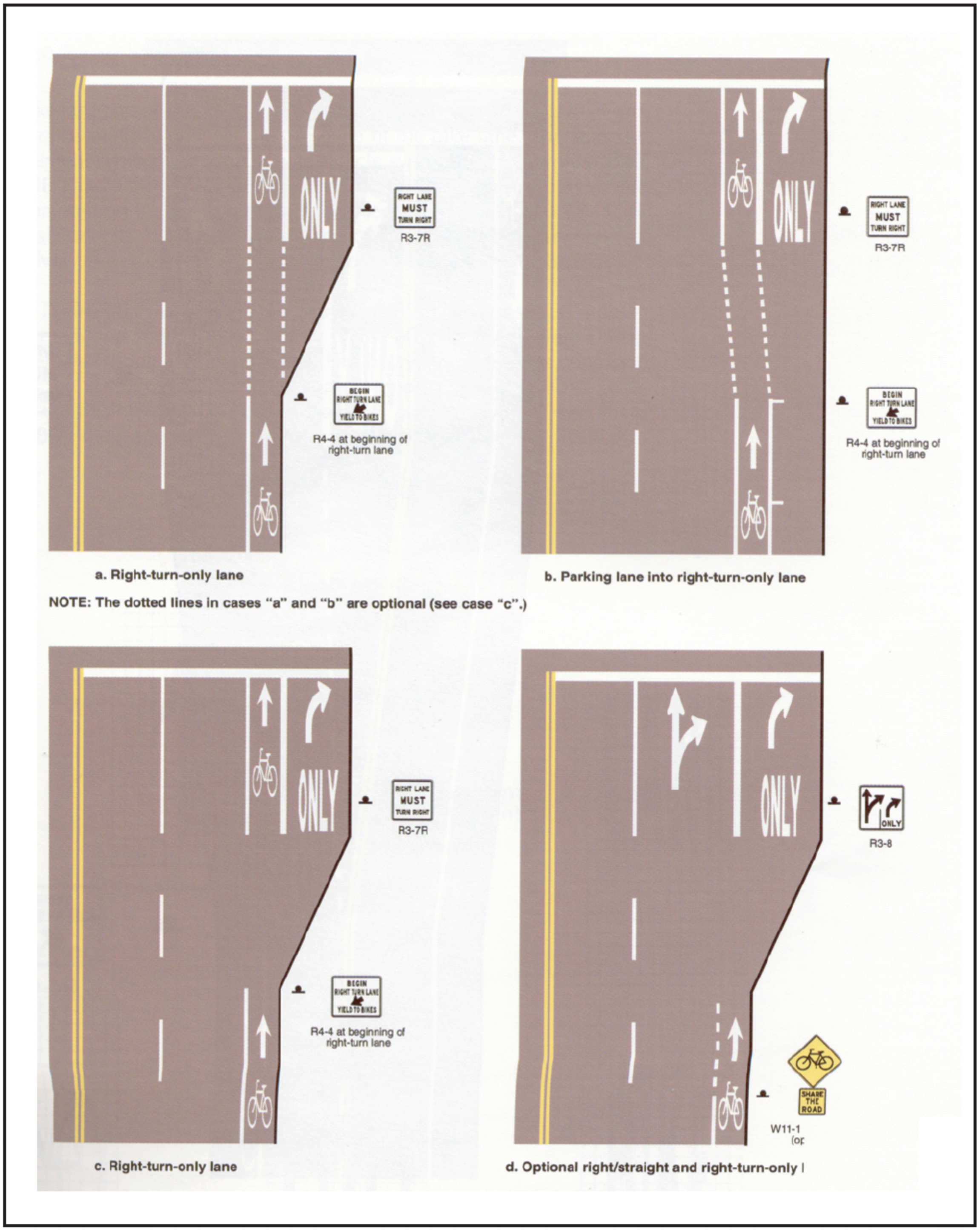


Figure 17B:Bicycle Lanes at Multi-Lane Intersections



B. Innovations

The following innovations appear in *Innovative Bicycle Treatments, An Informational Report,* published by the Institute of Transportation Engineers. Each one responds to problems that are typical in cities wishing to retrofit existing streets for bicycle lanes. They should be employed using good engineering judgement. Each of these devices has been used somewhere in California or in the United States, although most of them do not appear in state or national standards.

Advance Stop Line (ASL)/Bicycle Box

The bicycle box has two primary benefits. It can improve the visibility of cyclists at intersections and it enables bicyclists to correctly position themselves for turning movements during the red signal phase by allowing them to proceed to the front of the queue. As a secondary benefit, it also provides a transition from a left-side or median bike lane to a right-side lane.

The bicycle box is useful at intersections with high motor vehicle and bicycle volumes, frequent turning conflicts, and/or intersections with a high percentage of turning movements by both cyclists and motorists. Bike lane leading up to a bicycle "reservoir" located between the motor-vehicle stop line and the crosswalk. The bike box should be 4 to 5 meters deep. If it is shallower, bicyclists tend to feel intimidated by the motor vehicles, and if it is deeper, motorists tend to encroach. To increase its effectiveness, a bicycle stencil should be placed in the bike box and a contrasting surface color is strongly recommended for the reservoir and the approach bike lane. Instructional signs and separate cyclist signal heads can be installed in conjunction with the bike box. Encroachment and violation of the bike box must be enforced by local law enforcement.

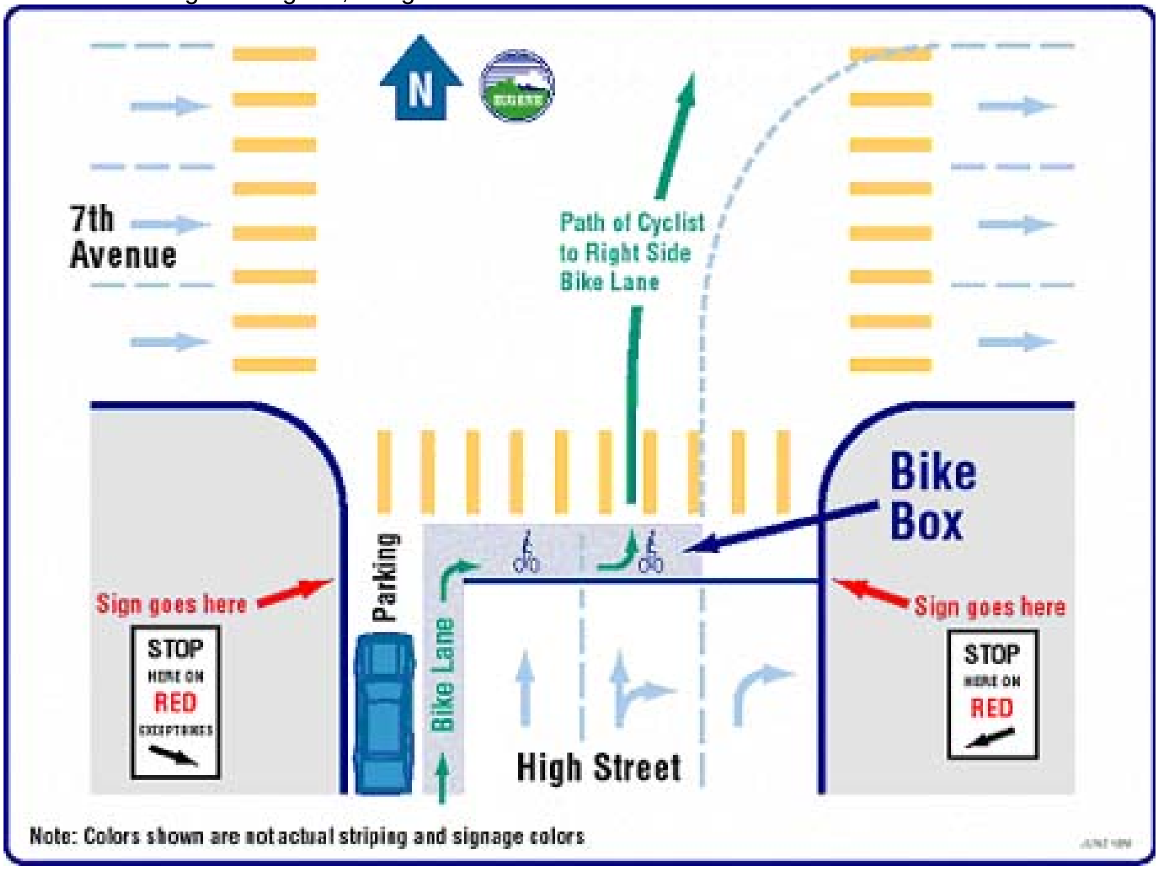
Evaluation Studies:

- TRL Project Report 181- Advanced Stop Line for Cyclists: The Role of Central Cycle Lane Approaches and Signal Timings
- A Wheeler (TRL) – Advanced Stop Lines: A Simplified Layout. Traffic Engineering and Control, May 1995
- William Hunter, "Evaluation of an Innovative Application of the Bike Box." University of North Carolina Highway Safety Research Center. Prepared for U.S. Department of Transportation, Federal Highway Administration. Publication Number FHWA-RD-00-141, August 2000
- Traffic Advisory Leaflet 10/86: Innovatory Cycle Scheme, Oxford-Parks Road/Broad Street, Advanced Cycle Stop Line, November 1986
- Traffic Advisory Leaflet 3/89: Innovatory Cycle Scheme, Newark, Advanced Cycle Stop Line, April 1989
- Traffic Advisory Leaflet 6/91: Innovatory Cycle Scheme, Bristol, Advanced Cycle Stop Line, September 1991
- Traffic Advisory Leaflet 8/93: Advanced Stop Lines for Cyclists, August 1993
- Traffic Advisory Leaflet 5/96: Further Development of Advanced Stop Lines, May 1996

Sample Sites:

<u>Eugene, OR:</u> High Street at Seventh Ave.
Hawaii, Cambridge, MA

A bike box design in Eugene, Oregon.



Source: City of Eugene

A bike box in Hawaii.
Source: Vincent Llorin
Advance marking and signage for a mid-block bike crossing in Sacramento, California.

Mid-block Bicycle Crossings

Mid-block bicycle crossings are constructed to improve the mid-block unsignalized intersection of an off-street bikeway with a street. There are two basic types. One is suitable for streets with faster moving traffic while the other is more appropriate on streets with slower speeds.

The crossing at streets with faster moving traffic consists of two four-foot long sections of one-foot wide diagonal stripes separated by an eight-foot clear section. Reflective pavement markers are installed on the near side of the crossing in front of each diagonal strip. A bicycle logo and "XING" pavement legend are installed prior to the crossing, at a distance dependent on the roadway design speed along with a bicycle warning sign (#W79). The bikeway traffic is controlled with "STOP" signs.

Sample Sites:
Sacramento, CA: The Jedediah Smith National Recreation Trail crossing Del Paso Boulevard, east of Northgate Boulevard (north of downtown); The Pocket Canal Parkway crossing Havenside Drive, south of Florin Road and crossing Rush River Drive, south of Havenside Drive (south Sacramento).

Mid-block crossing in Sacramento, California.

Advance marking and signage for a mid-block bike crossing in Sacramento, California.
Source: Debb Newton, City of Sacramento

The crossing suitable for roadways with slower moving traffic, such as in business districts or on residential streets is similar to a standard pedestrian crosswalk, with the addition of a standard bicycle logo pavement marking on each side of the roadway in the direction of travel. A yellow Bicycle Crossing sign is posted just before the crossing to warn drivers of the presence of bicycles. Pavement marking materials should have high skid resistance and be located outside of motor vehicle wheel paths to prevent falls in inclement weather.

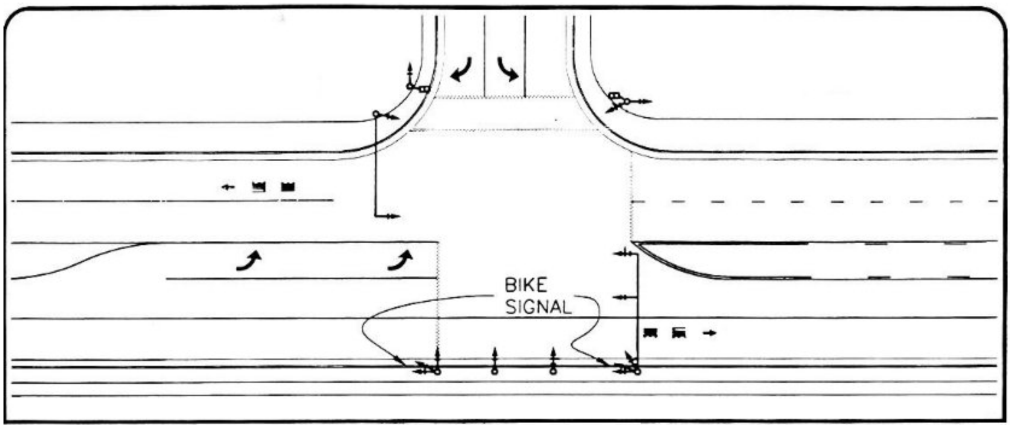
Sample Sites:
<u>Monterey, CA:</u> several locations downtown

A mid-block bicycle crossing in Monterey, California
Source: Matthew Ridgway

Bicycle Signals

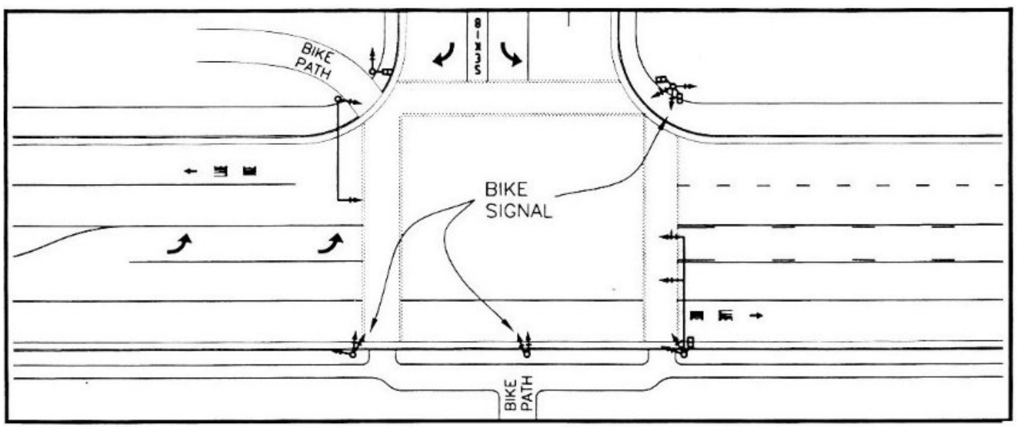
Bicycle signals are appropriate for use at intersections with considerable traffic volumes and conflicts. There are three kinds of intersections at which Davis, California has considered using bicycle signals and which have subsequently become standard in California: at tee intersections with “major bicycle movement along the top of the tee, at the confluence of an off-street bike path with an intersection, and where separated bike paths run parallel to arterial streets.” Bicycle signal heads have been approved by the California Traffic Control Devices Committee (CTCDC) for use in the state of California

Bike signal with major bicycle movement along the top of a tee intersection.



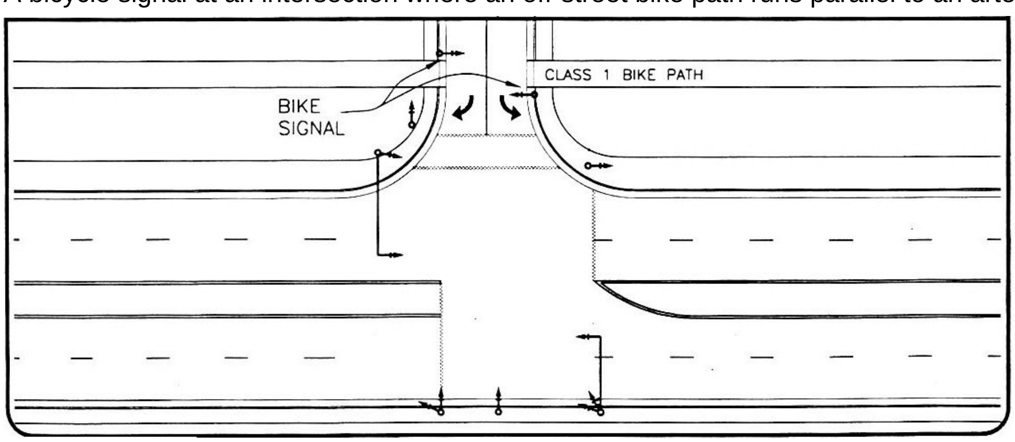
Source: City of Davis, California, “The Use of Bicycle Signal Heads at Signalized Intersections.” July 1, 1996.

Bike signal at an intersection with an off-street bike path.



Source: City of Davis, California, “The Use of Bicycle Signal Heads at Signalized Intersections.” July 1, 1996.

A bicycle signal at an intersection where an off-street bike path runs parallel to an arterial.



Source: City of Davis, California, “The Use of Bicycle Signal Heads at Signalized Intersections.” July 1, 1996.

A bicycle signal provides a separate signal to direct bicycle traffic through an intersection. Red, amber, and green bicycle indications are installed in addition to the standard red, amber and green ball and arrow indications. In California, since bicycles have the same rights and responsibilities as motor vehicles in most situations, the City of Davis changed their municipal code to clarify that at intersections with bicycle signals, bicycles should only obey the bicycle indications. In Davis, “the current signal phasing provides for a minimum bicycle green time of 12 seconds and a maximum green time of 25 seconds. Additionally, a two-second all red interval is provided at the end of this phase as opposed to only one second at the end of other phases. Pedestrian cycle times are five seconds of walk and 18 seconds of pedestrian clearance.” Other treatments included with the installation of the bicycle signal heads include advance signing warning users that “bicycle signals are in use at the intersection ahead,” and a “NO RIGHT TURN ON RED” LED changeable sign prohibiting motor vehicles from conflicting with bike and pedestrian traffic during the bike phase.

Evaluation Studies:
City of Davis, California, “The Use of Bicycle Signal Heads at Signalized Intersections” July 1, 1996. This study surveyed cyclists before and after installation of the bicycle signal heads at the intersection of Russell Boulevard and Sycamore Lane. Before and after collision data was collected as well as discussions with the City of Davis Police Department, the University of California, Davis Police Department, and the University of California Transportation and Parking Services (TAPS) staff.

Sample Sites:
Davis, CA: at the intersections of Russell Boulevard and Sycamore Lane, Russell Boulevard and Arthur Street, Arlington Boulevard and Shasta Drive, Covell Boulevard and Oak Avenue, Covell Boulevard, and Catalina Drive, F Street south of Covell Boulevard, and Covell Boulevard and Birch Lane
New York, NY; Tucson AZ

Bicycle signal head in Davis, California (left) and New York, NY (right).

Source: Michelle DeRobertis

Source: Andrew Vesselinovitch

Merge Zone at Intersection Approach

Objective: To allow room or time for bicyclists to merge, at their convenience, from the curbside bike lane to the through bike lane at an intersection approach with a dedicated right-turn lane.

Applications: For use at intersection approaches with a “drop” lane (a through-travel lane that becomes a right-turn only lane), with high traffic volumes and speeds.

Description: The through bike lane at the intersection approach is extended back so it overlaps with the curbside bike lane for approximately 100 feet. The through bike lane striping is dashed on both sides for the portion that it overlaps with the curbside bike lane.

Advantages:
- Allows bicyclists time to merge into the through bike lane more safely
- Reduces bicycle delay by providing smoother transition
- Encourages bicyclists to properly position themselves for intersection maneuvers by making it easier and safer
- Encourages motorists maneuvering into the dedicated right-turn lane to look for and yield to bicyclists

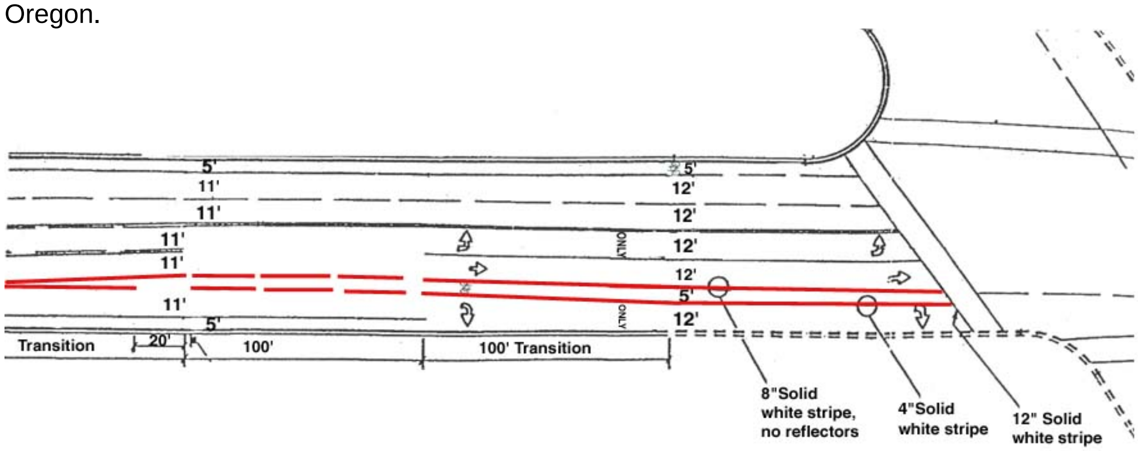
Disadvantages:
- Introduction of the merge zone may require additional street width, which may introduce costs to construct the lane
- Location of the zone may create conflicts between right-turning vehicles and bicycles
- Unfamiliar drivers may be confused or uncertain about intended purpose of markings

Cost: Dependent on design, but generally about the same as a typical signing and striping project if the pavement width exists.

Evaluation Studies: None found

Sample Sites:
Eugene, OR: Roosevelt Boulevard at Pacific Highway West

Diagram of the merge zone at Roosevelt Boulevard and Pacific Highway West in Eugene, Oregon.



Source: Diane Bishop, City of Eugene, Oregon

Photograph of the merge zone at Roosevelt Blvd and Pacific Highway West in Eugene, Oregon.
Source: Diane Bishop, City of Eugene, Oregon

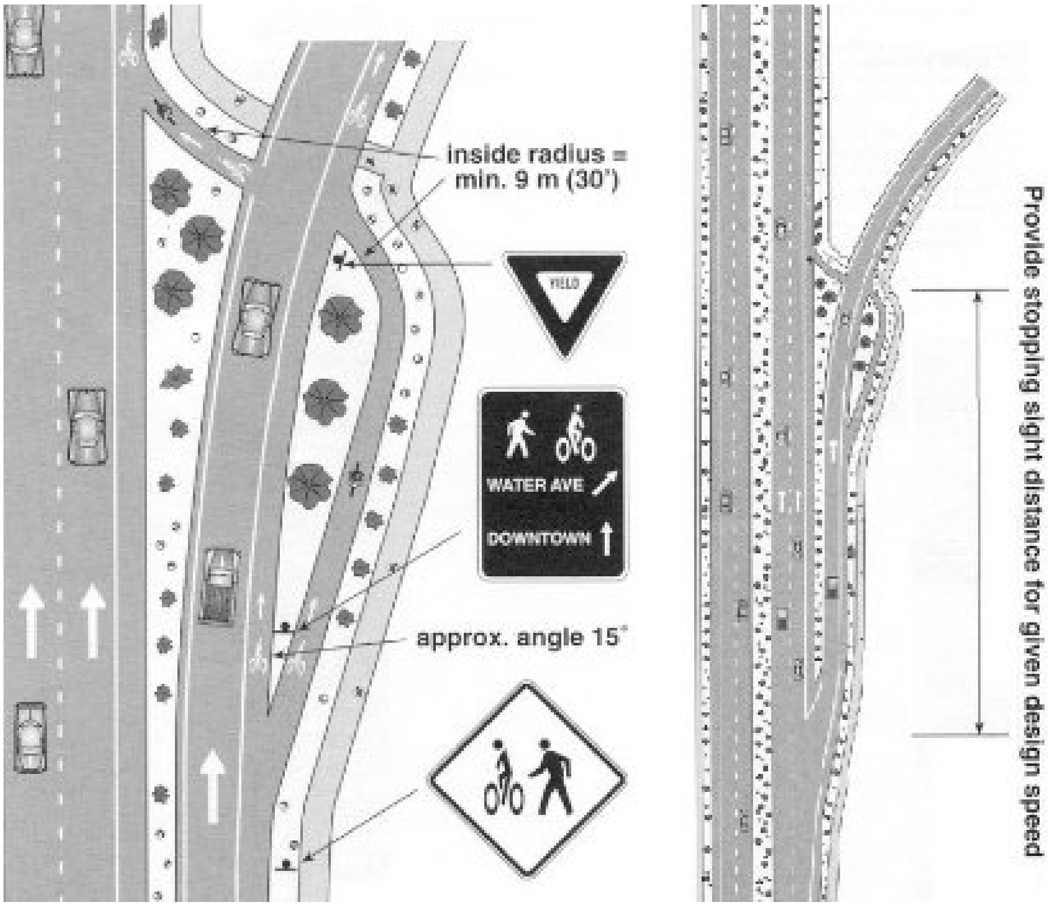
On-Ramp/Off-Ramp Crossings

This is another treatment to facilitate through bicycle movements at locations where motor vehicles are entering or exiting the roadway at high speeds and at an acute angle, such as at on-ramps and off-ramps. The on-street bikeway pulls away from the road and then turns to cross the road at a right (or close to right) angle. At this point, some kind of traffic control device should be installed to direct bicyclists to yield or stop before crossing the on-ramp or off-ramp. The Oregon Bike and Pedestrian Plan recommends a bicycle yield sign, while the example in Manchester is signalized.

Evaluation Studies:

- Traffic Advisory Leaflet 8/89: innovatory Cycle Scheme, Manchester, Mancunian Way Signalled Cycle Crossing
- Traffic Advisory Leaflet 1/88: Provision for Cyclists at Grade Separated Junctions
- Also mentioned in the Oregon Bicycle and Pedestrian Plan

Sample Sites:
<u>Manchester, UK:</u> Mancunian Way at Fairfield Street



Diagrams of an off-ramp bicycle crossing.
Source: Oregon Bicycle and Pedestrian Plan, Oregon Department of Transportation, 1995

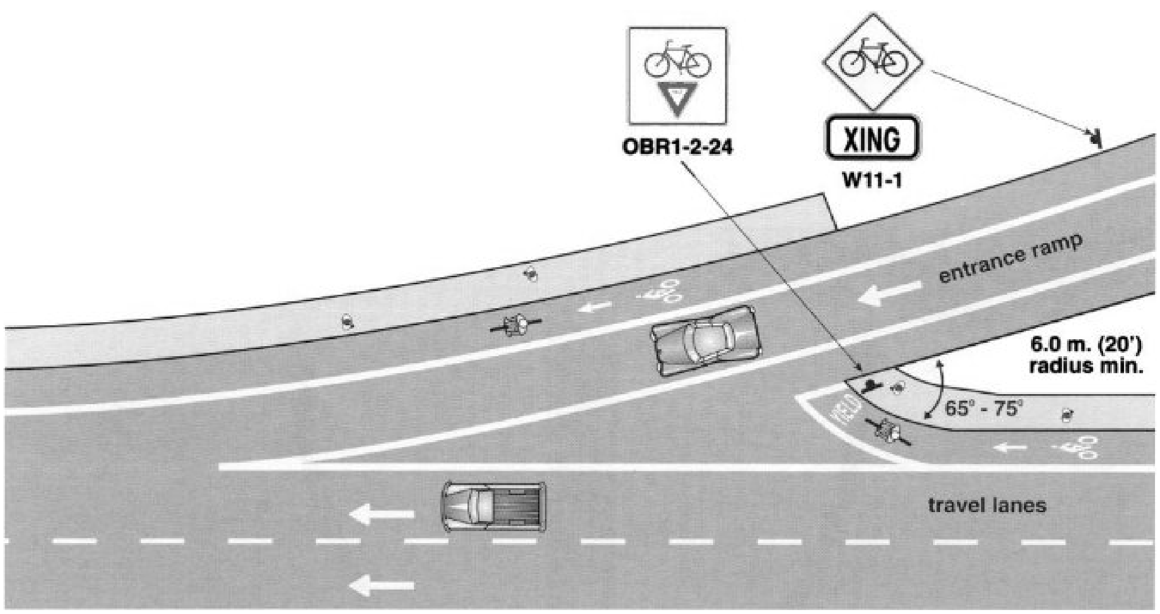


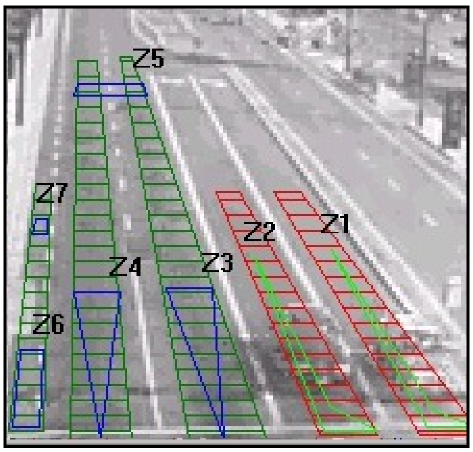
Diagram of an on-ramp bicycle crossing.
Source: Oregon Bicycle and Pedestrian Plan, Oregon Department of Transportation, 1995


An on-ramp bicycle crossing in Oregon.
Source: Oregon Bicycle and Pedestrian Plan, Oregon Department of Transportation, 1995

Video Camera Detection

This is an alternate method to allow bicycles to actuate traffic signals at intersections. Intersections where this is appropriate likely have bicycle lanes and video detection for vehicles. Detection zones are defined in the bike lanes of signalized intersections using video cameras for vehicle detection. The figure below shows the layout of bike lane detection zones in a video image on the approach to a signalized intersection. The detection zones to detect motorized vehicle traffic are also shown. Areas labeled Z 7 and Z 6 are bike lane detection zones.

Sample Sites:
Ventura, CA: There are cameras at Victoria Avenue and Telephone, and the operations center is in City Hall.
San Luis Obispo, CA: Foothill and California, Mill and Santa Rosa, Foothill and Chorro as well as other intersections



Video camera based bicycle loop detector layout.
Source: Jim Hanson

Advance Inductive Loop Traffic Signal Detection

This is an enhancement to a standard loop detector that actuates a traffic signal before or by the time the bicycle reaches the intersection to prevent the need for stopping. It is appropriate for use in locations with high bicycle usage, where bikeways cross major streets, especially where the side street receives a green light only when actuated. In addition to the electromagnetic bicycle sensitive detector loop at the intersection, one is placed a distance back (the one in Berkeley is approximately 20 ft from the crosswalk), such that the bicycle is forced to ride over it.

Sample Sites:
Berkeley, CA: Channing Street at Martin Luther King Jr. Way

Advanced inductive loop traffic signal detector on
Channing Street at Martin Luther King, Jr. Way
in Berkeley, California.
Source: Jumana Nabti

IV. Bicyclists and Traffic Calming

Traffic calming utilizes a variety of design techniques to create streets that are more livable and less dominated by the automobile. This is typically accomplished either by reducing the volume of automobile traffic directly with diversions or by reducing the volume of automobile traffic indirectly by making the street a slower route for automobiles. One objective of traffic calming is to create a safer and more comfortable environment for bicycles and pedestrians. Lower automobile volumes and slower speeds can create a more comfortable biking environment and may reduce the number of collisions and their severity. However, some traffic calming techniques can actually be counterproductive, creating an environment that is less comfortable for bicycles and pedestrians. Below, the most common traffic calming techniques are described with a focus on the impact to cyclists.

A. Speed Humps

These low broad installations of raised pavement in the roadway are designed to slow traffic to around 15 miles per hour. If designed properly they should not be hazardous or uncomfortable to cyclists. Gentle approach and exit gradients, flush leading edges, and smooth surfaces reduce the risk of cyclists losing control or experience discomfort when riding over speed humps. Installation of speed humps on streets with large gradients should be avoided due to the potentially higher speeds at which cyclists may be traveling. It is preferable to incorporate a sinusoidal, rather than parabolic design.

B. Lane Narrowing/Reduction

When done properly, narrowing lanes or reducing the number of lanes can both calm automobile traffic and provide a safer and more comfortable environment for cyclists, however improper implementation of this traffic calming technique can create an environment that is worse for cyclists. Unless narrowing is substantial and frequent, any reduction in vehicle speed is usually small, while at the same time forcing bicyclists and motorists together into a more constrained space or forcing cyclists to ride dangerously close to parked cars where a door opening could cause injury. One recommended guideline is that lanes shared by autos and bicycles should be at least 12-14 feet wide on streets with speeds over 30 miles per hour. When narrow lanes are present, especially along streets with higher speeds and parking, share the road signage is appropriate. The adjacent photo shows a sign designed to communicate to cyclists and motorists that bicyclists have the right to share the lane, particularly when riding to the right places them in the "door zone."

The photo above displays a customized sign used in the City of San Francisco. The sign is meant for use on streets with narrow lanes to clarify that cyclists may "take the lane" in this situation as there is not enough room to safely stay out of the travel lane.

C. Traffic Circles and Pedestrian Islands

These are placed at the center of low volume, neighborhood intersections in place of or in combination with stop signs. They narrow the roadway and force motorists to change direction which can help reduce auto speeds. In addition pass-thru volumes may be reduced by unfamiliar drivers due to the dead-end appearance traffic circles can create. As with lane narrowing, some bicyclists do object to the use of traffic circles. They feel it creates confusion by drivers unsure of how to complete their turning movements and decreases the clearance between bicyclists and cross-traffic. Signage and lane striping can help reduce motorist confusion.

D. Barriers/Diverters

This traffic calming device directly reduces the volume of automobile traffic by either completely blocking both directions of travel, blocking one direction of travel, or diverting vehicles at intersection such that thru movements are not allowed. A number of design considerations can help ensure that barriers and diverters don't reduce safety and comfort for cyclists. Appropriately sized gaps to allow cyclists to pass through or around the barriers should be provided. Setting barriers back from intersections can improve the visibility of bicyclists to conflicting traffic at the intersection and make it easier and safer for a cyclists turning onto the barrier controlled roadway.

E. Curb Extensions (Bulb-outs)

Primarily designed to reduce crossing distance and improve visibility, curb extensions when utilized with other design elements aid in calming traffic. However, the same consideration that applies to lane narrowing applies here. Curb extensions should not reduce the width of a shared line to less than 14ft in width and they should allow cyclists to maintain a straight line of travel.

REFERENCES

Bicycle Planning Resources

Guide for the Development of Bicycle Facilities, 1999., American Association of State Highway and Transportation Officials (AASHTO), P.O. Box 96716, Washington, DC, 20090-6716, Phone: (888) 227--4860.

Implementing Bicycle Improvements at the Local Level, (1998), FHWA, HSR 20, 6300 Georgetown Pike, McLean, VA.

North Carolina Bicycle Facilities Planning and Design Guidelines, 1994. North Carolina DOT, P.O. Box 25201, Raleigh, NC 27611. (919) 733-2804.

Bicycle Facility Planning, 1995. Pinsof & Musser. American Planning Association, Planning Advisory Service Report # 459. American Planning Association, 122 S. Michigan Ave, Suite 1600; Chicago, IL 60603.

Florida Bicycle Facilities Planning and Design Manual, 1994. Florida DOT, Pedestrian and Bicycle Safety Office, 605 Suwannee Street, Tallahassee, FL 32399.

Evaluation of Shared-use Facilities for Bicycles and Motor Vehicles, 1996. Florida DOT, Pedestrian and Bicycle Safety Office, 605 Suwannee Street, Tallahassee, FL 32399.

Oregon Bicycle and Pedestrian Plan, 1995. Oregon Department of Transportation, Bicycle and Pedestrian Program, Room 210, Transportation Building, Salem, OR 97310, Phone: (503) 986-3555

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TRANSPORTATION TEAM

- David Aladjem
- Mike Barnbaum
- Carol Borden
- Mary Brill
- Lea Brooks
- Margaret Buss
- Tim Cahill
- Barney Donnelly
- Tom Garcia
- Anne Geraghty
- Fran Halbakken
- Robert Holderness
- Nancy Kays
- Bob Lee
- Vicki Lee
- Larry Masuoka
- Pamela May
- Mike Penrose
- Mary Poole
- Mike Wiley