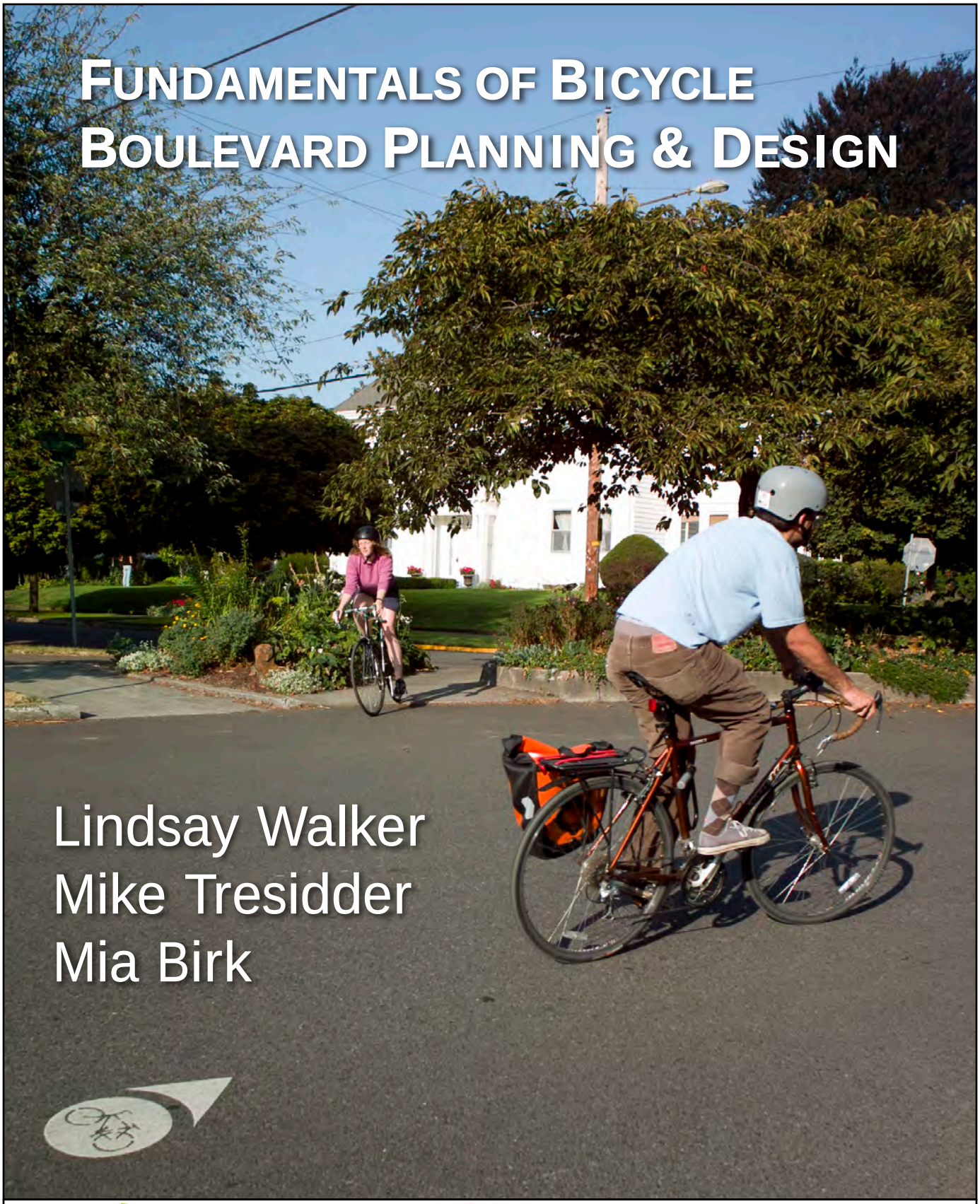
Fundamentals of Bicycle Boulevard Planning & Design



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July 2009
CUS-CTS-09-02

Acknowledgments

This report was prepared as a requirement for graduate coursework in the Nohad A. Toulan School of Urban Studies and Planning at Portland State University, in partnership with, and overseen by Alta Planning + Design. It has been reviewed by and approved for distribution by the course instructor, contributed to by national experts from the Association of Pedestrian and Bicycle Professionals and a steering committee of Portland-based practitioners.

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Acknowledgments

The authors would like to express their gratitude to all of the individuals who shared their knowledge and expertise in the making of this guidebook. Without your contributions the publication of this document would not be possible.

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I. Introduction

Overview of this report

This report is intended to serve as a planning and conceptual design guide for planners, engineers, citizens, advocates, and decision makers who are considering bicycle boulevards in their community. Data for this guide was developed from literature review, case study interviews, and input from a panel of professional experts.

Section two of this guide contains information on bicycle boulevard planning, including considerations for route selection, public involvement, and funding. Section three provides information on design elements commonly used on bicycle boulevards including descriptions, design and implementation recommendations, images, and cost range estimates as available. Section four discusses marketing, maintenance, and safety considerations for bicycle boulevards. Finally, Section five presents individual case studies of bicycle boulevards from across the United States.

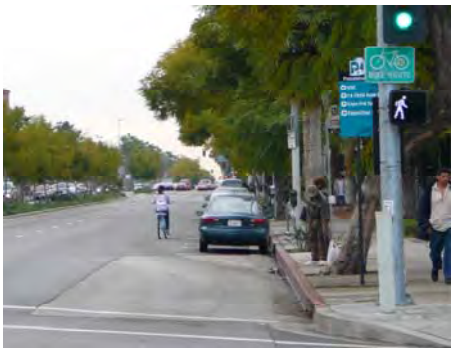
Additional resources, including a bicycle boulevard audit, can be found in the appendices.

What are Bicycle Boulevards?

Traffic engineers, planners, and bicycle activists often frame the development of their bikeway network around three types of bicycle facilities (Figure 1.1):

- Bicycle Path – a paved bicycle path physically separated from motor vehicle traffic (generally outside the road's right of way). It is often shared with pedestrians and other non-motorized users, and occasionally equestrians.
- Bicycle Lane – one-way on-street lanes that are signed and marked to designate the space occupied by cyclists on the roadway.
- Shared Roadway – A bike facility in which cyclists share the roadway with motor vehicles, cycling in a paved shoulder or a wide outside curb lane. It may or may not be signed as a preferred bicycle route.

Figure 1.1 Common types of bicycle facilities



Bicycle boulevards take the shared roadway bike facility to a new level, creating an attractive, convenient, and comfortable cycling environment that is welcoming to cyclists of all ages and skill levels (Figure 1.2). In essence, **bicycle boulevards are low-volume and low-speed streets that have been optimized for bicycle travel through treatments such as traffic calming and traffic reduction, signage and pavement markings, and intersection crossing treatments**. These treatments allow through movements for cyclists while discouraging similar through trips by non-local motorized traffic. Motor vehicle access to properties along the route is maintained.

Figure 1.2 A bicycle boulevard is attractive to cyclists and other non-motorized roadway users.

Bicycle boulevards are known by several different names. In Vancouver, British Columbia, bicycle boulevards are called Local Street Bikeways. In Minneapolis, Minnesota, they are known as Bike/Walk Streets. In other locations, bicycle priority streets. Further, there are bicycle routes that contain all the elements of a bicycle boulevard, but are not given a title.

There are also several European examples of roadway treatments similar to bicycle boulevards, such as the Fahrradstraße in Germany and the Fietstraten in the Netherlands. Literally translated as "bike streets," these roadways act as major cycling routes where motor vehicle traffic has been reduced or restricted and bicyclists have priority.

Although these low-volume, low-speed facilities vary greatly in their individual design elements, each shares the common theme of reducing the volume and speed of motor vehicle traffic (particularly non-local, cut-through traffic), and creating a comfortable space where bicyclists, and often pedestrians as well, have priority along the street. The primary characteristics of a bicycle boulevard are:

- low motor vehicle volumes
- low motor vehicle speeds
- logical, direct, and continuous routes that are well marked and signed
- provide convenient access to desired destinations
- minimal bicyclist delay
- comfortable and safe crossings for cyclists at intersections

Is there a street in the community that cyclists are naturally drawn to ride along? Are there fewer cars there and do they travel slower than on other streets? Do cyclists prefer this route because it has few stops and takes them directly to their destination?

If so, there may be potential for a new bicycle boulevard.

What makes a bicycle boulevard special?

Bicycle boulevards are attractive to cyclists and other non-motorized users

Bicycle boulevards are comfortable and attractive places to cycle. There are few motor vehicles and those on the road travel at low speeds reducing pressure on cyclists to hug the edge of the roadway. Intersections are designed to reduce the need for cyclists to stop frequently and are improved to allow convenient and safe crossings of major roadways. Clearly marked routes lead cyclists to the multiple destinations they need and want to go while clearly indicating to motorists that the street is intended for bicycle travel. Due to these conditions, bicycle boulevards attract cyclists of all ages and abilities. Research indicates that there is a strong preference by cyclists for bicycle boulevards, and suggests that they may be a key tool for attracting new cyclists who are typically less comfortable riding in traffic.[1] In addition, these low-speed and low-volume facilities are also pleasant places for pedestrians and other non-motorized users.

Bicycle boulevards are attractive to local agencies

Bicycle boulevards are attractive to local agencies for their ability to serve cyclists on existing road networks, including cyclists who may not feel comfortable riding on busy streets, even when bike lanes are provided. They may encourage people to consider cycling for one or more of their trips, which in turn may reduce local traffic congestion and help local agencies meet overall sustainability goals.

Bicycle boulevards also allow creation of bikeways along corridors where other bikeway treatments may not be feasible due to right of way or funding constraints. Although the cost of construction will vary depending on the specific traffic calming and intersection treatments implemented, bicycle boulevards can be relatively inexpensive compared to other bicycle facility improvements, particularly when the design builds upon existing traffic calming features.

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[1] Professor Jennifer Dill of Portland State University (Oregon) led a study researching how the built environment influences cycling behavior using Geographic Positioning Systems (GPSs). The study was funded by the Robert Wood Johnson Foundation Active Living Research program and the Oregon Transportation Research and Education Consortium (OTREC).

Preliminary analysis of the GPS data indicated that half of all cycling trips occurred on bicycle infrastructure (bike paths, bike lanes, bike routes, and bicycle boulevards) although bicycle infrastructure only accounts for 15% of the total roadway network available to cyclists in the Portland area. Notably, 10% of miles biked occurred on bicycle boulevards, a facility that accounts for less than 1% of the total bicycle infrastructure in the region.

Bicycle boulevards are attractive to property owners

Increasingly, proximity to bicycle facilities is being marketed as an amenity of a property. Real estate professionals in Portland, Oregon noted that a greater number of their clients are specifically looking for homes in close proximity to bicycle and transit facilities.

> *"I couldn't put a number to a higher sales price, but it [location of a property on a bicycle boulevard] is a definite plus. People are looking for more walkable/bikeable neighborhoods." – Jarrett Altman - Portland, OR Real Estate Professional*

Many homebuyers, particularly those with families, display preference for homes on streets that have low traffic volumes and speeds. Research finds that this preference for quiet neighborhood streets is the reason homes located on cul de sacs command a price premium.[2] Current residents also appreciate these conditions. Indeed, many communities have backlogged requests from citizens for traffic calming on residential streets. Bicycle boulevards that effectively incorporate traffic reduction and calming elements on residential streets may have similar impacts on housing values.

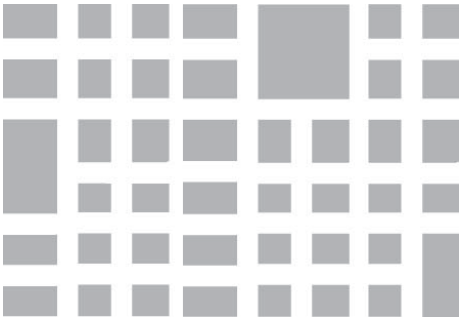
[2] An expanded discussion of these impacts is discussed in *Traffic Calming Benefits, Costs, and Equity Impacts* by Todd Littman of the Victoria Transportation Policy Institute.

II. Bicycle Boulevard Planning

Application in Different Contexts

Bicycle boulevards tend to work well in grid pattern road networks (Figure 2.1), which are often found in urban centers and in traditional neighborhoods. The logical and interconnected layout of these street networks are generally easy to navigate, tend to be continuous over long distances, and provide numerous route options to destinations. If one street is selected as the bicycle boulevard and treated to reduce through motor vehicle trips, several parallel streets remain available to motorists as alternates. In some locations, a large city block or park may reduce connectivity in the grid street system requiring cyclists to use higher speed streets. In these instances, identify opportunities to develop new non-motorized connections or design treatments that will increase cyclist comfort when traveling along the segments of higher speed roadway.

Figure 2.1 A traditional grid street system



Development of bicycle boulevards in suburban or rural settings can often be challenging due to a lack of alternate through roadways and the concentration of motor vehicle traffic on arterials. The "loop-and-lollipop" street patterns (Figure 2.2) commonly found in suburban housing developments may be reasonably good at keeping traffic speeds low and discouraging through traffic on residential streets, but these benefits often sacrifice connectivity. Trips that are relatively short "as the crow flies" become burdensome to walk or bike when a person must travel long distances just to get to the road that connects to their destination. In these systems, the through roads are generally the main streets with heavy, high-speed traffic with limited crossing opportunities, conditions that are intimidating for less traffic-tolerant cyclists.

Figure 2.2 "Loops and lollipops" in a typical suburban street

While this type of street pattern presents a challenge to bicycle boulevard creation in the suburban environment, there are often hidden opportunities. If right of way can be acquired (through purchase or easement), pathways can be constructed that connect dead-end streets. In a growing number of communities, such as Davis, California and Eugene, Oregon, cul-de-sacs are constructed and/or retrofitted to link up with nearby streets and trail systems. Communities have also begun to establish development policies that require greater street connectivity in order to reduce unnecessary out-of-direction travel. When a natural barrier, such as a waterway, creates discontinuity between two roadways, it may be possible to connect these streets by way of a bicycle and pedestrian bridge. Each of these strategies retains the benefit of motor vehicle reduction on roads, while creating continuous bikeways for non-motorized users.

Even without substantial connectivity improvements, opportunities for bicycle boulevard development within the "loop-and-lollipop" roadway pattern may exist, in some circumstances requiring little more than wayfinding improvements and careful attention to major intersections crossings to create a useful bicycle boulevard.

Bicycle boulevards work well to serve local trips, but they can also serve longer, regional trips as well. A single bicycle boulevard may be designed to span a long transportation corridor or to connect with a larger network of bicycle boulevards allowing cyclists to conveniently traverse great distances all on low-speed, low-volume streets. These regional bicycle boulevards or boulevard networks allow cyclists of all comfort and skill levels an opportunity to commute by bike, even if they work a great distance from their home. Due to the longer distances involved when traveling across a region, wayfinding and distance information on the connecting bicycle boulevards is essential.

Route Selection

Bicycle boulevard alignments are selected primarily based on the connectivity that can be provided to key destinations, the operational characteristics of the roadway corridor (or what may be achieved with the introduction of design elements), and how logical and direct the routing will ultimately be when completed. Other considerations, such as terrain, may also factor into routing decisions.

When possible, it is best that the alignment of the bicycle boulevard be selected within the scope of a comprehensive transportation plan for a corridor or neighborhood rather than focusing on a single street or corridor. This will help to avoid unintended problems (such as focusing excessive motor vehicle traffic onto nearby residential streets) and allow planners to assess the proposed bicycle boulevard within the context of the larger bicycle network.

Connectivity

A bike route to nowhere may provide a good workout, but it is not likely to likely to attract many cyclists beyond the recreational rider. To attract cyclists the route must first and foremost offer utility. Cyclists generally have the same destinations as motorists, and bicycle boulevards must provide access to the places cyclists need and want to go. Preferably, the bicycle boulevard will deliver the cyclist within a few blocks, if not directly to, the following destinations (Table 2.1).

Table 2.1 Connecting the bicycle boulevard to key destinations

Destination	Benefit
Neighborhoods	▪ Connected neighborhoods facilitate car-free play dates between children, as well as visits between adults.
Schools & Universities	▪ Schools and universities present natural populations of those who cannot or choose not to drive. ▪ A safe, low speed and low volume bicycle boulevard is appropriate for the skills of young cyclists and can provide an incentive for parents to let their children bike or walk to school. ▪ Improved conditions for bicycling to schools may reduce local congestion associated with dropping off and picking up children at school and may reduce excessive parking demand on university campuses.
Employment Centers	▪ Connections to employment centers such as office parks or downtown office buildings facilitate bicycle commute trips, potentially reducing peak hour congestion on arterials.
Commercial Centers	▪ Connections to commercial centers such as markets and retail establishments enable cyclists to complete errands such as grocery shopping or a trip to the post office as well as expanding commute options for employees. Links to theaters and restaurants increase transportation options for entertainment.
Recreational Facilities	▪ Cycling to recreational facilities such as gyms, parks, or sport fields is a great way to warm up and may reduce motor vehicle trips to these destinations.
Transit	▪ Bicycles can drastically expand the reach of a transit network, allowing transport up to five miles in less than 30 minutes at a leisurely pace. A viable bicycle boulevard connection may be the last barrier to mass transit use. ▪ Bicyclists must be able to either take their bicycle with them on their trip (i.e., bike-on-board) or leave their bicycle in a sheltered and secure location while they are away (i.e., bike-to-transit). Bicycle racks mounted on buses or inside trains, as well as short and long-term bicycle parking at transit stops, can enable bicycle-transit trips.
Bikeway Network	▪ A single bicycle boulevard cannot provide door-to-door passage to all destinations; however, it can provide connections to other facilities in the bikeway network. This assists cyclists traveling to destinations that may not be located directly on the bicycle boulevard. The bulk of the trip may occur on the bicycle boulevard, with shorter portions of the journey completed on a bike lane or path.

Operational Characteristics

Motor vehicle volumes on bicycle boulevards are usually less than 3000-4000 vehicles per day although volumes below 1500 vehicles per day are preferred. Roadways selected for bicycle boulevards ideally have maximum motor vehicle speeds of 25 mph and typically lack a centerline. In general, a speed differential between motor vehicles and cyclists of no more than approximately 15 mph is desirable. However, along segments of the route where these speed and volume conditions cannot be achieved, consider other measures that can increase cyclist comfort (such as providing a bicycle lane in areas with higher motor vehicle volume) or accept that a particular portion of the bicycle boulevard may be less attractive to less traffic tolerant cyclists.

An existing street that meets these operational characteristics may naturally stand out as a bicycle boulevard candidate and may only require the installation of design elements that maintain existing motor vehicle speeds and volumes. However, a street with higher motor vehicle speeds and volumes may also be retrofitted with traffic calming and traffic reduction design elements that intentionally lower the speed and volume of motor vehicles using the roadway. This second option may be preferable if doing it improves the bicycle boulevard connectivity to key destinations or provides a less circuitous route for cyclists. Communities are also likely to discover that the presence of cyclists along the completed boulevard combined with good traffic calming measures may further reduce motor vehicle speeds as motorists adapt to sharing the street with other roadway users and/or choose other routes.

Additional operational considerations include the frequency of intersections and motor vehicle turning movements along the route. Attention to these areas when planning the bicycle boulevard can highlight potential areas of potential areas of conflict between motorists and cyclists allowing them to be properly addressed or avoided entirely.

Direct Routes

Bicycle boulevards become "expressways" for bicyclists when they provide a direct route to popular destinations and design improvements to minimize bicyclist delay. While cyclists riding for recreation may favor a scenic route, cyclists commuting or running errands generally value an efficient and direct journey (perhaps even more so than motorists since cyclists have to propel themselves). For this reason bicycle boulevards frequently parallel nearby arterial roadways on which many destinations are frequently located. The availability of a parallel arterial roadway also encourages motorists to use arterials rather than cutting through local streets. This benefits both cyclists using the bicycle boulevard and the residents along local streets. However, considerations for terrain or the availability of a shortcut route may justify routing the boulevard away from parallel arterials.

Most cyclists are motorists as well. They are familiar with the main roadway networks and usually know which arterials will lead to a particular destination. Because the bicycle boulevard is located on a local street that may have little or no existing wayfinding, it will be less obvious than bike lanes on major roads. It must be clear to the cyclist that taking the bicycle boulevard route will lead them to their destination with a minimum of out-of-direction travel. Thus, a clear wayfinding system is essential, both on the bicycle boulevard and from arterial roadways.

Funding

Funding for bikeway planning, design and construction can come from a variety of sources, including federal, state, regional, and local programs. Additional funding opportunities include leveraging funds from Safe Routes To School programs, Green Streets/Stormwater Management projects, bond measures, systems development charges, local sales tax initiatives, and private funding.

Appendix C provides a summary of programs that fund bicycle and pedestrian projects.

Public Involvement & Outreach

Community Outreach

Community outreach and involvement is essential for successful public projects and bicycle boulevard development is no exception. Residents are naturally very interested in roadway changes proposed near their homes and eager to know how they may be affected by a project. Because bicycle boulevards are not yet a common bikeway type, it is likely to be a new concept that needs to be explained to community members. As such, the planning and construction of a bicycle boulevard (especially the first one in the community) will likely require an extensive amount of public outreach to communicate the purpose of bicycle boulevards, how they function, the benefits they may offer, and to build public strong support. Beyond education, public outreach early on in the planning process will allow residents opportunities to provide input on their goals for the project and allow planners to identify and address the concerns of those opposed to the project.

Local agency staff, working jointly with a local bicycle advisory committee, can provide residents with information about bicycle boulevards, and community members can identify desired cycling destinations and routes. A series of focused workshops on a particular bicycle boulevard route (or a segment of the route depending on length) can provide the opportunity to sketch out potential design elements of the bikeway and discuss how they will work together cohesively.

While public meetings and focused workshops are ideal forums for introducing bicycle boulevards, it is important to recognize that these types of meetings are often predominately attended by community members with a specific interest in bicycling. Make additional effort to engage community members who may not be naturally inclined to attend such a meeting, particularly residents and business owners located along or near any proposed routes. One method to gain interest from these not directly concerned with cycling is to frame the project in terms of the overall walkability and livability benefits extended to all residents in addition to the advantages that bicycle boulevard offer cyclists. Another method is to discuss traffic calming, a key characteristic of bicycle boulevards and a topic that many residents are already familiar with.

Meetings with neighborhood associations and direct mailings to residents are additional methods of getting in contact with key stakeholders and involving them in the project. Note that anyone potentially affected by the proposed bicycle boulevard, including residents who may not live directly on the bicycle boulevard, is a stakeholder and needs to be informed about opportunities to participate in the planning process.

Common Concerns & Challenges

Traffic Reduction and Traffic Calming Concerns

Traffic calming and traffic reduction design elements have been in use in several communities for many years. Concerns regarding traffic calming and reduction that occur on the bicycle boulevard are likely to be similar to concerns that are raised when these improvements are implemented anywhere else in the community. Most commonly, residents and officials will raise concerns about four potential issues related to traffic reduction and calming:

- Access to property;
- Impact on traffic patterns;
- Enforcement issues with motorcycles and mopeds; and
- Emergency response.

Planners need to be prepared to address these concerns and to respond to pressure to eliminate or modify traffic reduction and calming design elements in ways that reduce their effectiveness. Poorly designed traffic reduction and calming elements on so-called bicycle boulevards may backfire creating new traffic problems, such as attracting through motor-vehicle traffic to a bicycle boulevard with fewer stops. This reduces the comfort and safety of cyclists and negatively influences opinions regarding the utility of bicycle boulevards in general.

Access to Property

Bicycle boulevard designs commonly employ traffic reduction features that reduce the volume of motor vehicle traffic by partially or full restricting motor vehicle access to portions of the route. Such design elements make the single largest contribution to reduced motor vehicle volumes on bicycle boulevards, but are perhaps the most controversial and difficult element to implement due to concerns about resident access.

Residents must be assured that their access to their properties by motor vehicle will be maintained along sections of bicycle boulevards with traffic reduction elements. However, depending on the design, the route to access properties by car may change for some residents, potentially requiring slight out-of-direction travel to navigate around traffic restrictions. Local traffic patterns will adapt to motor vehicle restrictions over time and many residents come to appreciate the benefit of low-traffic streets as a tradeoff for any inconvenience in access. Traffic calming design elements such as speed humps prevent motor vehicles from speeding through neighborhoods, but generally have a negligible impact overall on the amount of time it takes for residents to access their property.

Trial installations of design elements can alleviate resident concerns regarding access and by allowing them to "try out" design features and allow any necessary modifications to be made before the city commits to a permanent installation.

Most design treatments used on bicycle boulevards do not impact on-street parking.

Impact on Traffic Patterns

When motor vehicle traffic is restricted or calmed on the bicycle boulevard it may induce an increase in motor vehicle traffic on adjacent streets. Local agencies must examine the impacts of traffic reduction elements both on the proposed bicycle boulevard and nearby streets, and include mitigation (e.g., additional traffic calming on adjacent streets) for any impact in their designs. Again, trial installations can allow residents to "try out" the design features and allow planners to evaluate and address impacts on traffic patterns.

Enforcement Issues with Motorcycles and Mopeds

Residents may be also be concerned that a bicycle boulevard will attract motorcyclists and moped riders who may not respect non-motorized only crossings. When Palo Alto, California implemented the first segment of the Bryant Street Bicycle Boulevard in the 1980's mopeds were popular. Bryant Street residents raised concerns early on that motorcyclists and mopeds would disregard the street closure elements intended to reduce motor vehicle volumes and use the bicycle boulevard for through travel. In practice, moped violations of street closures in Palo Alto were observed, however, they were overall very few. It seems that motorcyclists, like motorists, prefer to use the higher speed parallel facilities when they are available nearby.

Emergency Services Access

Reducing the volume and speed of traffic on a bicycle boulevard decreases the potential for and severity of collisions between motorists as well as other roadways users. However, traffic-calming elements can be a concern to fire and police personnel if the design substantially increases response times to properties along the bicycle boulevard. Without agency support for the design features, the development of a bicycle boulevard may be delayed or permanently deferred. Therefore, it is highly recommended that local agencies take steps early on in the bicycle boulevard planning process to engage emergency services and address their concerns:

- Actively develop relationships with fire and police services in the jurisdiction and involve them in the planning process for the proposed bicycle boulevard.
- The design elements acceptable to emergency services will vary among individual jurisdictions.
- Many jurisdictions have designated specific emergency response routes. Find out where these routes are located and avoid locating bicycle boulevards on these routes if necessary.
- Traffic reduction and calming design elements may be designed in such a way that allows a wide-chassis vehicle, such as a fire truck, to pass over, while preventing a similar movement of most passenger vehicles. However, these types of modifications may negate traffic calming and reduction benefits, as some passenger vehicles may also traverse these design elements. For this reason, it is generally preferable to identify emergency response streets where traffic calming and reduction improvements may be constructed rather than modifying these design elements for occasional emergency service access.
- Offer trial installations of street closures, medians, chicanes, or other design elements that may present an access concern to emergency services. This will assure them that the design will work with their equipment or allow time for design modifications.

A Bicycle Boulevard by Any Other Name?

The term bicycle boulevard, like the design concept, is still unfamiliar to many people. The "branding" of bicycle boulevards helps to ensure that planners, designers, and advocates are all talking about the same design concept, and the title lends itself to passive marketing of the bikeway network. However, to the general public the term can occasionally be confusing or off-putting.

Is this an improvement that only benefits bicyclists? Will my street become impassable due to the hordes of cyclists racing through my neighborhood? Will I be prohibited from driving to my own house? The answer to these questions is definitively no.

Nonetheless, depending on the sensitivity of the community or the unique design elements included in the proposed project, it may be preferable or more appropriate to call the bicycle boulevard by a different name. For example, BikeWalk Streets (as bicycle boulevards are called in Minneapolis, Minnesota) highlight street improvements that benefit both cyclists and pedestrians. Livable Streets and Neighborhood Greenway are other terms that suggest the benefits of the project extend beyond the bicycle route improvements to other road users such as pedestrians and residents. However, once a name has been decided, it is important to be consistent with its use throughout the community to avoid confusion and ensure that both drivers and cyclists understand what roadway conditions to expect on a modified street.

Bike Boulevards and Transit Routes Conflicts

Transit routes tend to be located on heavier traveled roadways in order to serve a greater number of passengers. Due to the high traffic volumes on these corridors, these roadways would generally not be good candidates for a bicycle boulevard treatment.

If the transit route is located along a lower volume roadway, there are still some conflicts that reduce compatibility with a bicycle boulevard. Bicycle boulevards are not intended to serve motor vehicle through trips. Transit provides through trips that would be disrupted by any bicycle boulevard traffic reduction and calming elements.

Furthermore, a bus sharing a bicycle boulevard (usually a local, two-lane street) plays a game of leap-frog with cyclists, overtaking them, then stopping to left off passengers at bus stops. As bicycle traffic increases on the bicycle boulevard, average bus speed will drop and bus-bike conflicts are likely to increase.

For these reasons, locating a bicycle boulevard along a transit route (or vice versa) is not generally recommended. However, depending on the frequency of transit service and the length that it travels on the bicycle boulevard, shared use of the route may present no problems.

Reduced Visibility of Cyclists and Cycling as a Transportation Mode and the Creation of a Hidden Bicycle Network

Cyclists riding on higher traffic streets in the bike lane or sharing the road can be seen by hundreds of motorists during their trip. Due to their location on low-volume local streets, cyclists using bicycle boulevards are not as visible. It is suggested that this lack of exposure can, in the long run, have both political and safety implications.

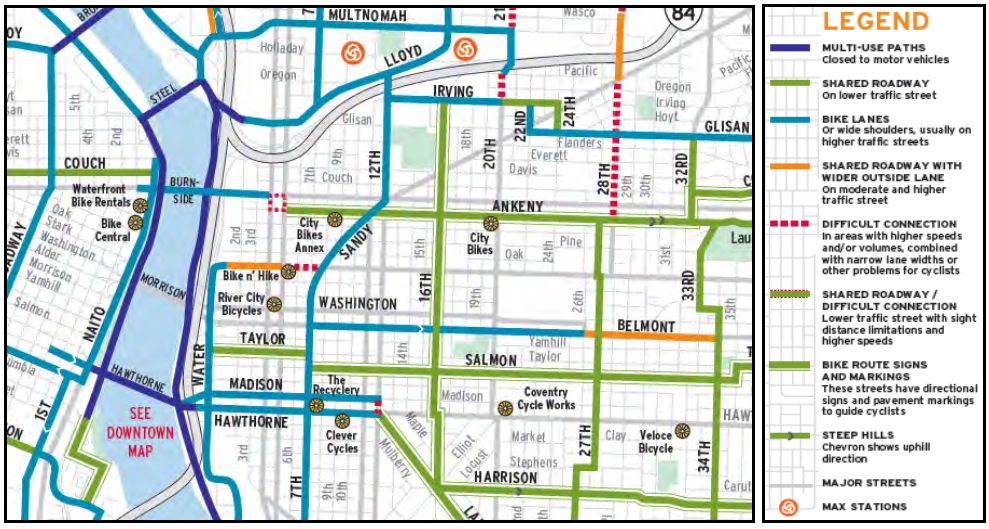
Some cyclists are concerned that reducing the number of cyclists visible to motorists on the roads will give the impression that fewer people are cycling. Citing the *Injury Prevention* study "Safety in Numbers: More Walkers and Bicyclists, Safer Walking and Biking," some have questioned whether this may ultimately lead to less caution among drivers and increased incidences of bicycle-vehicle collisions. These cyclists are also concerned that reduced exposure of cycling related to the "hidden" nature of the bicycle boulevard network also reduces cycling's presence as a transportation option and may diminish political support for investments in bicycle infrastructure and programs.

The bottom line is that bicycle boulevards provide a safe and more attractive option for confident, experienced cyclists as well as the large segment of the population who may never be willing to cycle on higher traffic roads served by bicycle lanes. Even if these less traffic-tolerant cyclists only ride on bicycle boulevards, it is ultimately an increase in cycling, and few things are better for political support, increased visibility, and safety than more cyclists on the road.

Will Bicycle Boulevards Eliminate the Need for Bicycle Lanes on Main Streets?

The establishment of a bicycle boulevard does not eliminate the need to properly accommodate bicyclists on nearby busy streets—typically with bicycle lanes, nor does the presence of bicycle lanes preclude the development of a parallel bicycle boulevard. When bicycle boulevards are located adjacent to streets with bicycle lanes (Figure 2.3), they increase the overall number of options available to facilitate bicycle transportation along a particular travel corridor. In circumstances where bicycle lanes will not fit or are not recommended on a main street, a parallel bike boulevard is a good alternative, and can work very well on its own, particularly if signs on the bicycle boulevard indicate and provide direction to key destinations located on the main street.

Figure 2.3 In Portland, Oregon, bicycle boulevards are located adjacent to streets both with and without bicycle lanes



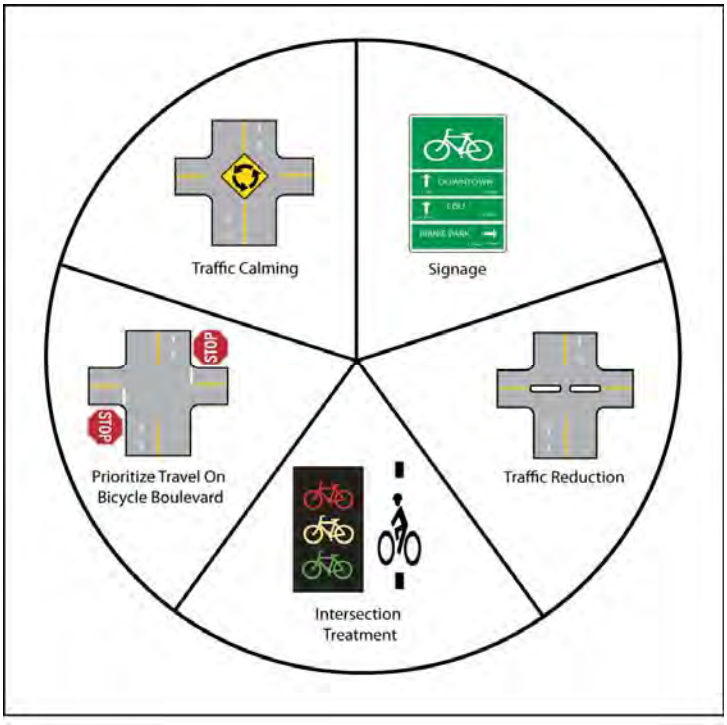
No single bikeway treatment is the solution in and of itself. Shared use paths and bicycle boulevards tend to attract novice and recreational riders, many of whom then become regular transportation cyclists. Bicycle lanes are critical for getting faster riders where they need to go, and for overcoming major barriers. Each treatment has its use. They must be employed *together* in order to create a

comprehensive, connected bikeway system that offers a full range of options for cyclists. Local agencies are encouraged conduct regular bicycle volume counts on bicycle boulevards, as well as other bikeways, to demonstrate use of the facility and to track usage trends.

III. Bicycle Boulevard Design Elements

The specific design elements needed to create a bicycle boulevard must be tailored to the unique conditions of each corridor. A variety of design options are available for use on a bicycle boulevard including traffic calming, signage and pavement markings, traffic reduction strategies, intersection treatments, and prioritization of cyclist travel (Figure 3.1).

Figure 3.1 Bikeway planners and engineers may pick and choose the appropriate mix of design elements needed for bicycle boulevard development along a particular corridor.



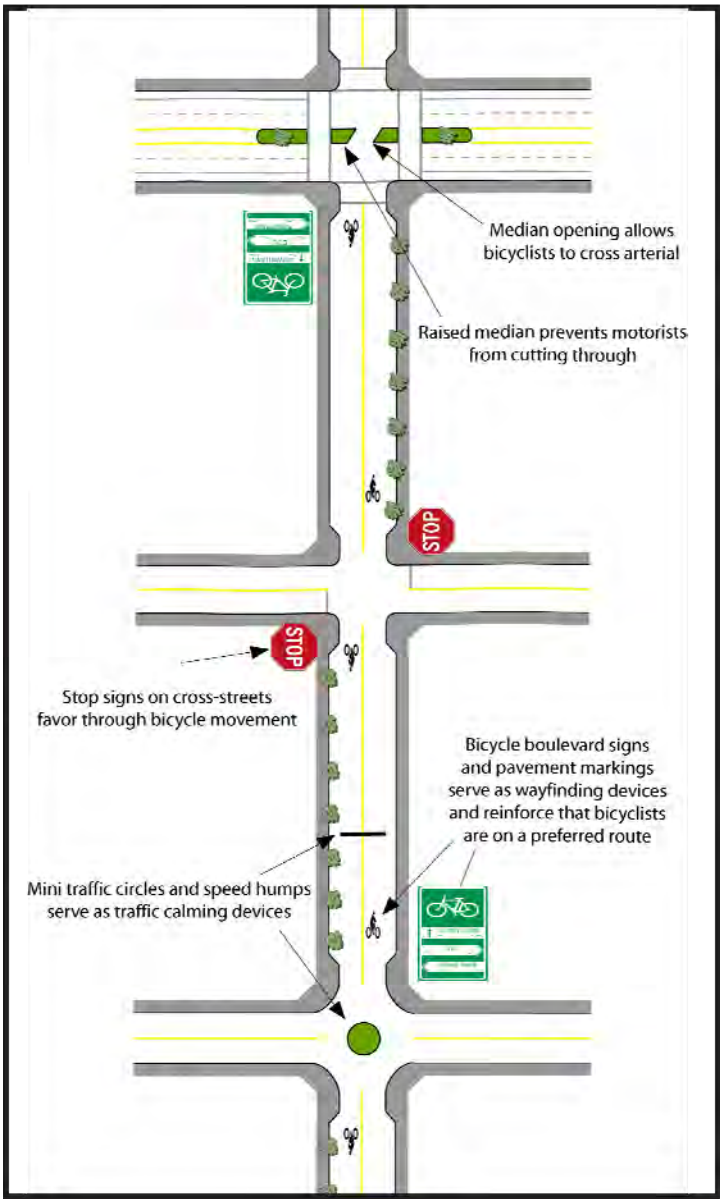
Mix and match design elements to:

- Reduce or maintain low motor vehicle volumes
- Reduce or maintain low motor vehicle speeds
- Create a logical, direct, and continuous route
- Create access to desired destinations
- Create comfortable and safe intersection crossings
- Reduce cyclist delay

All of these elements or a select few may be employed on a single corridor based upon how favorable existing conditions of the street or corridor are for bicycle travel. Bikeway planners and traffic engineers must employ good engineering judgment to select an appropriate combination of treatments that will work together to create the ideal conditions required for a bicycle boulevard (Figure 3.2).

Some local streets may already have traffic conditions optimal for a bicycle boulevard and will require little more than signage and pavement markings to create the new bikeway. Other streets, particularly roadways used frequently for through trips by motorists, will require features that reduce motor vehicle speeds and volumes and assist cyclists crossing busy intersections. The combined impact of theses elements is far greater than any single element alone.

Figure 3.2 Several design elements work together to create a bicycle boulevard



In the following section, descriptions of design elements commonly used on bicycle boulevards are presented along with recommendations and references for additional information (Table 3.1). When available, an estimated cost range for construction is provided. However, it should be noted that bicycle boulevard costs depend on a variety of factors and can vary significantly.

Design elements described in this document have been used effectively on bicycle boulevards and similar roadway designs in the United States and internationally. However, certain design elements may not yet be approved in local and national guidelines such as the Manual on Uniform Traffic Control Devices (MUTCD). This does not necessarily preclude the use of these design features. Local agencies may use these design features based on engineering judgment and the success of the design in other communities or can request permission for an experimental design.

Table 3.1 – Bicycle boulevard design elements

Signage	Identification Signs Wayfinding Signs Warning Signs
Prioritize Bicycle Travel on Bicycle Boulevard	Pavement Markings Stop/Yield Signs
Intersection Treatment	Bicycle Boxes/Advanced Stop Bar Bicycle Activated Signals Bicycle Activated Signals - Scramble Bicycle Activated Signals -Other Signals High Visibility Raised Crosswalk/Crossbike Crossing Islands Crossing at Off-Set Intersections
Traffic Calming	Traffic Circles Speed Tables Painted and Patterned Surfaces Chicanes Curb Extensions Residential Speed Limit Advisory Bicycle Lane Contraflow Bicycle Lane
Traffic Reduction	Non-Motorized Only Crossings Partial Non-Motorized Only Crossings

Signage

The purpose to signage on bicycle boulevards is to identify routes to both bicyclists and motorists, provide destination and distance information, and warn users about changes in road conditions as needed.

In addition to serving these roles, signage also helps to "brand" the bicycle boulevard network, fostering familiarity among cyclists and motorists with traffic conditions that are to be expected on these facilities. Unlike other marketing efforts, distinctive signage has the advantage of passively advertising the bicycle boulevard 24 hours a day.

Identification Signs — Signage

- Passively market the bicycle boulevard network.
- May employ distinctive symbols or colors.
- Signs alone do not create a bicycle boulevard. However, if traffic volumes and speeds are already low, intersections facilitate bicycle travel, and stop signs favor the boulevard, signage may be an enhancement that would help brand the street or corridor.

Design Recommendations

- Colors reserved by the Manual on Uniform Traffic Devices (MUTCD) for regulatory and warning road signs (red, yellow, orange, etc.) are not recommended. Colors commonly used for signage on bicycle boulevards include green (many jurisdictions) and purple (Berkeley and Emeryville California).
- Use retroreflective materials.
- Be aware of "sign clutter" that can diminish the effectiveness of signage overall. The use of modified street signs on bicycle boulevards, such as in Berkeley, California and Vancouver, British Columbia, is an effective way to provide identification of the route without introducing a new sign.

Cost Range

- $30 -150 per sign plus installation

References

- City of Berkeley Planning and Development Department. (2000). *Bicycle boulevard design tools and guidelines* (design guidelines). Berkeley, California: Retrieved from http://www.ci.berkeley.ca.us/ContentDisplay.aspx?id=6652

Berkeley, California

San Luis Obispo, California

Vancouver, British Columbia

Berkeley, California

Wayfinding Signs

Signage

- Provide cyclists with direction, distance and/or estimated travel times to destinations including commercial districts, transit hubs, schools and universities, and other bikeways.
- May only identify the direction the bicycle boulevard continues or alert cyclists to changes in the roadway.
- Inform motorists to expect cyclists and passively markets the bicycle boulevard network.
- Supplement bikeway identification signage and pavement markings.
- Install in advance of turns at a distance great enough to allow cyclists to recognize, prepare for, and safely execute a turn.
- Be aware of "sign clutter" that can diminish the effectiveness of signage overall.

Design Recommendations

- Employ distinctive symbols and/or colors to distinguish the bicycle boulevards from other roadway signs.
- Do not use colors commonly used for regulatory and warning road signs (red, yellow, orange) are not recommended. Colors commonly used for signage on bicycle boulevards are green (Portland, OR; MUTCD) and purple (Berkeley, CA).
- Use retroreflective materials.
- Sign size may vary, but lettering size should be no less than 2 inches height.
- Install ahead of or at the beginning of the bicycle boulevard and ahead of major intersections or connections with other bikeways.
- Ensure that signs are not obscured by vegetation through regular monitoring and maintenance.

Cost Range

- $30 -150 per sign plus installation

References

- United State Department of Transportation Federal Highway Administration. (2006). *BikeSafe: Bicycle countermeasure selection system*. Retrieved from http://www.bicyclinginfo.org/bikesafe/downloads.cfm
- City of Berkeley Planning and Development Department. (2000). *Bicycle boulevard design tools and guidelines* (design guidelines). Berkeley, California: Retrieved from http://www.ci.berkeley.ca.us/ContentDisplay.aspx?id=6652

Portland, Oregon

Emeryville, California

Vancouver, British Columbia

Berkeley, California

Warning Signs

Signage

- Alert motorists and cyclists of road condition changes including the end of the bicycle boulevard, upcoming traffic calming features, and traffic control devices.

Design Recommendations

- Ensure that signs are not obscured by vegetation through regular monitoring and maintenance.
- Be aware of sign clutter that reduces the effectiveness of signage overall.

Cost Range

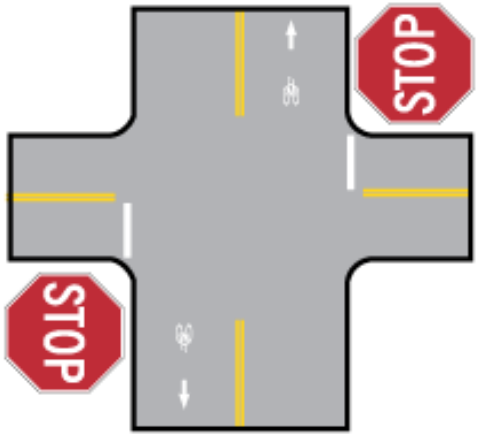
- $30 -150 per sign plus installation

References

- United State Department of Transportation Federal Highway Administration. (2006). *BikeSafe: Bicycle countermeasure selection system.* Retrieved from http://www.bicyclinginfo.org/bikesafe/downloads.cfm

Portland, Oregon

Prioritize Travel on Bicycle Boulevard



Design elements that prioritize travel on the bicycle boulevard are intended to raise awareness of the route as a bicycle priority thoroughfare and create conditions that reduce unnecessary delay for cyclists.

Pavement Markings

- Supplement wayfinding and identification signage, and serve as a reminder to cyclists and motorists that bicycle travel has priority.
- Encourage proper positioning by bicyclists while sharing the lane with motor vehicles.
- Frequent markings act as a "breadcrumb trail" for cyclists.

Design Recommendations

- Supplemental arrows may be used to indicate approaching turns.
- Install markings just after each intersection and in intervals of approximately 200 feet
- Install near high volume driveways or other conflict points to alert drivers.
- Sizes range from 12-24 inches in diameter in Portland, Oregon to 30 feet (length) by 6 feet (width) in Berkeley, California.
- Size and placement guidance for share the road markings or "sharrows" are provided in the California MUTCD.
- Apply markings with paint or thermoplastic. Thermoplastic tends be longer lasting.
- Increase the skid resistance and retroreflectivity by using glass beads.
- Do not use bicycle boulevard markings or shared lane markings within bicycle lanes.

Cost Range

- $75-150+ each, depending on size of marking and materials used.

References

- United State Department of Transportation Federal Highway Administration. (2006). *BikeSafe: Bicycle countermeasure selection system*. Retrieved from http://www.bicyclinginfo.org/bikesafe/downloads.cfm
- City of Berkeley Planning and Development Department. (2000). *Bicycle boulevard design tools and guidelines* (design guidelines). Berkeley, California: Retrieved from http://www.ci.berkeley.ca.us/ContentDisplay.aspx?id=6652
- State of California Department of Transportation (2006). Section 93.103(CA) Shared Roadway Bicycle Marking. *California Manual on Uniform Traffic Control Devices for Streets and Highways*. Retrieved from http://www.dot.ca.gov/hq/traffops/signtech/mutcdsupp/ca_mutcd.htm

Prioritize Travel On Bicycle Boulevard

Portland, Oregon

San Luis Obispo, California

Berkeley, California

San Francisco, California

Stop/Yield Signs

- Stop signs increase cycling time and energy expenditure due to frequent starting and stopping, leading to non-compliance by both cyclists and motorists alike, and/or use of other routes.
- Bicyclists should be able to travel continuously for the entire length of the bicycle boulevard with a minimum of stops.

Design Recommendations

- Do not install stop signs in the bicycle boulevard travel direction.
- Only install stop or yield signs to assign right of way to the bicycle boulevard and control cross traffic.
- If intersection control must be used in the bicycle boulevard travel direction, yield signs are preferred.
- Parking may need to be removed near the intersection for sight distance.
- After the intersection is modified, an increase in motor vehicle volume or speed along the route may occur. Mitigate through traffic calming.
- A traffic circle may be an alternative to stop and yield controlled intersections.

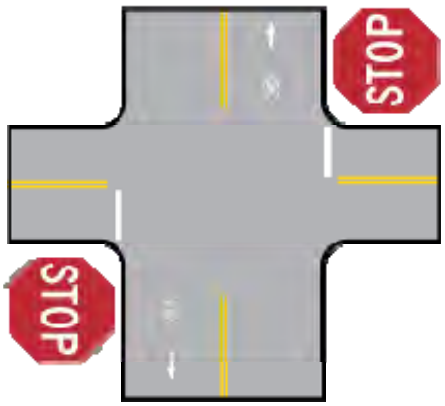
Cost Range

- Approximately $200 each

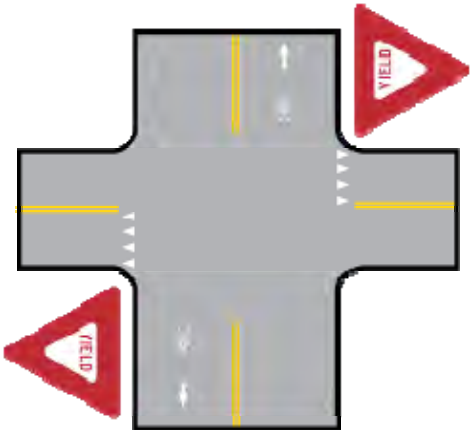
References

- American Association of State Highways and Transportation Officials (AASHTO). (1999). *Guide for the development of bicycle facilities*. Washington, D.C.

Prioritize Travel On Bicycle Boulevard



Stop Signs Assign the Right of Way to the Bikeway



Yield Signs Assign the Right of Way to the Bikeway

A Yield Controlled Crossing in Emeryville, California

Intersection Treatment

Improvements along bicycle boulevards are of limited utility if cyclists cannot safely *and* comfortably cross major roadways. Intersection improvements on bicycle boulevards enhance cyclist safety by eliminating or raising awareness of potential areas of conflict between motorists and cyclists, and by reducing the delay cyclists experience at traditional intersections where no accommodations have been made for cyclists.

Several innovative intersection crossing treatments for bicyclists were originally based on pedestrian crossing treatments. However, it is recommended that planners and engineers consider the unique characteristics of cyclists, such as cyclist positioning and crossing times, when applying these designs to bicycle boulevards.

The table *Selecting Intersection Treatments* is included in Appendix E to assist with identification of intersection crossing treatments based on motor vehicle traffic volume, posted motor vehicle speed limits, and the width of the roadway.

Planners and engineers are also strongly encouraged to reference the MUTCD for guidance on warrants for signals (MUTCD Chapters 4C, 4E, and 4F). When considering warrants, planners and engineers may use projected bicycle and motor vehicle volumes.

Bicycle Boxes/Advanced Stop Bar — Intersection Treatment

- Reduces right-turn ("right-hook") conflicts between bicyclists and motorists at intersections by increasing cyclist visibility to drivers and providing a space for cyclists to wait at signalized intersections.
- Cyclists pass through the intersection first during a green signal phase rather than queuing behind motor vehicles. This ensures they will get through the intersection during shorter green signal phases.
- Allows cyclists to position themselves properly to execute a left turn and increases their visibility to drivers traveling in the opposing direction.
- At a red light, cyclists queue inside the bike box. The bike box creates two stop bars: one located directly behind the crosswalk for cyclists and another farther back for motorists.
- During a green light, motorists continue through the intersection as usual but are alerted by the bike box and accompanying signage to watch for cyclists.
- A public education campaign is recommended to accompany installation.

Design Recommendations

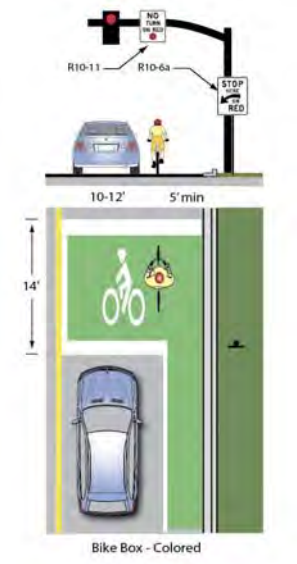
- Use green color to delineate the bicycle box.
- The bike lane may lead through the intersection (excluding the crosswalk if marked). The leading bike lane as well as a portion of the bike lane approaching to the bike box may be colored.
- Design the bike box wide enough to encompass the entire outer lane and the adjacent bicycle lane if present.
- Do not allow the bike box to extend into the crosswalk.
- "Wait Here" or "Stop Here" may marked.
- Right turns on red must be prohibited, though an exception may be made for cyclists ("Except Bikes"). Bicycle boxes may not be compatible at intersections with high volume of right-turning vehicles.

Cost Range

- Approximately $5,000 – $6,000 per installation.

References

- City of Portland Bureau of Transportation. (2007). *Platinum bicycle master plan phase I: Existing conditions report* (Draft Report). Portland, Oregon: Retrieved from http://www.portlandonline.com/transportation/index.cfm?c=44674&a=159806
- City of London Transport for London. *Advanced stop lines (ASLS) background and research studies*. London, United Kingdom: Transport for London. Retrieved from http://www.tfl.gov.uk/assets/downloads/businessandpartners/asl.pdf



Bike Box Dimensions

Tucson, Arizona

Photo: Tom Thivener

Portland, Oregon

Bicycle Activated Signals – Bicycle Detection — Intersection Treatment

- Assists bicyclists crossing signalized intersections by allowing a cyclist to call a green signal phase through the use of loop detectors or push-button.
- May reduce cyclist delay and discourage red-light running by cyclists.
- Signal activation loops are buried in the roadway surface and do not require that cyclists dismount activate a signal. However, loop placement and sensitivity may require adjustment to prevent unintended activation by motor vehicles.
- Install bicycle detection during intersection upgrades.
- Signal detection devices using video and radar are also being employed by agencies.
- Bicycle signal heads and a separate bicycle signal phase may be considered at intersections with very high volumes of cyclists.

Design Recommendations

- Standard detection loops may be used, but must often be calibrated to detect cyclists.
- Detection loops can be marked with a bicycle detector symbol (MUTCD, Figure 9C-7) to indicate optimum cyclist position to activate the signal.
- Push-buttons must be installed at the edge of roadway so that a cyclist does not need to dismount to activate.
- Install additional activation loops or push-buttons for cyclists within left-turn pockets.
- Activation loops may be installed in advance of the intersection, allowing cyclists to call a green signal phase as they approach without needing to stop.

Cost Range

- Approximately $75 for pavement marking of loop only.
- $1,000-$2,000 for loop detector installation.

References

- American Association of State Highways and Transportation Officials (AASHTO). (1999). *Guide for the development of bicycle facilities*. Washington, D.C.
- United States Department of Transportation Federal Highway Administration (2007). *Manual on Uniform Traffic Control Devices*. Retrieved from: http://mutcd.fhwa.dot.gov/pdfs/2003r1r2/pdf_index.htm
- Metropolitan Transporation Commision (2009). Bicycle and pedestrian safety toolbos: Engineering. Retrieved from Metropolitan Transporation Commision website: http://www.mtc.ca.gov/planning/bicyclespedestrians/tools/bikeSignals/index.htm

Berkeley, Calfornia

Bicycle Detection Signage - Portland, Oregon

Bicycle Signal Head - Portland, Oregon

Bicycle Activated Signals – Scramble — Intersection Treatment

- Stops all motor vehicle movements at an intersection, creating an exclusive phase for bicyclists and pedestrians to cross the intersection in any direction, including diagonally.
- Eliminates two-stage crossings, reducing crossing time.
- May reduce unsafe and illegal crossings by cyclists.
- Use at intersections with high volumes of pedestrian and cyclist crossings from several approaches and/or a high rate of conflict between pedestrians and cyclists and turning motor vehicles.
- Well suited to facilitate crossings to and from pathways (the entrances of which may not be well aligned with the intersection) or other configurations which may otherwise require a two-phase crossing by cyclists.
- May result in additional delay for motorists.

Design Recommendations

- Use bicycle signal heads (and if applicable pedestrian signals) to indicate the scramble crossing phase.
- Signal is activated through push-button or marked loop detection.
- Use pavement markings and supplementary signage to indicate diagonal crossings are permitted.
- Right turns on red by motor vehicles must be prohibited.
- Conduct educational outreach on function of scramble signal.

Cost Range

- $10,000 - $100,000+. Significantly lower cost if existing signal is present.

References

- Metropolitan Transportation Commission (2009). *Bicycle and pedestrian safety toolbox: Engineering.* Retrieved from Metropolitan Transportation Commission website: http://www.mtc.ca.gov/planning/bicyclespedestrians/tools/bikeSignals/index.htm
- Wolfe, M., J. Fischer, et al. (2006). *Bike scramble signal at North Interstate and Oregon.* Portland State University: 10.

Portland, Oregon

Portland, Oregon

Bicycle Activated Signals – Other Signals

Intersection Treatment

- The pedestrian hybrid signal (also known as a HAWK signal – **H**igh-Intensity **A**ctivated Cross**w**al**k**) and TOUCAN (**T**w**O** Gro**U**ps **CAN** cross) signal facilitate pedestrian and cyclist crossings at unsignalized locations at marked crosswalks.
- Use on major crossings that lack adequate gaps in traffic for safe pedestrian and cyclist crossings.
- The pedestrian hybrid signal utilizes both red (two) and yellow (one) signal heads in the following sequence:
  1. Signal remains dark until activated by a pedestrian or cyclist via push-button or loop detector activation.
  2. Signal flashes yellow upon activation followed by steady yellow.
  3. Signal is steady red during pedestrian/bicycle crossing interval.
  4. Signal flashes alternating red during pedestrian/bicycle clearance interval.
  5. Signal returns to dark and motorized traffic may proceed.
- The TOUCAN restricts motor vehicle through movements on minor streets, allowing only right turns to/from the major street by motor vehicles.
- TOUCANs use a special bicycle signal head and lane for cyclists in the center roadway. Pedestrians receive a standard "WALK" indication and have a separated crosswalk.
- Motorists on the major street receive a green signal until the TOUCAN signal is activated for a bicycle/pedestrian crossing interval. Minor streets are controlled with stop signs.
- Both signals may require educational outreach to explain function. A pedestrian hybrid signal's unlit signal may confuse drivers, conveying a broken signal. In some states, drivers are required to treat an unlit signal like a four-way stop.
- The pedestrian hybrid signal may be used at locations that do not meet other signal warrants to facilitate pedestrian crossings.
- Note that the HAWK signal was initially designed for pedestrian crossings. Signal design and timing may need to be modified for use by cyclists.

HAWK Signal - Portland, Oregon

TOUCAN Signal - Tucson, Arizona

Photo: Tom Thivener

Cost Range

- Pedestrian Hybrid Signal $100-175,000
- TOUCAN $350-500,00

References

- United State Department of Transportation Federal Highway Administration. (2008). *Proposed amendments to the Manual on Uniform Traffic Control Devices*. Retrieved from http://mutcd.fhwa.dot.gov/resources/proposed_amend/index.htm
- City of Tucson Department of Transportation. (2009). *Pedestrian Traffic Signal Operation*. Retrieved from http://dot.tucsonaz.gov/traffic3/tspedestrian.php

High Visibility Raised Crosswalk/Crossbike

Traffic Calming/Intersection Treatment

- Reduce motor vehicle speeds and create a visibly prominent crossing location for bicyclists and pedestrians
- Can combine with a speed table (a long and broad, or flat-topped speed bump).
- The speed table portion of the raises the crosswalk 3-4 inches above the roadway, making bicyclists and pedestrians more visible to drivers.
- Installed at midblock crossings.

Design Recommendations

- Do not install on sharp turns or steep grades.
- Use retroreflective pavement markings and signage.
- Install advanced warning speed and advisory signage.
- Install "X-ING Ahead" pavement markings in addition to the crosswalk signage.
- Optional enhancements include curb extensions to shorten crossing distance (may eliminate some on-street parking), a refuge island to assist crossing roadways with higher traffic volumes and/or multiple lanes, and Yield signs and triangle "shark's tooth" pavement markings.
- The design may be modified to facilitate unimpeded crossing by wide-chassis vehicles such as fire trucks.
- Install high-contrast and tactile warning strips at the edge of the crosswalk to aid the visually impaired.
- Refer to local ordinances regarding whether bicyclists are required to dismount at crossing and sign appropriately.

Cost Range

- $2,000 - $15,000 dependent on extent of treatment, size of the road, and drainage issues.

References

- United State Department of Transportation Federal Highway Administration. (2006). *BikeSafe: Bicycle countermeasure selection system.* Retrieved from http://www.bicyclinginfo.org/bikesafe/downloads.cfm

Berkeley, California

Delta, British Columbia

Crossing Islands

Intersection Treatment

- Facilitate crossings of multiple lane and/or high-volume arterials by providing a space in the center of the roadway for bicyclists or pedestrians to wait for gaps in traffic.
- Use on wide roadways with multiple lanes of traffic or few gaps in traffic that allow single-stage crossings.
- Allows the bicyclist or pedestrian to cross while focusing on one direction of traffic at a time (two-stage crossing).
- Effective when located between signalized intersections, as the signals create gaps between platoons of motor vehicles.
- Large refuge areas allow groups of cyclists, cyclists with trailers, and/or pedestrians to cross simultaneously.
- Restricts left-turn movements and consequently reduce the number of potential conflict points between motor vehicles and bicyclists.
- Provides space for street trees and landscaping.

Design Recommendations

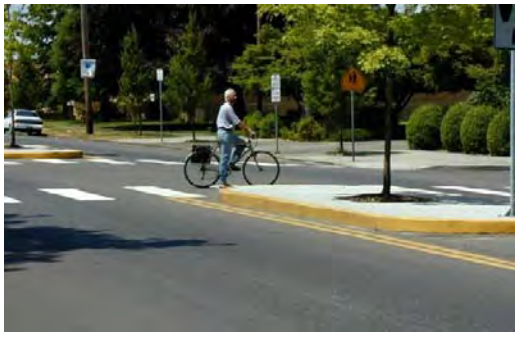
- The refuge area may be angled at an approximately 45 degrees to direct those crossing to face towards on-coming traffic. An 8 to 10 foot refuge area wide enough to accommodate a bicyclist with trailer is preferred.
- The refuge area may be enclosed on both sides of the cyclist, providing a waiting area separated from motor vehicle traffic by raised median.
- Cyclists may share the refuge area with pedestrians or another separated refuge area may be marked for cyclists only.
- Install reflectors at the refuge area to facilitate safe crossings at night.
- The roadway must be wide enough to accommodate the crossing island, on-street parking, two-directional travel, and bike lanes if used. This may require elimination of on-street parking and/or travel lanes, or narrowing of travel lanes.
- If landscaped, native or other low-maintenance plants are recommended to reduce maintenance.

Cost Range

- $15,000 - $30, 000 per 100 feet.

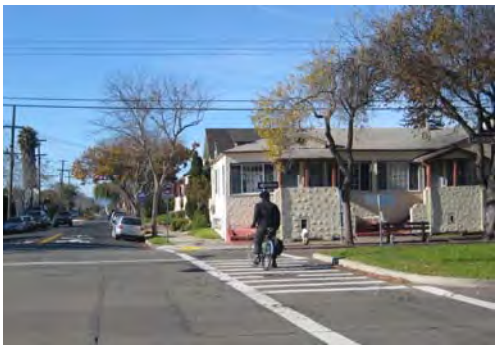
References

- City of Portland Bureau of Transportation. (2007). *Platinum bicycle master plan phase I: Existing conditions report* (Draft Report). Portland, Oregon: Retrieved from http://www.portlandonline.com/transportation/index.cfm?c=44674&a=159806
- United State Department of Transportation Federal Highway Administration. (2006). *BikeSafe: Bicycle countermeasure selection system*. Retrieved from http://www.bicyclinginfo.org/bikesafe/downloads.cfm



Portland, Oregon

Portland, Oregon



Berkeley, California

Crosswalk and Median Refuge

Crossings at Off-Set Intersections — Intersection Treatment

- Off-set intersections are created when the "legs" of an intersection to do not line up directly across from one another.
- Three designs have been developed to help cyclists negotiate off set intersections:

Bicycle left-turn lane

Creates a designated space for two-way left turns using pavement markings.

Bicycle left-turn with raised median

Creates a single protected left-turn lane using a raised curb median.

Bicycle sidepath

Creates a two-way (or alternatively, two one-way sidepaths) separated path on one side of the roadway. Cyclists enter the sidepath from the right side of the roadway or bike lane and ride up to a signalized intersection. At the intersection, cyclists use the crosswalk or median refuge to continue along the bike route.

Design Recommendations

- Use retroreflective materials on both raised and painted left-turn lanes to increase cyclist visibility and facilitate bicycling at night.
- Deisgn both painted and raised median left-turn lanes to at least 6 feet in width and 8 feet in length so that bicyclists can be completely separated from the travel lanes.

Cost Range

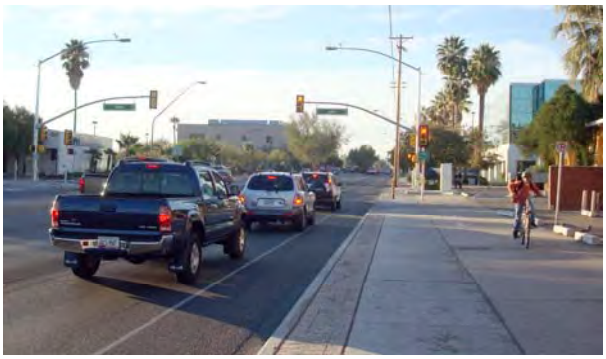
- Bicycle left turn lane – Approximately $4/foot (centerline removal and new 4 inch striping), $75 per bicycle symbol.
- Bicycle left-turn with raised median – Approximately $15,000 - $30,000 depending on length of median.
- Bicycle Sidepath – Approximately $10/square foot.

References

- Hendrix, M. (2007). Responding to the challenges of bicycle crossings at offset intersections. Paper presented at the *3rd Urban Symposium - Uptown, Downtown, Or Small Town: Designing Urban Streets that Work (June 24-27, 2007),* Seattle, Washington.

Two Way Center Left Turn - Portland, Oregon

Median Left Turn Pocket - Portland, Oregon



Bicycle Side Path – Tucson, Arizona

Photo: Tom Thivener

Traffic Calming

Traffic calming is a set of design elements that reduce the speed and volume of motor vehicle traffic on roadways. Although frequently applied on many streets throughout communities, traffic has a natural relationship with bicycle boulevard development due to the operational conditions required. Traffic calming features are typically self-enforcing: the physical conditions of the roadway as opposed to regulatory devices influence drivers to reduce their speed in order to comfortably and safely drive the route.

When implementing traffic calming on bicycle boulevards, special consideration must be given to ensure designs to not create adversely affect cyclists, such as poorly designed speed humps that unnecessarily jar cyclists who pass over them or curb extensions that enhance rather than reduce areas of conflict between motor vehicles and cyclists.

Traffic Circles

Traffic Calming

- Raised circular islands located in the center of an intersection.
- Eliminates stop signs.
- Slight reduction in traffic speeds by requiring vehicles to maneuver around the center island circulating in a counter-clockwise direction.
- Reduces potential for and severity of traffic collisions at the intersection.
- Eliminates stop signs, potentially reducing cyclists delay.
- Provide opportunity for street beautification.
- Cooperative maintenance agreements with residents may be created for watering and maintaining landscaping.
- Less effective than speed bumps at reducing motor vehicle speed. Average motor vehicle speed reduction of 11 percent based on 85th percentile speed (Ewing, 1999).
- Larger motor vehicles such as fire trucks or school buses may be required to make a left-turn in front of the traffic circle in order to negotiate the turn.
- Visually impaired pedestrians are provided fewer audible cues to identify gaps in traffic as vehicles do not stop.

Design Recommendations

- Generally yield controlled though typically not signed as such.
- Install signage indicating counter-clockwise circulation the traffic circle in advance and/or on the traffic circle.
- Multiple traffic circles at several intersections along the route are more effective at reducing motor vehicle speed than a single traffic circle.
- If landscaped, consider the use of native and other low-maintenance plants. Public art may also be considered.
- Splitter islands may be used on the approach legs of wider intersections to further reduce the speed of motor vehicles entering the intersection. Splitter islands can also provide a refuge area for crossing pedestrians.

Cost Range

- $5,000-$12,000 for mini traffic circles depending on landscaping and road material.
- $45,000+ for landscaped roundabout at neighborhood intersections.

References

- State Department of Transportation Federal Highway Administration. (2006). *BikeSafe: Bicycle countermeasure selection system*. Retrieved from http://www.bicyclinginfo.org/bikesafe/downloads.cfm

Portland, Oregon

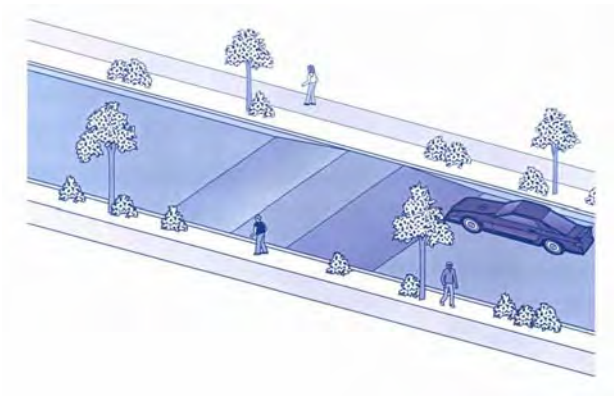
Berkeley, California

North Vancouver, British Columbia

Speed Tables

Traffic Calming

- Long and broad, flat-topped sections of raised roadway (3-4 inches high and 22 feet wide) that slow traffic by requiring motorists to reduce their speed.
- The shape of the speed table may be parabolic or trapezoidal.
- Motorist design speed varies depending on design. A 22 foot table has a motor vehicle design speed of 25 to 30 miles per hour.
- Typically installed in a series, spaced 300-500 feet apart.
- Motor vehicle speed and volume reduction is affected by the quantity and spacing of the speed tables along the street. If widely spaced, speeds between speed tables may not be reduced or even increased as motorists attempt to make up for lost time.
- Average motor vehicle speed reduction of 18 percent based on 85th percentile speed (Ewing, 1999).
- Gradual and longer speed tables are more comfortable for bicyclists to ride over without reducing their speed.
- Often combined with mid-block crossings, traffic circles, and other traffic calming design elements.



Speed Table

Design Recommendations

- Install advance signage and markings to warn motorists and bicyclists that they are approaching speed tables.
- Use retroreflective pavement markings and signage to increase visibility at night.
- Additional treatments (e.g., bollards) may need to be necessary to prevent motorists from driving around the speed hump if constructed on streets without curb.
- Do not use on sharp turns or steeped slopes.
- Carefully locate as to avoid conflict with underground utility access to boxes, vaults, and sewers.
- Do not construct at driveway locations.

Cost Range

- $2,000 - $15,000 dependent on extent of treatment, size of the road, and drainage issues.

References

- State Department of Transportation Federal Highway Administration. (2006). *BikeSafe: Bicycle countermeasure selection system*. Retrieved from http://www.bicyclinginfo.org/bikesafe/downloads.cfm
- United State Department of Transportation Federal Highway Administration. (2006). *University course on bicycle and pedestrian transportation* (University course No. FHWA-HRT-05-133). McLean, Virginia: Retrieved from http://www.tfhrc.gov/safety/pedbike/pubs/05085/pdf/combinedlo.pdf

Colored and Patterned Surfaces — Traffic Calming/Intersection Treatment

- Distinctive surface assists cyclists crossing conflict areas and provides traffic calming when used to visually narrow the traveled way.
- Employes tactile and visual signals to alert drivers to a change in the use of the roadway.
- Visually narrows the roadway.
- Delineates a pathway and assigns priority to cyclists, particularly within conflicts areas.
- Textured pavement creates an aesthetically pleasing surface and may be used at a "gateway" treatment.

Design Recommendations

- Stop bars and crosswalk markings are used in addition to color or pattern treatment at intersections and crosswalks to increase visibility, particularly at night.
- Use painted bike lanes in areas with potential motor vehicle and bicycle conflicts.
- Select textured materials carefully to prevent creating an uncomfortable riding surface for cyclists (e.g., cobblestone can create a jarring bicycle ride).
- Make painted surfaces slip resistant.

Cost Range

- Concrete Pavers – $15/per square foot
- Pattern Imprint – $100/per square foot
- Painted/Colored pavement – cost varies depending on material used

References

- State Department of Transportation Federal Highway Administration. (2006). *BikeSafe: Bicycle countermeasure selection system*. Retrieved from http://www.bicyclinginfo.org/bikesafe/downloads.cfm
- City of Berkeley Planning and Development Department. (2000). *Bicycle boulevard design tools and guidelines* (design guidelines). Berkeley, California: Retrieved from http://www.ci.berkeley.ca.us/ContentDisplay.aspx?id=6652

Portland, Oregon

Painted Bike Lane Through Conflict Area

Patterned Crosswalk at Mid-Block Crosswalk

Patterned Crosswalk at Intersection

Chicanes

Traffic Calming

- Raised curbs that create serpentine, horizontal shifting of the travel lanes along a roadway.
- The shifting lanes reduce speeds by eliminating long stretches of straight roadway where motorists can pick up speed and by forcing motor vehicles to shift laterally.

Design Recommendations

- Create a gradual shifting of the lanes.
- Barriers, such as a raised median may be installed to prevent motorists from avoiding the lateral shift by driving down the roadway centerline.
- Chicanes may be designed separated from the curb face to create a bicycle bypass and/or to allow water to continue draining along a gutter pan, but this may require maintenance to remove leaf matter and other debris build up.
- If landscaped, plant with low growing shrubs and/or trees with high canopies to preserve sight distance. Native plants may reduce maintenance requirements.
- Serpentine pavement markings may be used to "paint" chicanes on the roadway. Although the painted stripes may not achieve the same amount of horizontal diversion, they do visually narrow the roadway similar to raised chicanes.
- Installation may reduce on-street parking.
- Also can be achieved with on-street parking on alternating sides on the street.

Cost Range

- Landscaped chicanes: $10,000 (set of 3)

References

- State Department of Transportation Federal Highway Administration. (2006). *BikeSafe: Bicycle countermeasure selection system.* Retrieved from http://www.bicyclinginfo.org/bikesafe/downloads.cfm

Vancouver, British Columbia

Berkeley, California

Curb Extensions

Traffic Calming

- Curb extensions (also known as bulbouts) extend the sidewalk or curb face into the parking lane at an intersection. This visually narrows the roadway and reduces the width of the crosswalk, shortening bicyclist and pedestrian crossing distance.
- Install at intersection and mid-block crosswalks.
- Curb extensions can increase the amount of space available for pedestrian street furniture such as park benches, as well as bicycle parking. However, ensure that street furniture does not obstruct motorist view of pedestrians who may be entering the intersection.

Design Recommendations

- If bike lanes are not present, provide 12-14 feet of outside lane width at the curb extension.
- Curb extensions must not obstruct travel lanes or bicycle lanes when present.
- Consider the turning radius of larger vehicles, such as delivery vehicles and fire trucks when designing the curb extension. If frequently used by larger vehicles, modify the design to accommodate.
- If landscaped, plant with low growing shrubs to preserve sight distance and native plants to reduce maintenance.

Cost Range

- $2,000 - $20,000 per corner.

References

- State Department of Transportation Federal Highway Administration. (2006). *BikeSafe: Bicycle countermeasure selection system*. Retrieved from http://www.bicyclinginfo.org/bikesafe/downloads.cfm
- City of Portland Bureau of Transportation. (2007). *Platinum bicycle master plan phase I: Existing conditions report* (Draft Report). Portland, Oregon: Retrieved from http://www.portlandonline.com/transportation/index.cfm?c=44674&a=159806

Curb Extensions - Before and After

Landscaped Curb Extension

Residential Speed Limit

Traffic Calming

- Discourage motorists from traveling through residential neighborhoods by setting a residential speed limit of 20 mph.
- Signage alone may present enforcement issues. Combine with traffic calming as needed.
- May require legislation authorizing use of regulatory speed limits below standard. Some state traffic codes already include provisions for reduced speed limits in residential areas under certain conditions.
- Signs must be posted on all affected residential streets if standard speed limit for unsigned streets is higher than 20 mph.

Design Recommendations

- Generally implemented within a residential area on several streets rather than individual streets.
- May be combined with pavement markings and/or gateway treatments that indicate a reduced speed.

Cost Range

- $30 -150 per sign plus installation

References

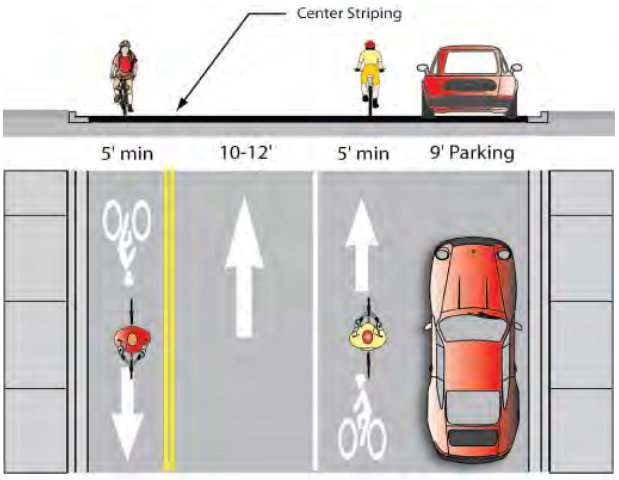
- City of Portland Bureau of Transportation. (2009). *Bikeway designs: Best Practices* (Draft Report). Portland, Oregon.

Residential Speed Limit Sign

Contraflow Lanes

Traffic Calming

- A designated bicycle facility that allows cyclists to travel against the flow of traffic on a one-way street.
- Provides direct access and improves cyclist connectivity, reducing cyclist travel time by eliminating out-of-direction detours and unauthorized wrong-way riding.
- Installed on left side of the street facing one-way traffic. The contraflow lane is generally separated from the motor vehicle lane with a double-yellow line.
- May require modifications to existing traffic signals to allow bicyclists to activate signal from "wrong" direction.
- Presents safety concerns due to cyclists traveling in a direction where motorists do not expect them. Engineers must carefully evaluate roadway conditions to determine whether a contraflow lane application is appropriate.
- In some cases, a contraflow may allow cyclists to avoid streets with high motor vehicle traffic speeds and volumes or create safer conditions at locations where cyclists frequently ride wrong-way.



Contraflow Lane with Parking

Design Recommendations

- Avoid use on streets with many driveways or streets that will intersect with the contraflow lane.
- Allow contraflow lane width of 5 feet or greater.
- Consider physical separation between the contraflow lane and motor vehicle travel lane.
- Consider painted bicycle lane to highlight presence of the contraflow lane to bicyclists and motorists.
- Post signage indicating cyclists may enter the one-way streets. Place signage on all streets intersecting the contraflow lane indicating that to motorists to expect two-way bicycle traffic.

Cost Range

- $5,000 - $50,000 per mile

References

- City of Portland Bureau of Transportation. (2009). *Bikeway designs: Best Practices* (Draft Report). Portland, Oregon.
- United State Department of Transportation Federal Highway Administration. (2006). *BikeSafe: Bicycle countermeasure selection system*. Retrieved from http://www.bicyclinginfo.org/bikesafe/downloads.cfm

Advisory Bicycle Lane

Traffic Calming

- Dashed white lines on both sides of a narrow roadway that delineate a space for cyclists.
- The travel lane is not wide enough to allow motorists to pass in both directions. Motorists may enter the bicycle advisory lane to pass when bicyclists are present, but must overtake vehicles with caution, yielding to oncoming traffic.
- Reduces motor vehicle speed due to friction created with oncoming vehicles and visual narrowing of the roadway..
- An option for streets too narrow for conventional bicycle lanes.
- May require special legislation for implementation.

Design Recommendations

- Advisory lane minimum width 4 feet.
- Two-way travel lane minimum width 13 feet.
- Use on local or neighborhood collector streets.
- Centerline of roadway is not marked.
- Consider maximum motor vehicle volume of 3000 vehicles per day and maximum motor vehicle speeds of 30-35 mph.
- Avoid use on streets with bends, inclines, or other sight restrictions.
- Consider use of painted bicycle lane to highlight bicycle lane and increase visual narrowing of the roadway.
- May require explanatory signage and public education.

Cost Range

- $5,000 per mile for lane marking.

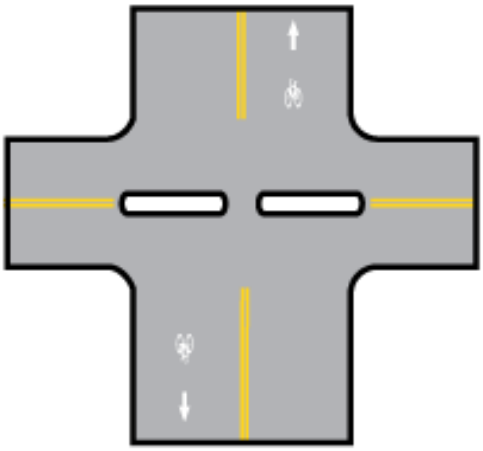
References

- City of Portland Bureau of Transportation. (2009). *Bikeway designs: Best Practices* (Draft Report). Portland, Oregon.
- CROW (2007). *Design manual for bicycle traffic.* Ede, The Netherlands: Dutch national information and technology platform for infrastructure, traffic, transport and public space.

Advisory Bicycle Lanes, Netherlands

Advisory Bicycle Lanes, Netherlands

Traffic Reduction



Traffic reduction design elements are effective tools to maintain existing low volumes or reduce the overall volume of motor vehicle through trips on the bicycle boulevard. While through trips by motor vehicles are eliminated or restricted in certain directions, continuous through travel by bicyclists and other non-motorized users is maintained and enhanced.

When implementing traffic reduction on bicycle boulevards, diversion of motor vehicle traffic off the bicycle boulevard and onto other local streets must be identified and addressed.

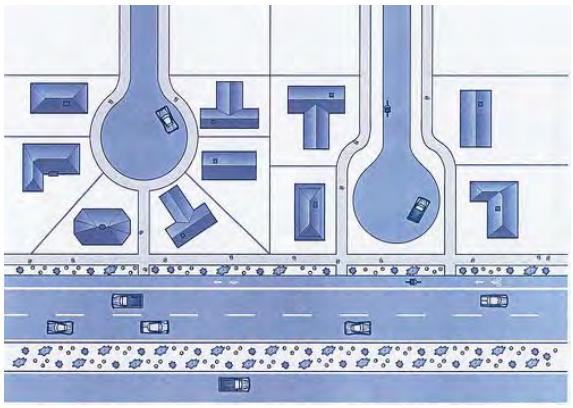
Non-Motorized Only Crossings

Traffic Reduction

- Increase bicycle and pedestrian connectivity by developing continuous non-motorized route connections not accessible to motor vehicles.
- Also referred to as a street closure or diverter.
- Typically placed on minor streets at an intersection with a major street to manage motor vehicle volumes on the minor street.
- Create a "dead-end" or cul-de-sac where a through street once existed, providing through access for non-motorized traffic. This may require purchase or donation of an easement.
- Construct a bicycle/pedestrian bridge across a water feature, a "dead end" roadway, park, or other physical barrier. Connect existing cul-de-sac streets to other streets using multi-use trails.
- Very effective at reducing motor vehicle traffic volumes along the roadway.
- Frequently landscaped, but can also be formed with raised curbs, medians, barrier placement, and signage.

Berkeley, California

San Luis Obispo, California



Cul de Sac Connects to Main Road

Design Recommendations

- Conduct a traffic analysis to assess potential motor vehicle traffic diversion onto nearby streets and consider additional traffic calming and reduction measures on nearby streets to mitigate any traffic impacts.
- Consider impacts to emergency vehicle or transit access or delay, and the overall affect on connectivity.
- Post signs permitting bicyclists to enter the closure.
- Design openings to a minimum of four feet in width.
- Bollards and other barriers intended to prevent motor vehicle access may be hazardous to cyclists. Use reflective materials on the barrier to increase visibility.
- If landscaped, consider the use of native or other low-maintenance plants. Stormwater management features may be integrated into the design.

Cost Range

- Costs will vary greatly depending on existing conditions and design of the connection.

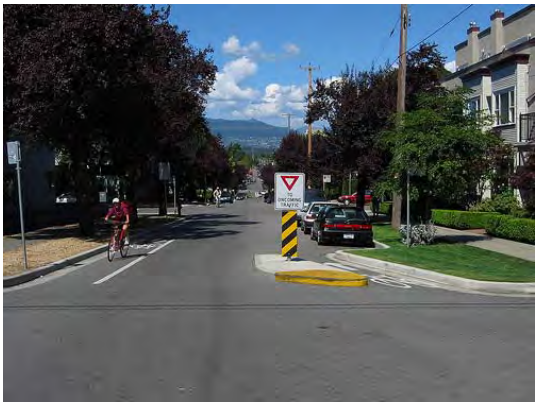
References

- City of Portland Bureau of Transportation. (2007). *Platinum bicycle master plan phase I: Existing conditions report* (Draft Report). Portland, Oregon: Retrieved from http://www.portlandonline.com/transportation/index.cfm?c=44674&a=159806
- City of Berkeley Planning and Development Department. (2000). *Bicycle boulevard design tools and guidelines* (design guidelines). Berkeley, California: Retrieved from http://www.ci.berkeley.ca.us/ContentDisplay.aspx?id=6652

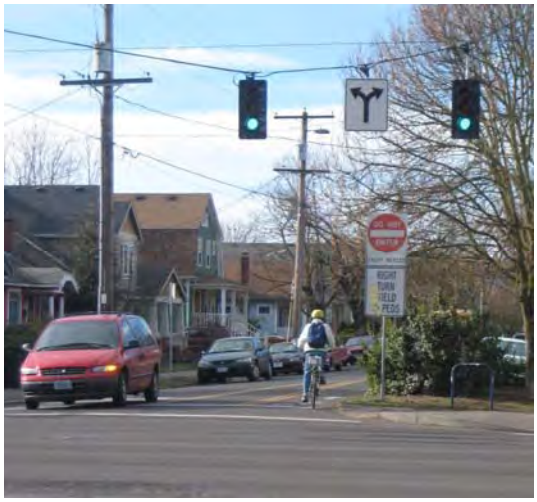
Partial Non-Motorized Only Crossings — Traffic Reduction

- Partial non-motorized crossings eliminate some motor vehicle movements at intersections, forcing motorists to turn off of and/or restricting turns onto the minor road.
- Also referred to as a partial closure, semi-diverter, or diagonal diverter.
- Partial non-motorized crossings include constructed barriers and signed restrictions that eliminate a motor vehicle turn movement.
- Diagonal diverters are barriers placed diagonally corner to corner across a four-way intersection. This design prevents through movements by motor vehicles but allows motorists to turn in one direction.
- Restrictions created through signage only may present enforcement issues.
- Frequently landscaped, but can also be formed with raised curbs, medians, barrier placement, and signage.

Berkeley, California



Vancouver, British Columbia



Portland, Oregon

Design Recommendations

- Conduct a traffic analysis to assess potential motor vehicle traffic diversion onto nearby streets and consider additional traffic calming and reduction measures on nearby streets to mitigate any traffic impacts.
- Consider impacts to emergency vehicle or transit access or delay, and the overall affect on connectivity.
- Post signs permitting bicyclists to enter the closure.
- The bicyclist's travel path may be marked or physically separated at the intersection to reduce potential conflicts with motor vehicles exiting the street.
- If landscaped, consider the use of native or other low-maintenance plants. Stormwater management features may be integrated into the design.

Cost Range

- Costs will vary greatly depending on existing conditions and design of the connection.

References

- City of Portland Bureau of Transportation. (2007). *Platinum bicycle master plan phase I: Existing conditions report* (Draft Report). Portland, Oregon: Retrieved from http://www.portlandonline.com/transportation/index.cfm?c=44674&a=159806
- City of Berkeley Planning and Development Department. (2000). *Bicycle boulevard design tools and guidelines* (design guidelines). Berkeley, California: Retrieved from http://www.ci.berkeley.ca.us/ContentDisplay.aspx?id=6652

Complementary Design and Programmatic Elements

Many design features and programs complement the development of a bicycle boulevard. These elements enhance the pedestrian and natural environment; multiplying the benefits of a bicycle boulevard. Moreover, some programs may help fund the planning or construction of a bicycle boulevard or individual bicycle boulevard design elements.

Safe Routes to School

Figure 3.3 School children in Portland, Oregon learn bicycling rules of the road through a Safe Routes To School Program

Safe Routes to School (SRTS) is a program that enables and encourages school children to walk and bike to school. Funding for SRTS is available at the Federal and State level (Federal funds are typically distributed by the States). The program provides funding for projects that make walking and biking to school safer and more appealing. A SRTS project typically contains an engineering, education, enforcement, or encouragement component (or a combination of the four) towards increasing active transportation options for children. Cooperation between school districts, public works, and law enforcement, is encouraged.

The low speed and low volume nature of bicycle boulevards make them an ideal bikeway for children bicycling to school. A bicycle boulevard is also a terrific classroom to teach school children the rules of the road (Figure 3.3).

An SRTS grant may also be used to help fund bicycle boulevard development if the route is within approximately 2 miles of a K-8 school.

For more information, visit the National Center for Safe Routes to School at:
www.saferoutesinfo.org

Green Streets/Green Stormwater Treatments

Figure 3.4 A Green Streets project in Portland, Oregon sustainably manages stormwater, slows traffic, and creates a welcoming and pleasant environment for bicyclists and pedestrians

Green Streets reduce the impact of stormwater runoff through stormwater collection swales and pervious asphalt or concrete. These design features capture excess stormwater runoff, filter stormwater impurities, increase groundwater recharging, and reduce the load of excess stormwater on existing drainage systems.

Green Streets programs also beautify the streetscape through the use of wetland plants and enhance the bicycle and pedestrian environment through stormwater management features that provide a dual benefit of traffic calming.

Examples of Green Streets traffic calming include curb extensions, chicanes, and medians that are landscaped to collect and retain stormwater (Figure 3.4). Like Safe Routes to School programs, funding for Green Streets improvements may be leveraged for bicycle boulevard development.

For more information, visit the United State Environmental Protection Agency's website on Green Streets programs across the United States:
http://www.epa.gov/owow/podcasts/greenstreetsusa.html

Public Art

Figure 3.5 Public art in Ocean City, New Jersey and Portland, Oregon give distinction to bicycle boulevards



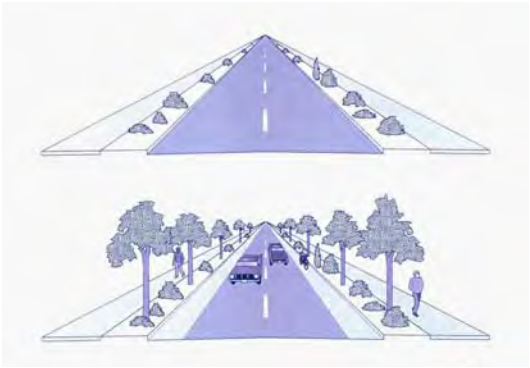
Public art defines the space along a bicycle boulevard, and is also a terrific way to increase public involvement (Figure 3.5). The art can even be functional, such as decorative bicycle parking. When public art is used for bicycle parking, form must meet function. The bicycle frame should be supported in two locations and the rack should accommodate a wide range of bicycle sizes.

Ideas for public art along bicycle boulevards include:

- Public competitions for artistic bicycle parking or intersection mural designs;
- Commissioned sculptures that identify the termini of a bicycle boulevard;
- Themed artwork or logos that identify a particular bicycle boulevard route.

Landscaping and Street Trees

Figure 3.6 Street trees



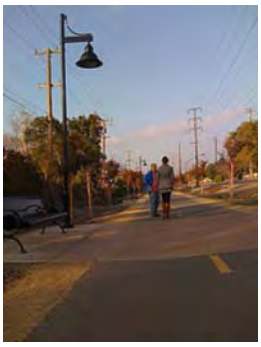
Corridors landscaped with street trees and planted medians beautify the streetscape and provide traffic calming benefits (Figure 3.6). Funding for landscaping can come through partnerships with parks and recreation and environmental services departments, as well as private funding sources.

Ideally, plants used for landscaping are native or low-maintenance. Cooperative agreements may be formed with nearby residents and business owners to provide for minor maintenance activities such as watering and pruning.

Pedestrian Amenities

Figure 3.7 Street furniture such as seating, drinking fountains and pedestrian-oriented lighting foster a comfortable environment for biking and walking in Portland, Oregon





The very design features that make bicycle boulevards wonderful places to cycle also make them terrific places to walk. These features can be further enhanced through the installation of pedestrian amenities such as park benches, water fountains, and pedestrian-oriented street lighting that create an inviting and comfortable pedestrian environment (Figure 3.7). The addition of pedestrian amenities advances the notion that the benefits of bicycle boulevards extend beyond bicyclists.

End of Trip Facilities

Figure 3.8 Adequate and safe parking in Berkeley, California and Portland, Oregon



Safe, secure and adequate parking is needed for cycling to be a viable transportation option (Figure 3.8). Comprehensive bicycle boulevard planning and construction will consider the need for parking at key destinations and work with appropriate business owners or local agency staff to create and maintain long and short-term bicycle parking facilities. Additional information on bicycle parking can be found at the Pedestrian and Bicycle Information Center website on Bicycle Parking: http://www.bicyclinginfo.org/engineering/parking.cfm

IV. Marketing, Maintenance & Safety

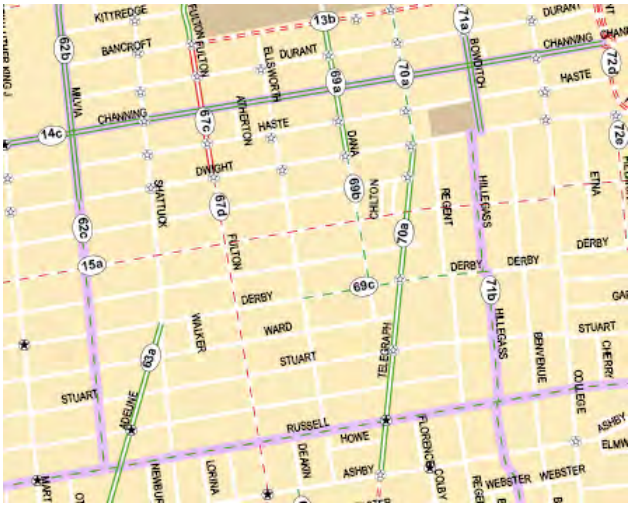
Marketing

Bicycle boulevard signage and pavement markings go a long way towards "advertising" the location of and destinations served by a bicycle boulevard 24 hours a day. However, it is not recommended that local agencies rely on signage alone to get the word out about bicycle boulevards in their communities. For the long-term success of the facility, including attracting new riders, communities are encouraged to actively market the location of bicycle boulevards and destinations they serve. Marketing of bicycle boulevards can be done in a variety of methods. Include funding for marketing activities in project cost estimates.

Bicycle Maps

Community bicycle maps are typically the first resource people turn to when looking for information on local bicycling and should be readily available in print and on the community website. Bicycle maps (Figure 4.1) generally highlight bike paths, lanes, or routes in different colors. Often, maps will differentiate bicycle boulevards by simply using another color, but this can also be accomplished by adding a unique pattern or outline to identify which of the shared roadway bike routes are also bicycle boulevards. To highlight the utility of bicycle routes, include symbols on maps for key destinations when possible.

Figure 4.1 The City of Berkeley bicycle map identifies bicycle boulevards as purple routes.



Community Rides

Get the word out about bicycle boulevards by holding community group rides that include bicycle boulevards. This allows community members to experience the difference of a bicycle boulevard and personally identify destinations served by the bicycle boulevard. Bicycle advocacy groups frequently hold such rides and prove to be an invaluable resource to communities with limited staff and resources.

Encouragement Programs

Several communities have developed programs that are focused on encouraging transportation alternatives to the single occupancy vehicle. These programs are an avenue to inform current and potential cyclists about what bicycle boulevards are and where they are located.

One such program, Portland SmartTrips (Figure 4.2), uses individualized marketing to inform residents of transportation options in their communities. Residents first receive a flyer in the mail that asks if they would like more information on bicycling, walking, and transit opportunities. Residents that opt-in may then select the type of additional information they would like to receive, including personalized walking, transit, and bicycle routes, bicycling safety information, calendars of free workshops and community events (some targeted specifically towards seniors or women), maps, as well as incentives like pedometer and coupon booklets.

Figure 4.2 Portland SmartTrips encourages bicycling, walking, and transit use

Celebrate New Bicycle Boulevards

When construction on a new bicycle boulevard is completed, the community can celebrate with a bicycle parade of school children—a wonderful way to tie into Safe Routes to School programs that encourage children and their parents to walk or bike to school (Figure 4.3)—or a press release. These types of activities raise awareness of the bicycle boulevard and are a fun way to recognize all the people who worked to make the new bikeway possible.

Figure 4.3 A parade of school children participating in a Safe Routes to School program can raise awareness about the bicycle boulevard

Maintenance

Pavement Quality & Maintenance

Smooth surfaces make for a pleasant bike ride. A street can have all the ideal characteristics of a bicycle boulevard, but miss on one important detail: pavement quality. Pavement in poor condition, including potholes, embedded objects such as abandoned railroad tracks, and debris, make for an uncomfortable and potentially dangerous journey. Inattention to pavement quality and debris can reduce the bicycle boulevard attractiveness and effectiveness.

Bicycle boulevards must be kept in good condition, with a smooth riding surface. Many cities have maintenance schedules for resurfacing and rehabilitating road surfaces. When possible and appropriate, prioritize these maintenance activities on the bicycle boulevards.

Pavement markings will wear over time and signage may be damaged or stolen. Incorporate funds for new markings and signs in maintenance budget. Signage programs that use consistent designs throughout the bicycle boulevard network keep expenses for sign replacement at a minimum.

Public-Private Partnerships

Landscaped design elements are often intentionally designed to be low-maintenance through the use of native plants, but may still occasionally require watering and/or sweeping, particularly as plants become established. Several communities with bicycle boulevards have partnered with local residents to help maintain these features.

Continued Evaluation

The contractors have been paid and bicyclists are riding down a brand new bicycle boulevard, but that is not that the end of this project. Continued evaluation of the bicycle boulevard, particularly a new bikeway or one where significant changes have occurred, is essential to the continued success of

the route. Project staff must regularly evaluate how the boulevard and adjacent streets are functioning and address any issues. Evaluation can include but is not limited to bicycle and motor vehicle counts and speed surveys, traffic collision analysis, and user surveys.

Common issues include:

- Several two-way stop signs were reoriented to assign right of way to the bicycle boulevard and reduce bicyclist delay. This change attracted through trips by motor vehicles from the nearby arterial.
- A street closure device is too low and passenger cars are ignoring the restriction.
- The loop detector on a bicycle-activated signal is no longer functioning and bicyclists can no longer call a green signal.

A bicycle boulevard audit worksheet has been included in the Appendix B of this report, and can be used to evaluate both streets with existing and proposed bicycle boulevards.

Safety

The safety benefits of bicycle boulevards are likely to be derived primarily from traffic calming and traffic reduction design features. Although the safety benefits specifically attributed to bicycle boulevards has yet to be studied, the safety benefits of traffic calming are well documented to reduce both the frequency and severity of collisions.

The same conditions that make a street safe for cycling create safer conditions for all roadway users regardless of travel mode. Lower motor vehicle speeds translate into greater motorist reaction time, potentially allowing collisions to be avoided in the first place. A lower speed (between 16-31 mph) also means that if pedestrians or cyclists are involved in a collision with a motor vehicle, they less likely to be fatal[3].

One study, conducted to determine if there are quantifiable collision reduction benefits of traffic calming, found that when several traffic calming treatments were employed as part of a single plan (similar to what may occur on a typical bicycle boulevard design), an average 65% reduction in collisions were reported[4].

[3] Sarkar, et al., 1997
[4] Zein, et al., 1997

V. Bicycle Boulevard Case Studies

Overview of Findings

- Milwaukie, Oregon
- Arcata, California
- St. Paul, Minnesota
- Santa Monica, California
- Syracuse, New York
- Pasadena, California

These are merely a handful of the bicycle boulevards that are currently being planned and constructed in communities across the United States. There are also many terrific examples of bicycle boulevards (and bicycle boulevard-like) designs across Europe. Countries like the Netherlands and Denmark have decades of experience in bicycle transportation planning. Many of the bikeway designs implemented in these countries have applicability on bicycle boulevards in the United States, and may be included in future versions of this guidebook.

In the following section, case studies of several bicycle boulevards present what has worked in the United States. These case studies represent a wide range of bicycle boulevards, from the stand-alone bicycle boulevard that relies primarily on signage and pavement markings, to robust bicycle boulevard networks where traffic is aggressively calmed through the use of multiple design elements.

Themes common across all case study interviews:

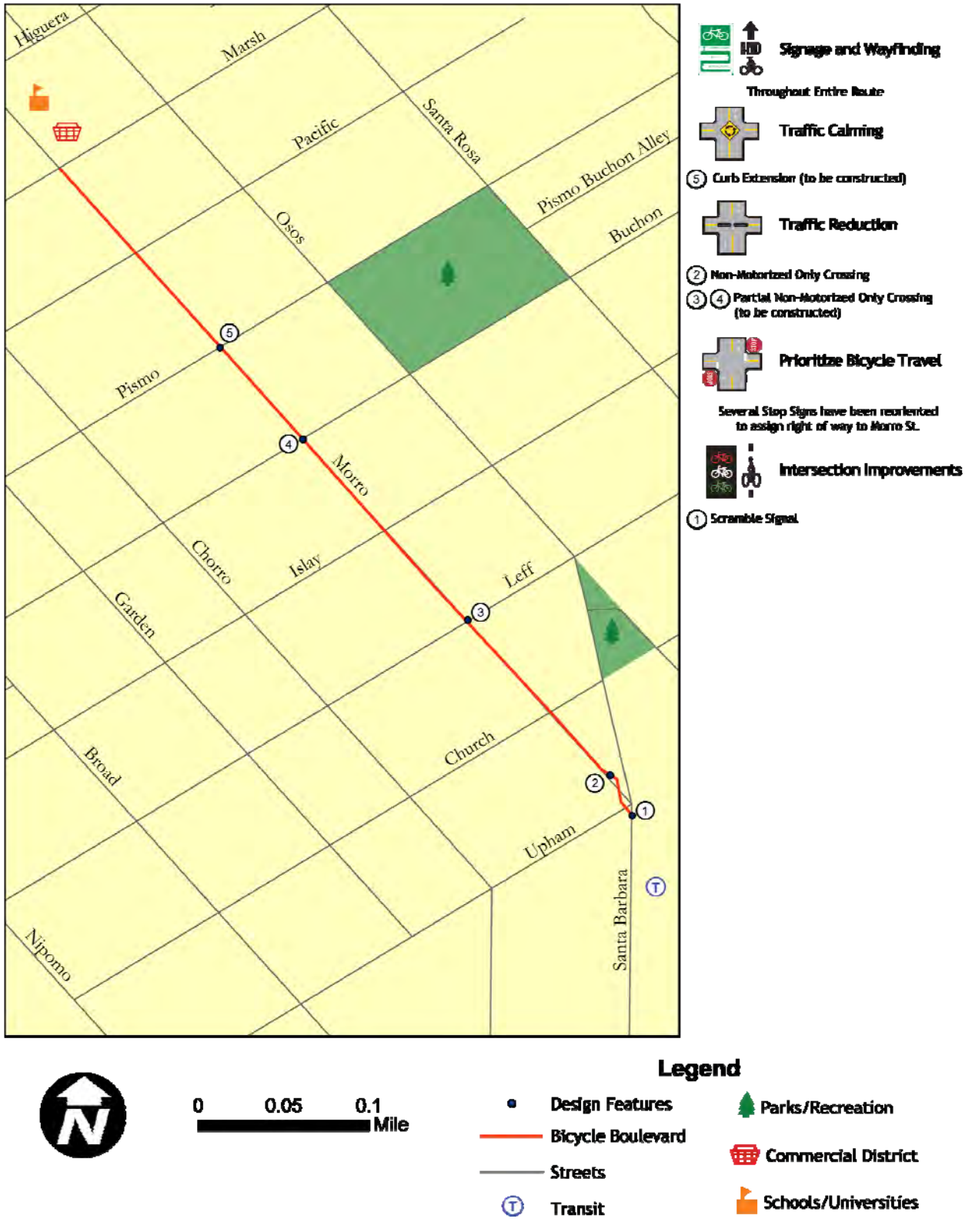
- Bicycle boulevards are described as well-loved in each community. Nearly all representatives indicated that they have plans for additional bicycle boulevards.
- Public involvement in the planning and design of the bicycle boulevard is key.
- Residents along proposed bicycle boulevards, as well as those on nearby streets, are frequently concerned about changes to traffic along their streets and access to their homes. Particularly in locations where no bicycle boulevard previously existed, the purpose and function of bicycle boulevards needs to be communicated to the public.
- Consult with local emergency services regarding traffic calming and reduction designs.
- Continually evaluate the performance of the bicycle boulevard as well as traffic impacts on nearby streets.
- Bicycle maps are the most common method of disseminating information about the bicycle boulevards. Organized community bicycle rides and other creative methods are also frequently mentioned.
- Use what is already available. Capitalize on existing features that reduce the speed and volume of motor vehicle traffic including non-motorized bridges and one-way streets, but remember that the boulevard still needs to connect to key destinations.
- Current bicycle and motor vehicle traffic data (before and after construction), as well as cost information on the planning, design, and construction of bicycle boulevards is often unavailable.

Case Study Summaries

Bill Roalman "Morro Street" Bicycle Boulevard – San Luis Obispo, California
Bryant Street "Ellen Fletcher" Bicycle Boulevard – Palo Alto, California
Channing Street Bicycle Boulevard – Berkeley, California
Haven Avenue "OC-1 Bikeway" – Ocean City, New Jersey
Lincoln-Harrison Bicycle Boulevard – Portland, Oregon
Monroe-Friendly Bicycle Boulevard – Eugene, Oregon
Third Street Bicycle Boulevard – Tucson, Arizona
40's Bikeway – Portland, Oregon

Google Earth tours are available for several of these bicycle boulevards. Download instructions and files at: http://bicycleboulevards.altaprojects.net/

Bill Roalman "Morro Street" Bicycle Boulevard – San Luis Obispo, California



Overview

- The Bill Roalman "Morro Street" bicycle boulevard is approximately 1/2 mile in length and runs along a primarily residential street in downtown San Luis Obispo (Figure 5.1).
- Morro Street was selected due to its proximity to Osos Street, a busy and narrow parallel arterial used by cyclists heading downtown.
- A bicycle boulevard was chosen specifically due to lack of room for bicycle lanes on either Osos Street or Morro Street.
- During a railroad station upgrade, Morro Street was closed at Santa Barbara Street by creating a landscaped cul-de-sac with pedestrian and bicycle access (Figure 5.2). A bicycle scramble signal was later installed at Santa Barbara to facilitate bicycle movements from Santa Barbara onto Morro (Figure 5.3).
- The City promotes the bikeway using advertisements on public access channels, public service announcements at local theaters, bike maps, and volunteer-led group bicycle tours.

Key Destinations

Transit – Amtrak	Other Bikeways –including a rail-trail
California Polytechnic University	Downtown San Luis Obispo

Lessons Learned & Advice

- Stop sign reorientation to favor the bicycle boulevard resulted in increased motor vehicle speeds and volumes along the route. In response, a project was recently approved to install partial-closures (cars forced into right turn; bikes can continue through) at two intersections, as well as a curb extension.
- In the future, the City would prefer to construct a complete design for a bicycle boulevard rather than phase improvements over time.
- Parking was removed near intersections to ensure adequate sight distance.
- Approval of traffic-calming design elements by emergency services agencies is essential.
- Continue evaluating operation after construction is completed and make design adjustments as needed.

Public Involvement

- Nearby residents were invited to neighborhood forums on the project.
- Neighborhood residents participated in a joint neighborhood-parks street tree planting activity to make the route an enticing place to bike and walk.
- The City Bicycle Advisory Committee acts as a sounding board for how the bikeway is functioning.

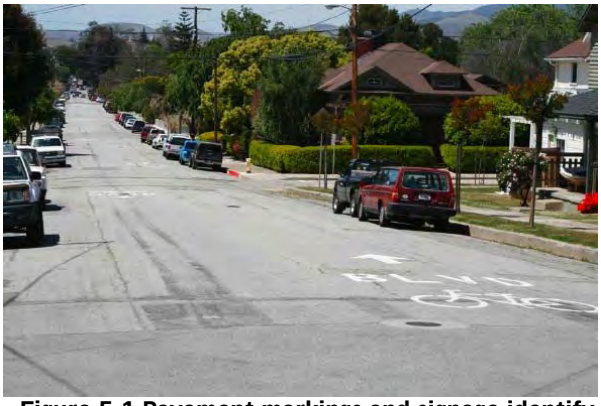


Figure 5.1 Pavement markings and signage identify the street as a bicycle boulevard.

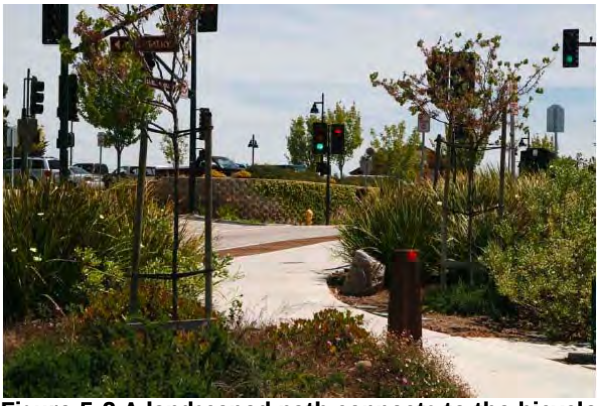


Figure 5.2 A landscaped path connects to the bicycle "scramble" signal.

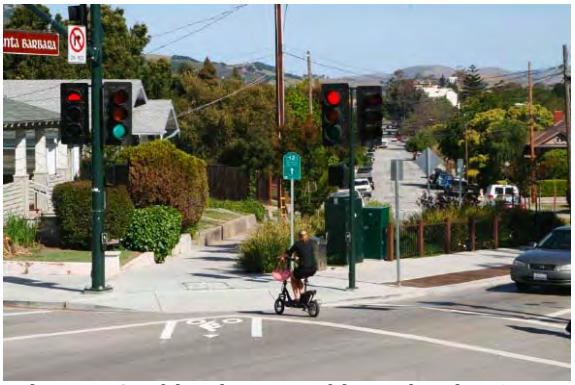


Figure 5.3 A bicycle "scramble"" signal at Santa Barbara Street connects the bicycle boulevard to the Amtrak station and a regional trail system.

Data

2007 Traffic Volumes: 345 (2-hour count)
2008 Bicycle Volumes: 75 (2-hour count)
Construction Cost::
Phase I & II (street closure, bicycle signal, signage, pavement markings): $370,000 (2003 dollars)
Phase III (slurry seal, curb extension, non-motorized only crossing): $361,711 (2008 estimate)
Speed Limit (assumed): 25 mph

Contact

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990 Palm Street
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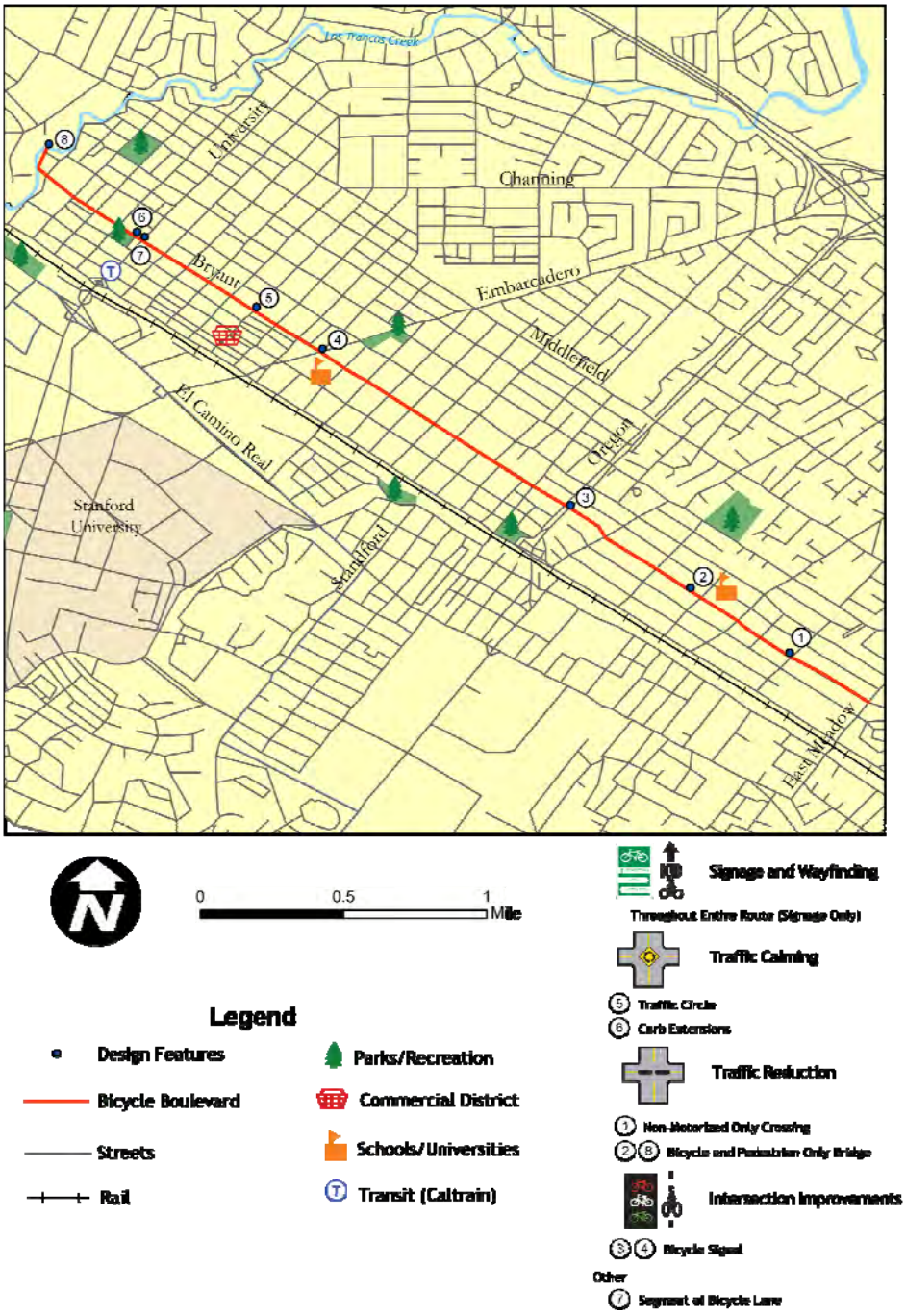
Bryant Street "Ellen Fletcher" Bicycle Boulevard – Palo Alto, California



Overview

- The Bryant Street "Ellen Fletcher" bicycle boulevard is approximately 3.25 miles in length and runs along a primarily residential street in downtown Palo Alto.
- Connects the City of Palo Alto and the City of Menlo Park.
- Credited as the first bicycle boulevard in the United States.
- Implemented in two phases constructed 11 years apart due to the cost of a signal required to assist bicyclist and pedestrian crossings.
- The first segment (East Meadow Drive-Churchill Avenue) was constructed in 1981 and utilized an existing bicycle/pedestrian bridge (Figure 3.5). The second segment (Churchill Avenue-Northern City Limits) was constructed in 1992 and included a new signalized crossing.

Key Destinations

Intercity Transit (Caltrain)	Other Bikeways – including a rail-trail
Schools & Stanford University	Downtown Palo Alto
Libraries	Parks

Lessons Learned & Advice

- Remove unwarranted stop signs on the bicycle boulevard. Convert 4-way stop-controlled intersections to 2-way stops that assign right of way to the bicycle boulevard, or replace with traffic circles.
- Install traffic calming and/or non-motorized only crossings to maintain low motor vehicle speeds (Figure 5.4 and Figure 5.6).
- Use bicycle/pedestrian bridges or tunnels to create continuous through routes for non-motorized users that naturally restrict motor vehicles (Figure 5.5).
- Bicycle traffic on Bryant Street increased dramatically upon completion of the bicycle boulevard and attracted bicyclists from nearby parallel routes. Due to the success of the bicycle boulevard, there is currently a shortage of bicycle parking in downtown Palo Alto.

Public Involvement

- The City Transportation Division worked with the Bicycle Advisory Committee and held neighborhood outreach meetings.
- Any changes to traffic control or traffic calming along the bicycle boulevard must go through City Council where the public is encouraged to comment.
- In addition to a bicycle map, the City works with student groups from nearby Stanford University to "get the word out" about the route.
- Residents have requested the development of additional bicycle boulevards. Two new routes are currently being evaluated.

Figure 5.4 A non-motorized only crossing forces motor vehicles to turn at an intersection

Figure 5.5 A bicycle/pedestrian bridge creates a non-motorized only crossing at Matadero Creek

Figure 5.6 Bicycle activated signal

Photos: John Ciccarelli, Bicycle Solutions, www.bicyclesolutions.com

Data

Traffic Volumes: Not Available
1997 Bicycle Volumes: 385 (8-hour count)
Construction Cost:
Phase I (southern segment – bicycle bridge): $35,000(1983-84 dollars)
Phase II (traffic signal): $243,000 (1992 dollars)
Speed Limit (assumed): 25 mph

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Channing Street Bicycle Boulevard – Berkeley, California

Legend

0 0.5 1 Mile

- Design Features
- Bicycle Boulevard
- Other Bicycle Boulevards
- Streets
- Parks/Recreation
- Commercial District
- Schools/Universities
- Transit

Signage and Wayfinding

Throughout Entire Route

Traffic Calming

(1) (9) (10) Traffic Circle
(3) Curb Extensions
(4) Colored/Patterned Pavement

Prioritize Bicycle Travel

(7) Stop Signs have been reoriented to assign right of way to Channing.

Traffic Reduction

(6) Partial Non-Motorized Only Crossing

Intersection Improvements

(5) Bicycle Signal
(8) (11) Medians

Other

(2) Segment of Bicycle Lane

Overview

- The Channing bicycle boulevard is approximately 2.5 miles in length and provides an east-west connector route in Berkeley, California.
- Includes sections of bicycle lane.
- Distinctive purple wayfinding and street signage is used on all bicycle boulevards (Figure 5.9).
- Large pavement markings (30'L x 6'W) (Figure 5.7) are installed approximately every 20 feet and at each intersection. The prominent markings reinforce the message to motorists that they are on a street prioritized for cyclists, act as a "breadcrumb trail" for cyclists, and contribute to a "sense of place."
- Most bicycle boulevards in Berkeley began as traffic calming installed during the 1960's to reduce cut-through traffic in neighborhoods. In the 1990's, the City formalized the network with the adoption of the City bike plan, building upon the existing traffic calming elements with signage, pavement markings, and new traffic calming features.
- Part of a well-connected network of bicycle boulevards.

Figure 5.7 Large pavement markings

Key Destinations

Schools & University of California Berkeley
Commercial District
Transit
Other Bicycle Routes
Downtown Berkeley
Bicycle/Pedestrian Bridge crossing Freeway

Figure 5.8 Landscaped non-motorized crossings allow cyclists through but restrict motorists

Lessons Learned & Advice

- Not all arterial crossings require signalization or other expensive improvements. A crossing located between two signals can create gaps between platoons of motor vehicles allowing bicyclists to safely cross. Wide medians can provide a refuge area when gaps are not sufficient in both directions.
- Schedule bicycle boulevard improvements in coordination with repaving and other major projects.
- Build upon existing traffic calming
- Plan bicycle boulevard network parallel to and within short distance of arterial and major collector streets.

Public Involvement

- Public input solicited through a series of public workshops to develop the conceptual design of the network.
- Several landscaped features are informally maintained by nearby residents (Figure 5.8).
- Marketed through a city bike map and individual bicycle tours. Passively marketed by way of signage and pavement markings.

Figure 5.9 Purple signs are used on bicycle boulevard streets

Data

Traffic Volumes: 524 (2-hour A.M.) 789 (2-hour P.M)
Bicycle Volumes: 207 (2-hour A.M.) 257 (2-hour P.M)
Construction Cost: Not Available
Speed Limit (assumed): 25 mph

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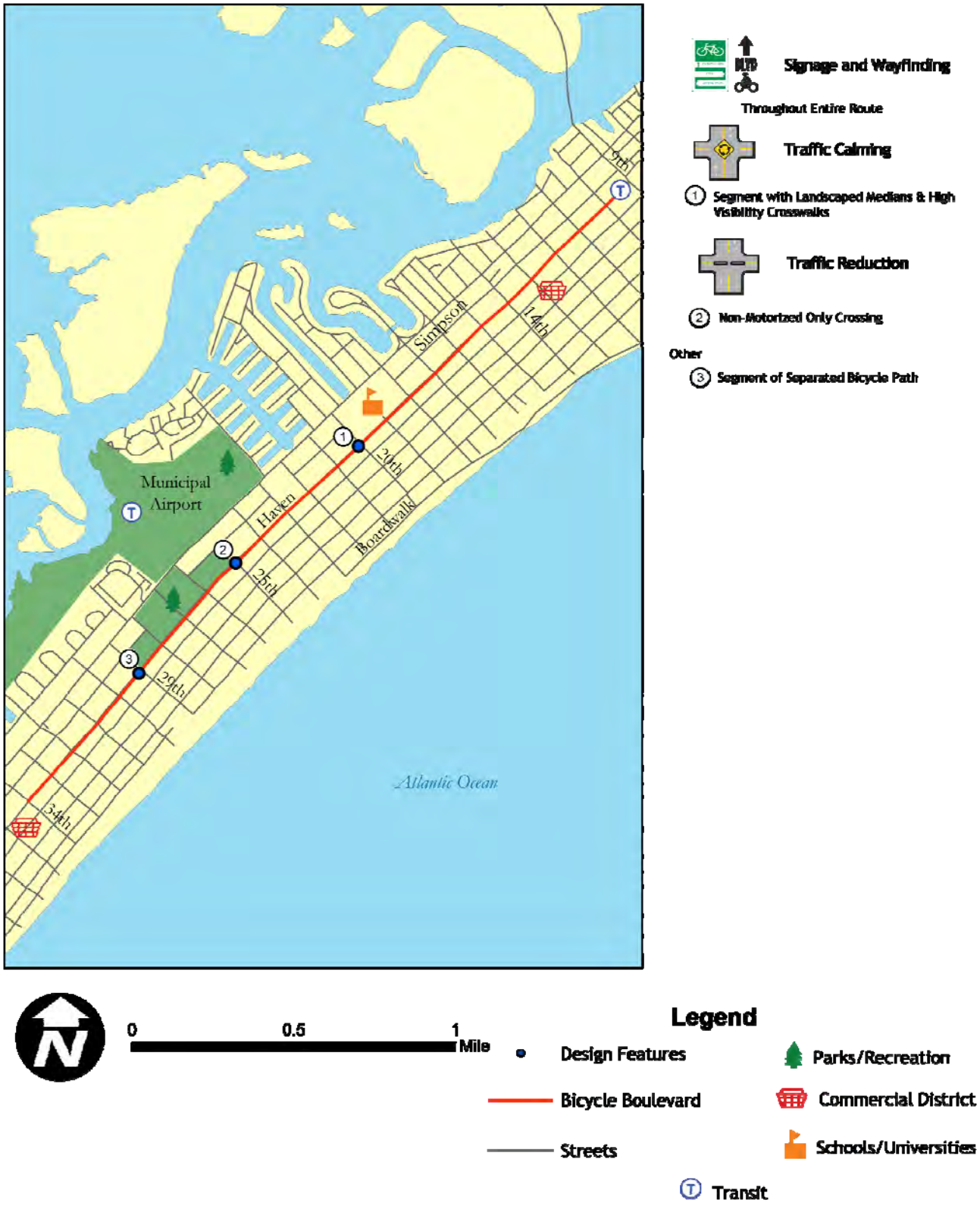
Haven Avenue "OC-1 Bikeway" – Ocean City, New Jersey



Overview

- Located in the island city of Ocean City, New Jersey. At a length of approximately 2.7 miles, OC-1 connects State Routes 9 and 52, the primary gateways to the community.
- OC-1 provides a much-needed north/south bicycle route.
- Composed of bicycle boulevard, bicycle sidepath, and multi-use trail.
- Landscaped medians restrict through and left-turn movements by motorists. Curb extensions and refuge areas within the median facilitate pedestrian crossing (Figure 5.11).
- The stylized bicyclist used in a sculpture at 9th & Haven is used throughout on signage and pavement markings.
- Grid street layout offers parallel route alternatives for motorists. During summer, the OC-1 serves as parallel route to the popular beach boardwalk which is restricted to bicycles at noon due to large pedestrian volumes.
- OC-1 will be extended to the full length of Haven Avenue and east-/west connections to the route will be improved.

Key Destinations

Transit Center	Community Center
Beach & Wildlife Refuge	Recreational Facilities
Commercial Center	Schools

Lessons Learned & Advice

- Consider creative financing. OC-1 was funded mainly with private monies.
- Actively promote the bicycle boulevard with a ribbon-cutting ceremony, press releases, tourist brochures, and on the City website.
- Take advantage of existing traffic calming elements and multi-use trail connections.

Public Involvement

- Development of the OC-1 was an entirely community-driven project to create a bicycle-friendly community.
- Signage and the sculpture (Figure 5.10) were privately-funded. Pavement markings were installed by the City during regular road maintenance.
- This seaside "family resort" community has a year-round population of 15, 000 which swells to 130, 000 during the summer months. Tourists are strongly encouraged to cycle during their visit.
- Ties into a larger community goal of reducing the City's carbon-footprint.
- Select intersections will be painted with murals colored by school children.

5.10 Sculpture art and matching signage

Figure 5.11 Landscape medians restrict motorist movements

Figure 5.12 Posted speed is 15 mph

Data

Traffic Volumes: N/A
Bicycle Volumes: N/A
Construction Cost: N/A
Speed Limit (posted): 15 mph (Figure 5.12)

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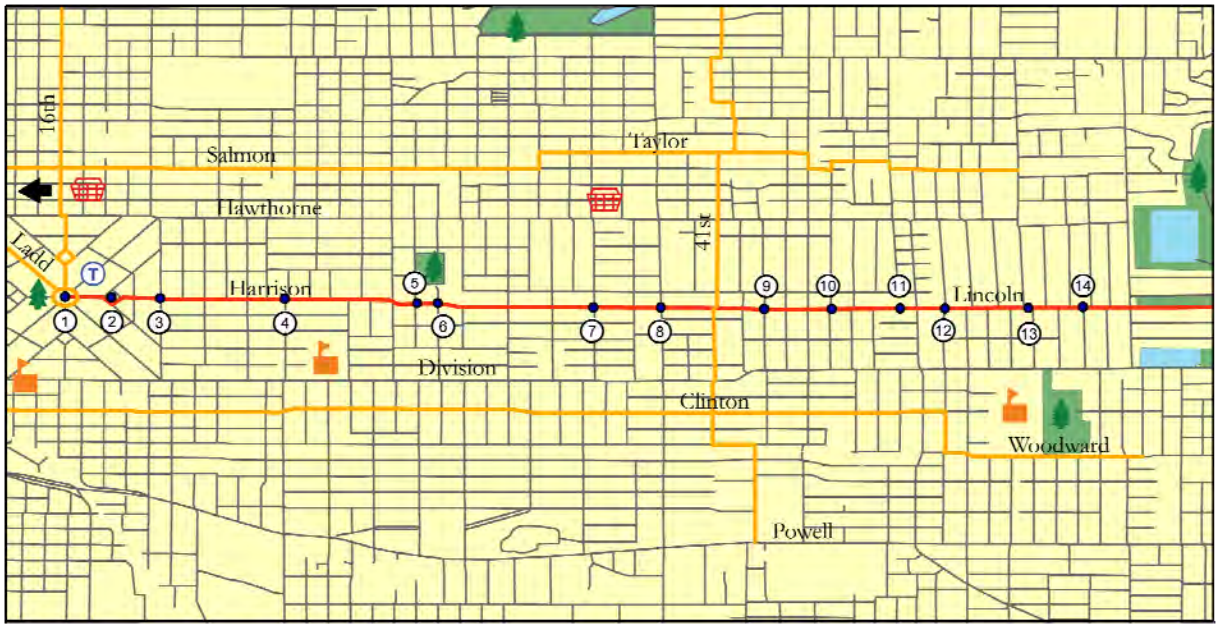
Lincoln-Harrison Bicycle Boulevard – Portland, Oregon



Legend

- Design Features
- Bicycle Boulevard
- Other Bicycle Boulevards
- Streets
- Parks/Recreation
- Commercial District
- Schools/Universities
- Transit

Signage and Wayfinding
Throughout Entire Route

Traffic Calming

1 2 3 4 7 9 10 12 13 14 Traffic Circle
5 Speed Bumps Begin
11 Speed Bumps End

Traffic Reduction

3 4 Partial Non-Motorized Only Crossing

Intersection Improvements

8 Partial Non-Motorized Only Crossing with Bicycle Signal

Overview

- The Lincoln-Harrison bicycle boulevard is approximately 3 miles in length and provides an east-west connector route in central Portland, Oregon.
- The project was completed in phases:
- A bicycle route was initially identified in the 1970's.
- In the late 1980's, a traffic calming and reduction project was implemented to reduce motor vehicle traffic on neighborhood streets using traffic circles and non-motorized only crossings (Figure 5.13 and Figure 5.14).
- In the late 1990's, the route was further enhanced with the installation of 22-foot wide speed bumps that force motorists to slow but allow cyclists to cross comfortably with no reduction in speed (Figure 5.15).
- In 2005, wayfinding signage and pavement markings were developed and installed with a federal grant.
- Pavement markings 12-inch in diameter are used along the route for wayfinding purposes. In addition, other larger markings are planned to further enhance the visibility of the route.
- Between 1996-2008, bicycle volumes on this route have increased 755%.
- Part of a well-connected network of bicycle boulevards.

Key Destinations

Schools	Other Bikeways
Transit	Parks
Central Business District	Neighborhoods

Lessons Learned & Advice

- When implementing traffic calming and reduction on the bicycle boulevard, analyze and mitigate potential traffic impacts to nearby streets through additional traffic calming.
- Speed bumps are more effective at speed reduction than traffic circles.
- In order to maintain free-flow conditions for cyclists, recommends yield-controlled intersections rather than stop signs and/or two-way stop control that assigns right of way to the bicycle boulevard.
- To avoid conflicts with emergency vehicles, the City does not put bicycle boulevards on routes identified as primary emergency response routes.

Public Involvement

- The concept of bicycle boulevards can be difficult to convey to a public that is unfamiliar with their purpose and function. The success of the "universally-beloved" Lincoln-Harrison route familiarized the public with bicycle boulevards and contributed to public interest and support for later bicycle boulevards.
- Marketed through group rides and events, bicycle maps, and the SmartTrips and Safe Routes to School programs. Best advertisement is its key connections to destinations – there are clear reasons to use the route.

Figure 5.13 A signalized partial non-motorized crossing only allows motorists to exit the bikeway while cyclists may continue through.

Figure 5.14 Landscaped traffic circles eliminate the need for stop signs at several intersections

Figure 5.15 22-foot wide speed bumps slow motor vehicle traffic but not cyclists

Data

Traffic Volumes (2008): 1438 (24-hour count)
Bicycle Volumes (2008): 1900 (extrapolated total count)
Construction Cost: Not Available
Speed Limit (assumed): 25 mph

Contact

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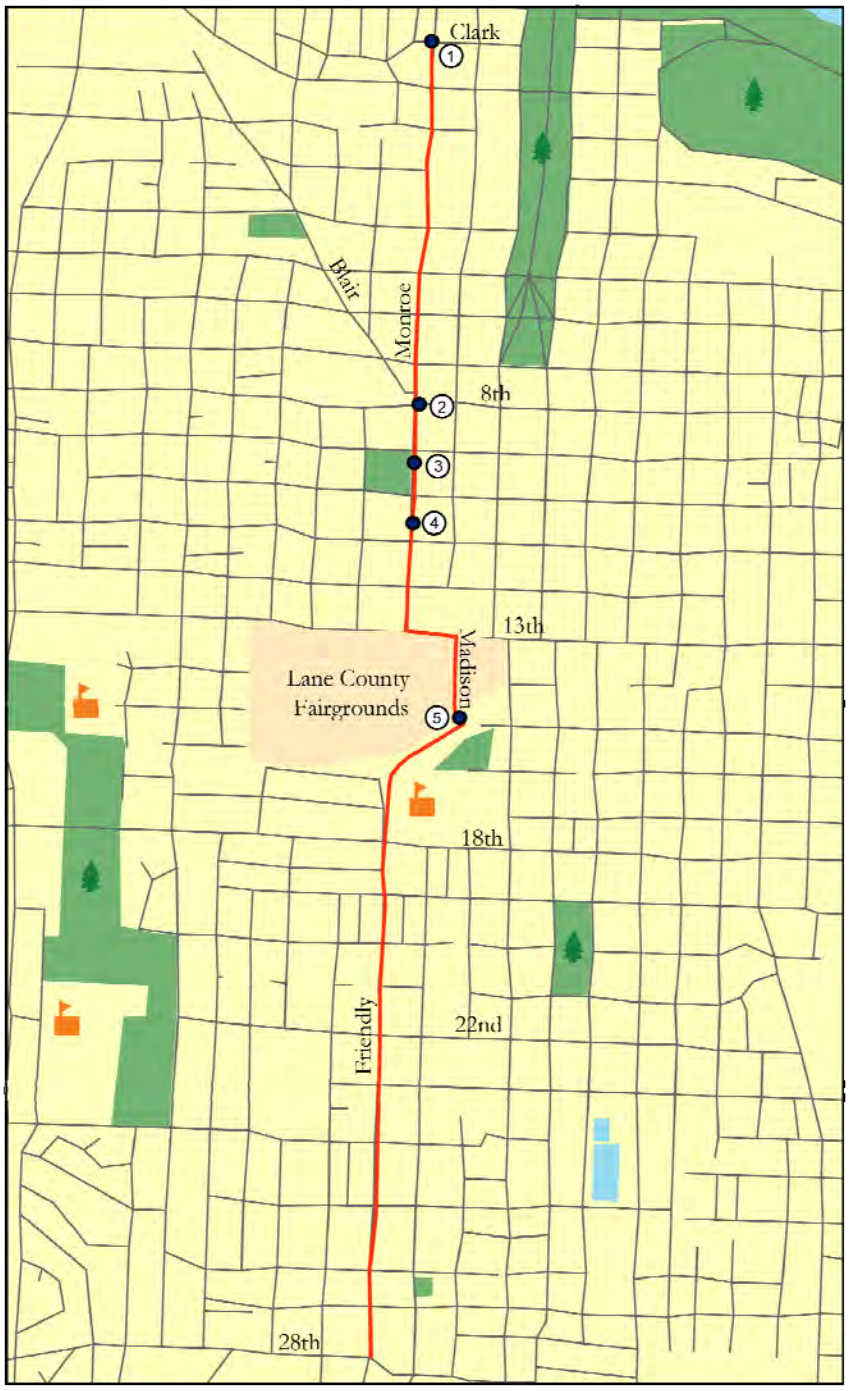
Monroe-Friendly Bicycle Boulevard – Eugene, Oregon



Signage and Wayfinding
Throughout Entire Route

Traffic Calming
3 Speed Bumps Begin
4 Speed Bumps End

Traffic Reduction
5 Pedestrian & Bicycle Only Bridge

Intersection Improvements
2 Reconfigured Intersection (Sight Distance Improvements, Landscaping & Sidewalk Construction)

Other:
1 Connection to Bicycle & Pedestrian Trail

N

0 0.25 0.5 Mile

Legend
- Design Features
- Bicycle Boulevard
- Streets
- Parks/Recreation
- Schools/Universities
- Transit

Overview

- The Monroe-Friendly bicycle boulevard is approximately 3 miles in length and runs along a residential street in Eugene, Oregon (Figure 5.16).
- Parallels Jefferson Street, a high traffic arterial two blocks east.
- Provides north-south cycling route and connects two popular multi-use trails: Ruth Bascom Riverbank Trail and Fern Ridge Path at Amazon Ridge.
- The Lane County fairgrounds bisect the bicycle boulevard and discourage its use as a through route by motorists. Pavement markings with arrows (Figure 5.18) guide cyclists east around the fairgrounds, however, cyclists may shortcut through the fairgrounds when they are open.
- Signage and pavement markings were modeled after those used in Portland, Oregon (Figure 5.17)
- Project included an intersection improvement that enhanced bicycle, pedestrian, and motor vehicle safety. The project included an intersection realignment to create a "T" intersection, sidewalk extension, landscaping, public art, and installation of bicycle-friendly drainage grates.
- One of several bicycle boulevards in the City's well-connected bikeway network.

Key Destinations

Schools & University of Oregon	Other Bikeways
Small Commercial Center	Parks
Downtown Eugene	Fairgrounds

Lessons Learned & Advice

- Consult with emergency services regarding proposed traffic calming devices.
- In response to cyclist feedback that the pavement markings were too small, the markings were enlarged to 18 inches in circumference.
- Pavement markings were installed towards the center of traffic lanes to reduce wear caused by motor vehicle traffic.

Public Involvement

- City staff met with adjacent property owners to discuss the project and design features. Residents were very supportive and particularly interested in features that would calm traffic.
- Landscaping and public art funded through a neighborhood matching grant incorporated bicycle art into intersection improvements at Monroe and 8th Streets.

Figure 5.16 Speed tables, wayfinding signage, pavement markings, and non-motorized only crossings work together to create the bicycle boulevard

Figure 5.17 Wayfinding signs are modeled after those used in Portland, Oregon

Figure 5.18 Pavement markings with arrows are used to guide cyclist through turns along the bikeway

Data

Traffic Volumes (2007): 2800
Bicycle Volumes (2008): 67 a.m., 127 p.m. (2-hour counts)
Construction Cost (2007 dollars): $440,000
Speed Limit (prima facie): 25 mph

Contact

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858 Pearl Street
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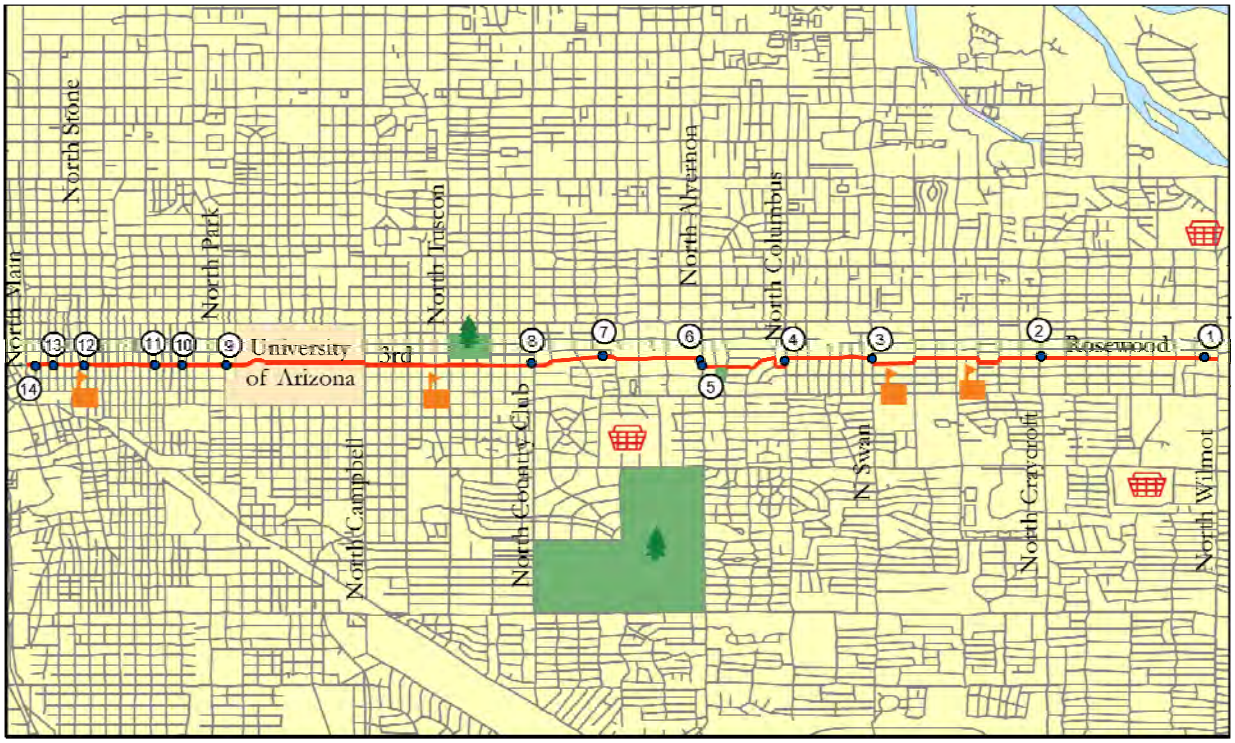
Third Street Bicycle Boulevard – Tucson, Arizona



0 0.5 1 Mile

Legend

- Design Features
- Bicycle Boulevard
- Streets
- Parks/Recreation
- Schools/Universities
- Commercial District

Signage and Wayfinding

Throughout Entire Route

Traffic Calming

(1) (7) (14) Speed Bumps (short sections)
(9) (10) (11) Speed Bumps (short sections)
(2) Traffic Circle

Intersection Improvements

(2) Median
(5) (8) (12) TOUCAN Signal

Other:

(3) (4) Segment of Bicycle Lane
(3) Bicycle Sidepath

Overview

- The Third Street bicycle boulevard is approximately 7 miles in length and provides an east-west connector route from midtown to downtown via the University of Arizona.
- East of the University the bicycle boulevard is located on a local street. West of the University the routes uses bicycle lanes on a collector roadway shared with a historic trolley car and planned modern streetcar tracks.
- Utilizes TOUCAN ("two groups can cross") signals at three major intersections (multi-lane, 20,000+ ADT)(Figure 5.20 and 5.21). TOUCAN signals have a designated lane, a bicycle push-button to activate the signal, and restrict through motor vehicle movement.
- A HAWK signal with a sidepath is being constructed in 2009 at the intersection of Swan and Third.
- The intersection at Alvernon Street and Third Street is offset (cyclists must briefly ride along and cross Alvernon Street in order to continue on Third Street). To facilitate this movement, a two-way bicycle sidepath has been constructed on the west side of Alvernon. The sidepath leads to a TOUCAN signal (Figure 5.19).
- Back-in diagonal parking is used in some areas. It provides motorists greater visibility when pulling out of the parking space.
- One of several existing and planned bicycle boulevards in Tucson.

Key Destinations

Schools & University of Arizona	Other Bikeways
Small Commercial Centers	Recreational Facilities & Parks
Midtown & Downtown Tucson	Neighborhoods

Public Involvement

- Providing a direct connection to the University of Arizona parallel to a major arterial, Third Street was already a preferred bicycle route before it evolved into a bicycle boulevard. Additional traffic calming (traffic circles, speed bumps, curb extensions), traffic reduction (right-turn only for motorists), and intersection signal improvements are planned.
- Motor vehicle restrictions were controversial.

Figure 5.19 A two-way bicycle side path and signalized crosswalk at East Third Street and North Alvernon Way.

Figure 5.20 TOUCAN signal heads at North Stone Avenue and East Third Street

Figure 5.21 A TOUCAN signal at North Country Club Road and East Third Street requires motorists to turn right while a bicycle signal head allows through movements by cyclists

Data

Traffic Volumes (2007): 2000
Bicycle Volumes (2008): 4000 (extrapolated total count)
Construction Cost: Not Available
Speed Limit (posted): 25 mph

Contact

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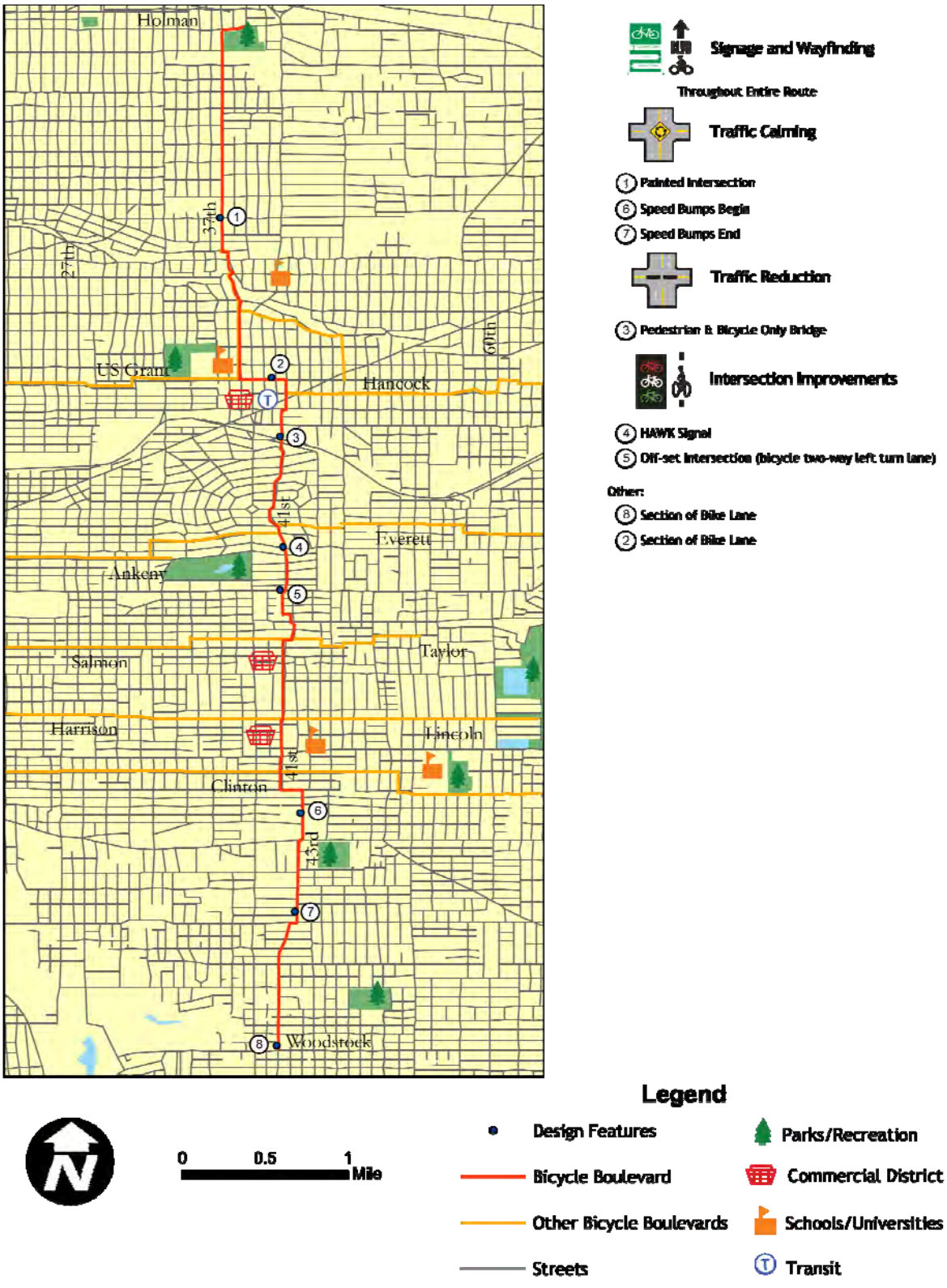
40's Bikeway – Portland, Oregon



Overview

- The 40's bicycle boulevard is approximately 10 miles in length and provides a north-south connector route in central Portland, Oregon.
- Composed of a mixture of bicycle boulevard, bike lanes, and signed bike route. The route jogs along several parallel north-south streets, primarily on residential streets (Figure 5.22).
- Arterial crossings are enhanced with median refuges and curb extensions, and bicycle activated signals are marked.
- A HAWK signal was installed funded with an Oregon Department of Transportation grant (Figure 5.23).
- In addition to wayfinding signage, pavement markings with arrows indicated turns along the route.
- Parking was removed on one side of the street along a portion of the route to accommodate bike lanes. City policy states that parking not essential to served adjacent uses can be removed on city bikeways to proved bicycle lanes.
- Provides a direct connection to the Hollywood Transit Center, a major regional transit center.
- Part of a well-connected network of bicycle boulevards.

Key Destinations

Transit Center	Other Bikeways
Commercial Districts	Schools
Parks	Neighborhoods

Public Involvement

- Project involved extensive public outreach, including the creation of a project steering committee, multiple open-houses and public meetings (advertised through a variety of mediums), private presentations on request, and project newsletters delivered to residents along the proposed route.
- The Central Northeast Neighbors Association and City Repair painted and added landscaping to an intersection along the bicycle boulevard (Figure 4.24).

5.22 Cyclists traveling the boulevard

Figure 5.23 Cyclists crossing at a HAWK signal

Photo: Central Northeast Neighbors

Figure 5.24 A painted and landscaped intersection created by a neighborhood association has a traffic calming effect

Data

Traffic Volumes (2005-09): 976-5278 (24 hour count)
Bicycle Volumes (2006-07): 850-1000 (extrapolated total count)
Construction Cost: Approximately $200, 000 (not including HAWK signal)
Speed Limit (prima facie): 25 mph

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VI. Appendix A - Literature Review Summary & References

References to bicycle boulevards primarily occur within the last decade, however earlier reference to this design treatment appears in the mid-to-late 1990's in both Oregon and California planning documents. Several key themes emerge from the literature review:

General Description & Overview of Bicycle Boulevards

As a relatively new design treatment, much of the existing documentation focuses on providing a general description or overview of bicycle boulevards and the intent of this bicycle treatment. A definition is often provided, along with a sampling of design elements commonly used and their intent.

Case Studies and Specific Bicycle Boulevard Project Documentation

In addition to describing the concept of bicycle boulevards, many documents also provide or make reference to specific case studies. Bicycle boulevards in both Palo Alto, CA and Berkeley, CA are frequently referenced.

Several local governments are currently planning for and designing bicycle boulevards in their communities, and there is an increasing amount of project documentation becoming available. Project documentation offers a glimpse of site-specific planning, design, and construction costs associated with implementation of a particular bicycle boulevard; however the information is at times transferable to other projects.

Descriptions of Bicycle Boulevard Design Elements

Within general descriptions and case studies of bicycle boulevards, individual design elements are discussed. However, some references go into greater detail of the these elements, providing information on the intent of the treatment, the typical or recommended application, design suggestions, illustrations (photos, drawings, and cross-sections), cost, and impact on motor vehicle traffic.

- Bicycle Transportation Alliance – Bicycle Boulevard Design Tools Matrix by "Goal"
- Berkeley, CA – Basic and Site Specific Design Guideline Strategies
- Bike/Walk Streets – Organizes Design Elements by Level of Treatment, Including Elements to Enhance the Pedestrian Environment

Transportation Plans and Policies in Support of Bicycle Boulevard Implementation

Relatively few communities have developed specific policies towards bicycle boulevards. Berkeley, CA and Napa, CA are exceptions.

What is missing from the existing literature? Very little empirical safety and traffic operations data is available for bicycle boulevards. There are many possible reasons for this omission. Traffic circulation patterns and historic collision histories are very site-specific, as are the design elements and level of treatment chosen for a particular bicycle boulevard. Due to the lack of consistency between sites, it can be difficult to generalize impacts from one design to the next.

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VII. Appendix B - Bicycle Boulevard Audit

The Bicycle Boulevard Audit can be used to assess a roadway for bicycle boulevard development or to assess the function of an existing bicycle boulevard. Before beginning the audit, we recommend that you obtain a map of the street surveyed so you can note destinations and parallel arterials near the bicycle boulevard, the location of existing and proposed design elements, as well as roadway maintenance needs. You may also want to bring a camera along during your audit to photograph these features/conditions.

Auditor: Date: Day of the Week: Time:

Overview

Bicycle Boulevard Street Name(s): _____

Route Begin Point _____
Route End Point _____

Length _____

Describe the land uses along the street (check all that apply):

- o Residential
- o Commercial – Retail
- o Commercial – Offices
- o Mixed of Commercial/Residential
- o Industrial
- o Institutional
- o Recreational
- o Other:

Destinations Served by the Bicycle Boulevard (On or Nearby)

- o Schools & Universities
- o Commercial Districts
- o Major Employment Centers
- o Recreational Centers/Facilities
- o Neighborhoods
- o Transit Facilities
- o Other Bicycle Routes
- o Other:

Bicycle Parking Facilities
Bicycle short-term (racks) and long-term (lockers) facilities that provide parking for cyclists at destinations along the route.

- o Exists - Location (or note on map):
  Describe:
- o Needed - Location (or note on map):
  Describe:

Motor Vehicle Parking

- o No Parking Allowed
- o Parallel Parking
- o Perpendicular Parking
- o Angled Parking
  - o Pull-in
  - o Back-in

Is there any transit service along the route?
Yes No Don't Know

If yes, what is the approximate frequency of service?
_____ Don't Know

Is the street on an Emergency Service Priority Route?
Yes No Don't Know
Intersections Requiring Stops by Cyclists
Number of Stops on Bicycle Boulevard

Number of Stops on Parallel Arterial Streets
Street Name #1 _____
Street Name #2 _____

Speed & Volume
The speed and volume of roadway users before and/or after bicycle boulevard improvements.

Bicycle Boulevard Speed & Volume

Motor-Vehicle Volume
Before: ADT _____ Or Light, Moderate, Heavy Unknown
After: ADT _____ Or Light, Moderate, Heavy Unknown

Bicycle Volume
Before: ADT _____ Or Light, Moderate, Heavy Unknown
After: ADT _____ Or Light, Moderate, Heavy Unknown

Motor Vehicle Speed
Posted or Prima Faciae Speed _____
Observed Speed (85% if available) _____
Before: MPH _____ Or OK, Too Fast Unknown
After: MPH _____ Or OK, Too Fast Unknown

Collision History on the Bicycle Boulevard (Include Time Period)
Before: Motor Vehicles_____ Bicycles_____ Pedestrians_____ Unknown
After: Motor Vehicles_____ Bicycles_____ Pedestrians_____
Unknown

Intersection Speed & Volume

Motor-Vehicle Volume
Before: ADT _____ Or Light, Moderate, Heavy Unknown
After: ADT _____ Or Light, Moderate, Heavy Unknown

Bicycle Volume
Before: ADT _____ Or Light, Moderate, Heavy Unknown
After: ADT _____ Or Light, Moderate, Heavy Unknown

Maintenance
Does the condition of the roadway provide a safe and comfortable cycling experience?

Pavement Quality
- Good Condition (Smooth riding surface, free of debris)
- Fair Condition (Rough spots in some locations, needs some maintenance but overall OK)
- Poor Condition (Degraded and crumbling, several potholes, collected debris, extensive maintenance required)

Note the location of maintenance issues on your map.

Drainage Grates
- None
- Bike Friendly
- Bicycle –Unfriendly (Bars parallel to riding direction, wheels could get stuck)

Bicycle Boulevard Design Elements

Signage
Signage that indicates to motorists and bicyclists that they are on a bicycle boulevard (Identification Signs) and may also indicate destinations on or near the bicycle boulevard (Wayfinding).

Wayfinding
- Exists - Location (or note on map):
- Needed - Location (or note on map):

Bicycle Boulevard Identification Signage
- Exists - Location (or note on map):
- Needed - Location (or note on map):

Roadway Markings
Roadways markings painted on the road that identify the street as a bicycle boulevard and/or indicate that bicycles and motor vehicles share the road.

- Exists - Location (or note on map):

  What does it look like (Sketch)?
  How large is it?
  How often does it repeat?

- Recommended - Location (or note on map):

Intersection Treatments
Bicycle intersection treatments that assist cyclists in crossing busy streets.

1. Stop Sign Orientation Favoring	2. HAWK Signals	3. High Visibility & Raised Crosswalks	4. Off-set Intersections Side Path Bicycle L-turn Lane L-turn Pocket in Median
5. Bike Boxes	6. Bicycle Detection Loops	7. Refuge Islands	8. Choker Entrance
9. Bicycle Signals	10. Scramble Signals	11. Elevated Crossings	12. Other:

Location(s) or note on map:

Traffic Calming
Roadway elements that reduce the speed of motor vehicles using the street(s).

1. Traffic Circles	2. Speed Bumps/Humps	3. High Visibility & Raised Crosswalks	4. Colored/Patterned Pavement
5. Landscaping & Street Trees	6. Medians	7. Chicanes	8. Pinch Points

9. Curb Extensions/Bulb outs
10. Stop Sign Orientation
11. Radar Feedback Signs
12. Other:

Location(s) or note on map:

Traffic Reduction

Roadway elements that discourage through traffic from using the roadway.

- Full Diversion
- Partial Diversion
- Non-Motorized Only Crossings & "Cul-de-Sac Connectors"

Location(s) or note on map:

Complementary Features

Design features and programs that enhance the environment and experience for pedestrians and cyclists.

Pedestrian Amenities

- Sidewalk
  - Condition (Good, Fair, Poor)
- Ramps at Intersections
  - Exists - Location (or note on map):
  - Needed - Location (or note on map):
- Street Furniture (Benches, trash receptacles)
  - Exists - Location (or note on map):
  - Needed - Location (or note on map):

Lighting

- No Lighting
- Auto-Oriented Lighting
  - Amount of Lighting:
  - OK Needs More
- Pedestrian-Oriented Lighting
  - Amount of Lighting:
  - OK Needs More

Public Art

- Exists - Location (or note on map):
- Recommended - Location (or note on map):
  Describe:

Landscaping

- No
- Yes
  - Well Maintained
  - Needs Maintenance

Safe Routes to School

Is there a primary or middle school (K-8) within 2 miles of the street?

Yes No Don't Know

Does the school have a Safe Routes to School program?

Yes No Don't Know

VIII. Appendix C - Funding Programs

Federal Highway Administration Programs	
Program/Primary Purpose	**Eligible Pedestrian and Bicycle Activities**
Metropolitan Planning (23 USC 104(f))	
Transportation planning in urbanized areas in accordance with 23 USC 134 and 49 USC 5303.	Bicycle and pedestrian planning as part of the metropolitan planning process.
Statewide Planning (23 USC 505)	
Statewide transportation planning in accordance with 23 USC 135 and 49 USC 5304.	Bicycle and pedestrian planning as part of the statewide planning process.
National Highway System (NHS) (23 USC 103)	
Improvements to rural and urban roads that are part of the NHS or that are NHS Intermodal connectors.	Construction of pedestrian walkways and bicycle transportation facilities on land adjacent to any highway on the NHS.
Surface Transportation Program (STP) (23 USC 133)	
Construction, reconstruction, rehabilitation, resurfacing, restoration, and operational improvements for highways and bridges including construction or reconstruction necessary to accommodate other transportation modes.	Construction of pedestrian walkways and bicycle transportation facilities; nonconstruction projects for safe bicycle use; modify public sidewalks to comply with the Americans with Disabilities Act. Projects do not have to be within the right-of-way of a Federal-aid highway.
Surface Transportation Program Transportation Enhancements Set-aside (TE) (23 USC 133(d)(2))	
12 specific activities included in the definition of Transportation Enhancement Activities in 23 USC 101(a)(35).	3 of the 12 eligible categories are pedestrian and bicycle facilities, safety and education for pedestrians and bicyclists, and rail-trails.
Interstate Maintenance (IM) (23 USC 119)	
Resurfacing, restoring, rehabilitating, and reconstructing most routes on the Interstate system.	No specific eligibility, but funds may be used to resurface, restore, rehabilitate, and reconstruct pedestrian and bicycle facilities over, under, or along Interstate routes.
Highway Bridge Replacement and Rehabilitation (HBRRP) (23 USC 144)	
Replace and rehabilitate deficient highway bridges and to seismically retrofit bridges located on any public road.	Pedestrian walkways and bicycle transportation facilities on highway bridges. If a highway bridge deck is replaced or rehabilitated, and bicycles are permitted at each end, then the bridge project must include safe bicycle accommodations (within reasonable cost). (23 USC 217(e))
Highway Safety Improvement Program (HSIP) (23 USC 148)	
To achieve a significant reduction in traffic fatalities and serious injuries on public roads. Improvements for pedestrian or bicyclist safety.	Construction and yellow-green signs at pedestrian-bicycle crossings and in school zones. Identification of and correction of hazardous locations, sections, and elements (including roadside obstacles, railway-highway crossing needs, and unmarked or poorly marked roads) that constitute a danger to bicyclists and pedestrians. Highway safety improvement projects on publicly owned bicycle or pedestrian pathways or trails.

Federal Highway Administration Programs	
Program/Primary Purpose	**Eligible Pedestrian and Bicycle Activities**
Highway Safety Improvement Program (HSIP) (23 USC 148)	
To achieve a significant reduction in traffic fatalities and serious injuries on public roads. Improvements for pedestrian or bicyclist safety.	Sign installation at pedestrian-bicycle crossings and in school zones. Identification of and correction of hazardous locations, sections, and elements (including roadside obstacles, railway-highway crossing needs, and unmarked or poorly marked roads) that constitute a danger to bicyclists and pedestrians. Highway safety improvement projects on publicly owned bicycle or pedestrian pathways or trails.
Congestion Mitigation and Air Quality Improvement Program (CMAQ) (23 USC 149)	
Funds projects in nonattainment and maintenance areas that reduce transportation related emissions.	Construction of pedestrian walkways and bicycle transportation facilities; nonconstruction projects for safe bicycle use. Projects do not have to be within the right-of-way of a Federal-aid highway, but must demonstrate an air quality benefit.
National Scenic Byways Program (NSBP) (23 USC 162) [Added 3/27/06]	
Eight specific activities for roads designated as National Scenic Byways, All-American Roads, State scenic byways, or Indian tribe scenic byways. The activities are described in 23 USC 162(c). This is a discretionary program; all projects are selected by the US Secretary of Transportation.	Construction along a scenic byway of a facility for pedestrians and bicyclists and improvements to a scenic byway that will enhance access to an area for the purpose of recreation. 23 USC 162(c)(4-5). Construction includes the development of the environmental documents, design, engineering, purchase of right-of-way, land, or property, as well as supervising, inspecting, and actual construction. [Note: Construction of the recreation facility is not eligible.]
Federal Lands Highways Program (FLHP) (23 USC 204)	
Coordinated program of public roads and transit facilities serving Federal and Indian lands. Funding is broken into 4 discrete sources: ▪ Indian Reservation Roads (IRR) ▪ Public Lands Highway - Discretionary & Forest Highways ▪ Refuge Roads ▪ Parkways & Park Roads	Construction of pedestrian walkways and bicycle transportation facilities.
Transportation, Community, and System Preservation Program (TCSP) (S-LU Sec. 1117, formerly TEA-21 Sec. 1221)	
Provides funding for a comprehensive program including planning grants, implementation grants, and research to investigate and address the relationships among transportation and community and system preservation plans and practices and examine private sector based initiatives	Pedestrian and bicycle projects meet several TCSP goals, are generally eligible for the TCSP program and are included in many TCSP projects.
Coordinated Border Infrastructure Program (S-LU Section 1303)	
To improve the safe movement of motor vehicles at or across the border between the United States and Canada and the border between the United States and Mexico.	Eligible as part of an overall project.

Federal Highway Administration Programs	
Program/Primary Purpose	**Eligible Pedestrian and Bicycle Activities**
Safe Routes to School (SRTS) (S-LU Sec. 1404)	
1. To enable and encourage children, including those with disabilities, to walk and bicycle to school; 2. To make bicycling and walking to school a safer and more appealing transportation alternative, thereby encouraging a healthy and active lifestyle from an early age; and 3. To facilitate the planning, development, and implementation of projects and activities that will improve safety and reduce traffic, fuel consumption, and air pollution in the vicinity of schools	Eligible Infrastructure Projects are planning, design, and construction of infrastructure-related projects that will substantially improve the ability of students to walk and bicycle to school, including ▪ sidewalk improvements, ▪ traffic calming and speed reduction improvements, ▪ pedestrian and bicycle crossing improvements, ▪ on-street bicycle facilities, ▪ off-street bicycle and pedestrian facilities, ▪ secure bicycle parking facilities, and ▪ traffic diversion improvements in the vicinity of schools. Eligible Non-infrastructure activities to encourage walking & bicycling to school, including: ▪ public awareness campaigns and outreach to press and community leaders, ▪ traffic education and enforcement in the vicinity of schools, ▪ student sessions on bicycle and pedestrian safety, health, and environment, and ▪ funding for training, volunteers, and managers of safe routes to school programs
Nonmotorized Transportation Pilot Program (NTPP) (S-LU Sec. 1807)	
To demonstrate the extent to which bicycling and walking can carry a significant part of the transportation load, and represent a major portion of the transportation solution, within 4 identified communities (Marin County, CA; Sheboygan County, WI; Columbia, MO; and Minneapolis-St Paul, MN).	Construction of nonmotorized transportation infrastructure facilities, including sidewalks, bicycle lanes, and pedestrian and bicycle trails, that connect directly with transit stations, schools, residences, businesses, recreation areas, and other community activity centers. Educational programs; promotion; network and project planning; data collection, analysis, evaluation, and reporting of results
Metropolitan Planning Program (MPP) (49 USC 5305(d))	
To carry out the metropolitan transportation planning process under 49 USC 5303.	Bicycle and pedestrian planning as part of the metropolitan planning process.
Statewide Planning & Research (SPR) (49 USC 5305(e)	
To carry out the provisions of 49 USC sections 5304, 5306, 5315, and 5322.	Bicycle and pedestrian planning as part of the statewide planning process.
Urbanized Area Formula Grants (49 USC 5307)	
Transit capital and planning assistance to urbanized areas with populations over 50,000 and operating assistance to areas with populations of 50,000 - 200,000.	Improve bicycle and pedestrian access to transit facilities and vehicles, including bike stations.

Source: Federal Highway Administration & Federal Transit Administration (http://www.fhwa.dot.gov/HEP/bkepedtble.htm)

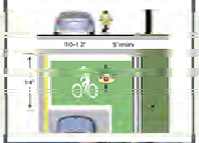
State Programs
State Transportation Improvement Program (STIP)
The Statewide Transportation Improvement Program (STIP) represents the four-year, fiscally-constrained and prioritized program of transportation projects, compiled from local and regional plans, along with the Washington Transportation Plan. The STIP contains Federally-funded projects plus state and local regionally-significant projects programmed for calendar years 2007 through 2010. These projects have been identified through planning process as the highest priority for the available funding to the State's transportation program.
Regional Transportation Improvement Program (RTIP)
Part of State Transportation Improvement Program (STIP), the main state program for transportation project funding. For "improving transportation within the region." The Regional Transportation Planning Agency must program funds.
State Bicycle Funding Programs
Several states have created programs to exclusively fund bicycle transportation projects. Examples include California's Bicycle Transportation Account, and Michigan and Oregon's Bicycle Bill's which allocate 1% of gas tax revenue to bicycle projects.
Special Interest License Plate Programs
Several bicycle advocacy groups generate revenue through the sale of special interest license plates. Drivers pay an additional fee to the State department of motor vehicles for the license plates which often bear the image of a cyclist and a slogan. A portion of the additional license fee is then allocated to bicycle and pedestrian educational programs and projects. Examples include "share the road" license plate program in Oregon, Texas, and Florida.
State Routes to Schools (SR2S)
Recent SAFETEA-LU legislation, which requires each state's Department of Transportation to designate a Safe Routes to Schools Coordinator, also contains a SR2S program. This state-level program is meant to improve the safety of walking and bicycling to school, and to encourage students to walk and bicycle to school through bicycle safety and traffic calming projects.
High Risk Rural Roads Programs
Authorized under SAFETEA-LU, the purpose of this program is to reduce the frequency and severity of collisions on rural roads by correcting or improving hazardous roadway locations or features. For a project to be eligible for HR3 funds, the project must be located on a roadway functionally classified as a rural major or minor collector, or a rural local road. There are 21 categories of projects eligible for funding under this program, including a category for projects that improve pedestrian or bicyclist safety.

Local Programs
Local Bond Measure
Local bond measures, or levies, are usually initiated by voter-approved general obligation bonds for specific projects. Bond measures are typically limited by time based on the debt load of the local government or the project under focus. Funding from bond measures can be used for right-of-way acquisition, engineering, design and construction of pedestrian and bicycle facilities.
Tax Increment Financing/Urban Renewal Funds
Tax Increment Financing (TIF) is a tool that uses future gains in taxes to finance current improvements that will create those gains. When a public project (e.g., sidewalk improvements) is constructed, surrounding property values generally increase and encourage surrounding development or redevelopment. The increased tax revenues are then dedicated to finance the debt created by the original public improvement project. Tax Increment Financing typically occurs within designated Urban Renewal Areas (URA) that meet certain economic criteria and approved by a local governing body. To be eligible for this financing, a project (or a portion of it) must be located within the URA.

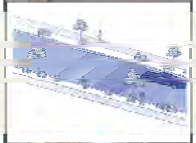
Local Programs
System Development Charges/Developer Impact Fees
System Development Charges (SDCs), also known as Developer Impact Fees, represent another potential local funding source. SDCs are typically tied to trip generation rates and traffic impacts produced by a proposed project. A developer may reduce the number of trips (and hence impacts and cost) by paying for on- or off-site pedestrian improvements encouraging residents to walk, bicycle, or use transit rather than drive. In-lieu parking fees may be used to help construct new or improved pedestrian facilities. Establishing a clear nexus or connection between the impact fee and the project's impacts is critical to avoiding a potential lawsuit.
Street User Fees
Local agencies may administer street user fees though residents' monthly water or other utility bills. The revenue generated by the fee could be used for operations and maintenance of the street system, with priorities established by the Public Works Department. Revenue from this fund could be used to maintain on-street bicycle and pedestrian facilities, including routine sweeping of bicycle lanes and other designated bicycle routes
Local Improvement Districts
Local Improvement Districts (LIDs) are most often used by cities to construct localized projects such as streets, sidewalks or bikeways. Through the LID process, the costs of local improvements are generally spread out among a group of property owners within a specified area (with the City providing a predetermined match). The cost can be allocated based on property frontage or other methods such as traffic trip generation.
Business Improvement Districts
Pedestrian improvements can often be included as part of larger efforts aimed at business improvement and retail district beautification. Business Improvement Districts collect levies on businesses in order to fund area-wide improvements that benefit businesses and improve access for customers. These districts may include provisions for pedestrian and bicycle improvements, such as wider sidewalks, landscaping, and ADA compliance.
Other Local Sources
Residents and other community members are excellent resources for garnering support and enthusiasm for a bicycle and pedestrian facility, and the local agency should work with volunteers to substantially reduce implementation and maintenance costs. Local schools, community groups, or a group of dedicated neighbors may use the project as a project for the year, possibly working with a local designer or engineer. Work parties can be formed to help clear the right-of-way for a new trail or maintain existing facilities where needed. A local construction company could donate or discount services. Other opportunities for implementation will appear over time, such as grants and private funds. The local agency should look to its residents for additional funding ideas to expedite completion of the bicycle and pedestrian system.

IX. Appendix D - Design Elements Comparison Chart

BICYCLE BOULEVARD DESIGN ELEMENTS

TOOLS	DESIGN ELEMENT	PHOTO	SPEED REDUCTION	LESS TRAFFIC	EMERGENCY DELAY	DESCRIPTION	WORKS WELL WITH:
SIGNAGE	**Identification**		**No**	**No**	**No**	**Identifies and passively markets streets that are bicycle boulevards.**	**Pavement Markings Wayfinding Signage**
	Wayfinding		No	No	No	Provides cyclists with direction, distance, and/or estimated travel times to destinations.	Pavement Markings Wayfinding Signage
	Warning		**Maybe**	**No**	**No**	**Alert motorists and cyclists to changes in road conditions such as traffic calming and the presence of other road users.**	**Traffic Calming**
PRIORITIZE TRAVEL ON THE BICYCLE BOULEVARD	Pavement Markings		No	No	No	Supplements wayfinding and identification signage. Serves as a reminder to cyclists and motorists that bicycle travel has priority.	Wayfinding Signage Identification Signage
	Stop/Yield Signs		**No**	**Maybe**	**Yes**	**Requires car traffic to stop or yield. Oriented to assign right of way to the bicycle boulevard.**	**Traffic Calming**
INTERSECTION TREATMENT	Bicycle Box/ Advanced Stop Bar		No	No	No	Improves bicyclist visibility at intersections by providing a waiting space in front of motor vehicles. Reduces risk of right hook collisions.	Warning Signage
	Bicycle/Pedestrian Activated Signals		**No**	**No**	**No**	**Allows cyclists to call a green signal at traffic lights.**	**Pavement Markings**
	Crossings at Off-Set Intersections		No	No	No	Helps cyclists to negotiate intersections where the "legs" of the intersection are not aligned directly accross from one another.	Pavement Markings Bicycle Activated Signals
	High Visibility Raised Crosswalk		**Yes**	**Maybe**	**Yes**	**Reduces vehicle speeds and creates a visibly prominent crossing location for cyclists and pedestrians.**	**Warning Signage Pavement Markings**
	Crossing Islands		No	No	Maybe	Provides a space for cyclists and pedestrians to cross the road one direction at a time. May limit auto access.	Pavement Markings High Visibility Crosswalks Warning Signage
	Painted and Patterned Surfaces		**Maybe**	**No**	**No**	**Highlights potential conflict areas and may provide some traffic calming.**	**Warning Signage Traffic Calming**

BICYCLE BOULEVARD DESIGN ELEMENTS

TOOLS	DESIGN ELEMENT	PHOTO	SPEED REDUCTION	LESS TRAFFIC	EMERGENCY DELAY	DESCRIPTION	WORKS WELL WITH:
TRAFFIC CALMING	**Traffic Circles**		**Yes**	**Maybe**	**Yes**	**Reduces traffic speeds by requiring vehicles to maneuver around center island. Eliminates stop signs. Reduces conflict points at intersections due to elimination of left turns.**	**Warning Signage**
	Speed Tables		Yes	Maybe	Yes	Reduces vehicle speed. Long and broad shape does not jar cyclists or require cyclists to reduce speed.	Warning Signage
	Chicanes		**Maybe**	**Maybe**	**Maybe**	**Create a serpentine, horizontal shifting of the travel lanes along a roadway.**	**Warning Signage**
	Curb Extensions		Maybe	No	Maybe	Extend the sidewalk or curb face into the roadway, visually narrowing the roadway and reduces crossing width.	Medians Colored/Textured Pavement
	Residential Speed Limit		**Yes**	**No**	**No**	**Reduces motorist speed by instituting a 20 mph speed limit in residential area.**	**Traffic Calming**
	Contraflow Bicycle Lanes		Maybe	No	No	A designated bicycle facility that allows cyclist to travel against the flow of traffic on a one-way street.	Warning Signage Colored/Textured Pavement
	Advisory Bicycle Lane		**Yes**	**No**	**No**	**Dashed bicycle lanes on a narrow roadway that delineates space for cyclists. Travel lane is narrow and motorists must overtake with caution.**	**Warning Signage Colored/Textured Pavement**
TRAFFIC REDUCTION	Non-Motorized Only Crossings		No	Yes	Yes	Restricts motor-vehicle movements (creating dead end or forcing turns) while allowing through movements by cyclists.	Warning Signage
	Partial Non-Motorized Only Crossings		**No**	**Yes**	**Maybe**	**Restricts motor-vehicle movements requiring turns or limiting access directionally while allowing through movements by cyclists.**	**Warning Signage Pavement Markings**

X. Appendix E - Selecting Intersection Treatments

The following table is based on information contained in the 2002 U.S. Department of Transportation Federal Highway Administration Study *Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Intersections* (Report No. FHWA-HRT-04-100) and is based on pedestrian crossing time.

Roadway Type (Number of Travel Lanes and Median Type)	Motor Vehicle ADT ≤ 9,000			Motor Vehicle ADT > 9,000 to 12,000			Motor Vehicle ADT > 12,000 to 15,000			Motor Vehicle ADT > 15,000		
	Speed Limit **											
	30 mi/h	35 mi/h	40 mi/h	30 mi/h	35 mi/h	40 mi/h	30 mi/h	35 mi/h	40 mi/h	30 mi/h	35 mi/h	40 mi/h
2 Lanes	1	1	1/1+	1	1	1/1+	1	1	1+/3	1	1/1+	1+/3
3 Lanes	1	1	1/1+	1	1/1+	1/1+	1/1+	1/1+	1+/3	1/1+	1+/3	1+/3
Multi-Lane (4 or more lanes) with raised median ***	1	1	1/1+	1	1/1+	1+/3	1/1+	1/1+	1+/3	1+/3	1+/3	1+/3
Multi-Lane (4 or more lanes) without raised median	1	1/1+	1+/3	1/1+	1/1+	1+/3	1+/3	1+/3	1+/3	1+/3	1+/3	1+/3

*General Notes: Crosswalks should not be installed at locations that could present an increased risk to pedestrians, such as where there is poor sight distance, complex or confusing designs, a substantial volume of heavy trucks, or other dangers, without first providing adequate design features and/or traffic control devices. Adding crosswalks alone will not make crossings safer, nor will they necessarily result in more vehicles stopping for pedestrians. Whether or not marked crosswalks are installed, it is important to consider other pedestrian facility enhancements (e.g., raised median, traffic signal, roadway narrowing, enhanced overhead lighting, traffic-calming measures, curb extensions), as needed, to improve the safety of the crossing. These are general recommendations; good engineering judgment should be used in individual cases for deciding which treatment to use.

For each pathway-roadway crossing, an engineering study is needed to determine the proper location. For each engineering study, a site review may be sufficient at some locations, while a more in-depth study of pedestrian volume, vehicle speed, sight distance, vehicle mix, etc. may be needed at other sites.

** Where the speed limit exceeds 40 mi/h (64.4 km/h), marked crosswalks alone should not be used at unsignalized locations.

*** The raised median or crossing island must be at least 4 ft (1.2 m) wide and 6 ft (1.8 m) long to adequately serve as a refuge area for pedestrians in accordance with MUTCD and AASHTO guidelines. A two-way center turn lane is not considered a median.

1= Type 1 Crossings. Ladder-style crosswalks with appropriate signage should be used.

1/1+ = With the higher volumes and speeds, enhanced treatments should be used, including marked ladder style crosswalks, median refuge, flashing beacons, and/or in-pavement flashers. Ensure there are sufficient gaps through signal timing, as well as sight distance.

1+/3 = Carefully analyze signal warrants using a combination of Warrant 2 or 5 (depending on school presence) and EAU factoring. Make sure to project pathway usage based on future potential demand. Consider Pelican, Puffin, or Hawk signals in lieu of full signals. For those intersections not meeting warrants or where engineering judgment or cost recommends against signalization, implement Type 1 enhanced crosswalk markings with marked ladder style crosswalks, median refuge, flashing beacons, and/or in-pavement flashers. Ensure there are sufficient gaps through signal timing, as well as sight distance.

XI. Appendix F - Photo Credits

John Ciccarelli
Figure 5.6 Bicycle activated signal
Figure 5.5 A bicycle/pedestrian bridge creates a non-motorized only crossing at Matadero Creek
Figure 5.4 A non-motorized only crossing forces motor vehicles to turn at an intersection

Tom Thivener
Page 26 Bicycle Box – Tucson, Arizona
Page 29 TOUCAN Signal – Tucson, Arizona
Page 32 Bicycle Side Path – Tucson, Arizona

Greg Raisman
Page 41 Bicycle Advisory Lanes – Netherlands

Central Northeast Neighbors
Figure 5.24 A painted and landscaped intersection created by a neighborhood association has a traffic calming effect

Alta Planning + Design
All other images