# Chapter 6 – Case Studies

The 50 engineering, education, enforcement and promotional countermeasures are described in Chapter 5. Included in this chapter are case studies that illustrate these treatments or programs as implemented in a state or municipality. Examples are included from many States. Provided on the following pages is a list of the 59 case studies by countermeasure group. A more detailed matrix showing the case studies by specific countermeasure is included in Appendix B.

Each case study includes a description of the problem that was addressed, relevant background information, a description of the implemented solution, and any quantitative results from evaluation studies or qualitative assessments.

Many communities find it difficult to conduct formal evaluations of projects due to staff and budget limitations, but assessing whether a treatment has helped toward the intended objectives and not caused unexpected adverse impacts is critical to long-term improvement. We tend to think that some evaluation is better than none but occasionally may be misled by short-term or single-event types of assessments. In these cases, the judgment of experienced practitioners may help to fill in the gaps in knowledge or interpret results that seem "too good to be true." By far, longer-term evaluations (bicyclist/traffic counts, speed studies, etc.) are preferable to short-term project assessments. Multiple short-term studies of the same types of facilities do, however, build on each other and help to provide a more complete picture of the effectiveness of bicycling countermeasures. These cautions should be borne in mind when reviewing the case studies that follow.

Included for each study is a point of contact in the event that further information is desired. Please note that in some cases the specific individual listed may have left the position or agency. There should still be someone at the municipal or state agency who is familiar with the project and can provide any supplemental information.

Not all traffic control devices (TCDs) in the case studies comply with the *Manual on Uniform Traffic Control Devices* (MUTCD). The Federal Highway Administration (FHWA) does not endorse the use of non-compliant TCDs except under experimentation, which must be approved by the FHWA Office of Transportation Operations.

| Page Number | Case Study Title | Shared Roadway | On-Road Bike Facilities | Intersections Treatments | Maintenance | Traffic Calming | Trails/Shared-Use Paths | Markings, Signs, Signals | Education and Enforcement | Support Facilities and Programs |
|---|---|---|---|---|---|---|---|---|---|---|
| 145 | #1 – Roadway Surface Hazards for Bikes | X | | | X | | | | | |
| 148 | #2 – A Tale of Portland Bridges | X | X | X | | | X | X | | |
| 155 | #3 – Lighting in the Knapps Hill Tunnel | X | | | | | | | | |
| 157 | #4 – Back-in Diagonal Parking with Bike Lanes | X | | | | | | X | | |
| 164 | #5 – Valencia Street Road Diet—Creating Space for Cyclists | X | X | | | | | X | | |
| 168 | #6 – Shoreline Park Expansion Project—Provision of Bicycle and Pedestrian Enhancements | X | X | | | | X | | | X |
| 171 | #7 – Bicycle Treatments on a Former Pedestrian Mall | X | | | | X | | X | | X |
| 176 | #8 – Bike Lane Safety Evaluation | | X | | | | | | X | |
| 181 | #9 – Establishing Bike Lanes—Chicago's Streets for Cycling Plan | | X | | X | | | | X | X |
| 185 | #10 – How Hampshire Street Pavement Markings Influence Bicycle and Motor Vehicle Positioning | | X | | | | | | | |
| 190 | #11 – Raised Bicycle Lanes and Other Traffic Calming Treatments on Ayres Road | X | X | | | X | | | | X |
| 196 | #12 – Floating Bike Lanes in Conjunction with Part-time Parking | X | X | | | | | X | | |
| 199 | #13 – Incorporating a Bicycle Lane through a Streetcar Platform | | X | | | | | | | |
| 201 | #14 – Red Shoulders as a Bicycle Facility | | X | | | X | | | | |
| 204 | #15 – Conversion of 14-foot-wide Outside Lanes to 11-foot Travel Lanes with a 3-foot Undesignated Lane | X | X | | | | | X | | |
| 207 | #16 – Preferential Transit-Bicycle Lanes on Broadway Boulevard | | X | | | | | X | | |
| 209 | #17 – Taming the Urban Arterial | X | X | | | | | X | | |
| 212 | #18 – Contraflow Bicycle Lanes on Urban Streets | | X | | | | | X | | |
| 216 | #19 – Left Side Bike Lanes on One-Way Streets | | X | | | | | X | | |
| 221 | #20 – Curb Radii/Curb Revisions | | | X | | | | | | |
| 223 | #21 – Combined Bicycle Lane/Right-Turn Lane | | X | X | | | | X | | |
| 226 | #22 – Blue Bike Lanes at Intersection Weaving Areas | | X | | | | | X | | |
| 230 | #23 – Crossing an Arterial on an Offset Intersection: Bicycle-Only Center-Turn Lane | | X | X | | | | | | |
| 232 | #24 – Improving Sight Distance between Cyclists and Motorists | X | | X | | | X | X | | |
| 235 | #25 – Grandview Drive Roundabout and Corridor Improvements | X | X | X | | | | X | | |
| 238 | #26 – Innovative Application of the Bike Box | | | X | | | | X | | |
| 242 | #27 – Comprehensive Maintenance Planning for Bicycle Facilities | X | | | X | | | X | | |
| 246 | #28 – Road Hazard Identification Project | | | | X | | | | | |
| 249 | #29 – Bikeway Speed Humps | | | | | X | | | | |
| 252 | #30 – Speed Cushions for the Evergreen Corridor Bike Lane Project | | | | | X | | | | |
| 258 | #31 – Neighborhood Mini Traffic Circles | | | | | X | | | | |

| Page Number | Case Study Title | Shared Roadway | On-Road Bike Facilities | Intersections Treatments | Maintenance | Traffic Calming | Trails/Shared-Use Paths | Markings, Signs, Signals | Education and Enforcement | Support Facilities and Programs |
|---|---|---|---|---|---|---|---|---|---|---|
| 260 | #32 – Bicycle Boulevards—Bryant Street Example | | | X | | X | | X | | |
| 265 | #33 – Planning, Designing and Implementing a Shared-Use Path | | | | | | X | | | |
| 268 | #34 – Path and Roadway Intersections | X | | | | | X | X | | |
| 273 | #35 – Grade Separated Crossing Treatments | X | | | | | X | | | |
| 278 | #36 – Share the Trail: Minimizing User Conflicts on Non-motorized Facilities | | | | | | X | | X | |
| 283 | #37 – Shared Lane Markings | | X | | | | | X | | |
| 286 | #38 – Bicycle Detection Program | | | | | | | X | X | |
| 289 | #39 – Bicycle Signal Heads | | | | | | | X | | |
| 292 | #40 – Pedestrian/Bicycle Crosswalk Signals (Half-Signals) | | | | | | | X | | |
| 294 | #41 – Share the Road Sign Initiative | | | | | | | X | | |
| 296 | #42 – Placement of 20-mph School Zone Signs | | | | | | | X | X | |
| 302 | #43 – Shared-Use Arrow | | | | | | | | | |
| 305 | #44 – Enforcement for Bicycle Safety | | | | | | | | X | |
| 308 | #45 – Bicycling Ambassadors and Bike Lane Education | | | | | | | | X | X |
| 310 | #46 – Comprehensive Child Bicycle Safety Program | | | | | | | | X | |
| 316 | #47 – Share the Road: Motorist/Bicyclist Traffic Education and Enforcement Programs | | | | | | | | X | |
| 320 | #48 – Hitching Posts for Bicycle Parking | | | | | | | | | X |
| 323 | #49 – Bicycle Access on Caltrain | | | | | | | | | X |
| 327 | #50 – Bike and Bus Program | | | | | | | | | X |
| 333 | #51 – Mapping for Bicyclists | | | | | | | | | X |
| 336 | #52 – Commuter Coach: Commuter Bicyclist Recruiting | | | | | | | | X | X |
| 339 | #53 – Bike to Work Promotion | | | | X | | | | X | X |
| 344 | #54 – Free Cycles Program | | | | | | | | | |
| 347 | #55 – Bicycle Destination Signing System | | | | | | | X | | X |
| 349 | #56 – Urban Forestry | | | | | | | | | X |
| 351 | #57 – Raising Funds for Bicycle Safety Programs through Specialty License Plates | | | | | | | | | X |
| 355 | #58 – A Transit Oriented Development Financial Incentive Program—A Tool to Encourage More Bicycling and Walking | | | | | | | | | X |

# Minimizing Roadway Surface Hazards for Bikes

## BACKGROUND

The goals of the city of Seattle's Bicycle Program are to get more people bicycling more often and to reduce the number of crashes involving bicyclists. To accomplish this, the city of Seattle has adopted two main objectives: 1) to complete a comprehensive urban trails system (rail-trails and other trail facilities); and 2) to make all streets and bridges bicycle-friendly. The second objective was developed with the knowledge that up to 80 percent of all bicycle trips within the city will always be on streets shared with motor vehicles, regardless of how many trails are completed. There is simply no way to build a trail to every residence and every place of business. Even bicycle trips that involve the use of a trail typically involve on-street elements getting to and from the trail.

Bicyclists riding on city streets often encounter road hazards that can cause them to suddenly weave, possibly causing a conflict with motor vehicles, or even fall. In other cases, it discourages people from even attempting to ride. Typical road hazards include drainage grates that can catch bicycle tires, drainage grates that are either above or below the road surface, gaps between pavement seams, gutter pans that are too wide, poorly placed or slippery utility covers, railroad tracks that cross streets at obtuse angles, textured crosswalks that are slippery or excessively bumpy, pot holes, bad pavement around utility patches, and broken pavement caused by tree roots.

## COUNTERMEASURES

Seattle's solution has been to "institutionalize" good design practices into standard plans and specifications and to establish a "Bike Spot Safety Program."

Peter Lagerwey, Pedestrian & Bicycle Program Coordinator, City of Seattle

Surface irregularities become hazards for bikers long before they become so for automobile drivers.

### INSTITUTIONALIZE GOOD INITIAL DESIGN

The intent of the program, to institutionalize good design practices into standard plans and specifications, is to make sure that as streets are re-built and maintained, the right designs happen automatically (typically referred to as "routine accommodation"). The following are examples of how the city has incorporated and adopted standard practices that benefit bicyclists by removing road hazards:

- drain grates—standard, required specification grate is baffled in a way that prevents bike tires from getting caught in the gaps; drain grates are required to be flush with the street;
- seamless curbs—new, concrete streets have seamless curbs that are integrated into the curb lane (no gutter pan);
- utility covers—where possible, utility covers are located outside the travel area for bicyclists (1.2 m (4 ft) from curb or, if there is parking, to the left of the parked cars); utility covers must be flat, have texture and be void of unnecessary protrusions that could divert a bicycle tire;

- utility cuts—utility cuts must be repaired twice, once with a temporary patch to allow for settling, and later, with a permanent patch.

The effort to do an even better job of "routine accommodation" continues. Over the next three years, the "Cities Street Design Manual" will again be completely revised.

### BIKE SPOT SAFETY PROGRAM

The intent of the Bike Spot Safety Program is to make low-cost repairs and improvements that enhance bicycle safety and access on Seattle's streets. The program relies on citizens to identify problems that need attention. Utilizing citizen input is done with the recognition that the bicycling public is going to have the best knowledge and information as to where problems exist. Additionally, city staff simply does not have the time to spend riding the streets to identify all problems that need attention.

The city has developed a Citizen Bicycling Improvement Request form that is distributed to bike shops, community centers, and published in the local bicycle club newsletter. On one side is space for an individual to fill out the location and nature of the problem and their name, address and phone number. The other side has the address of the bicycle program and a place for a stamp, which allows the request form to be mailed without the use of an envelope. When the form is received by the bicycle program, a staff person makes a quick assessment of the request and calls the person who filled out the form to let them know that: a) the problem will be fixed; b) the problem needs further investigation; or c) the problem is something that the Bike Spot Safety Program cannot address. In all cases, the staff person makes sure to let the resident know about how long it will take to respond to their request. A pothole, for example, may be filled in 24 hours while a bike rack request might take six weeks to install. After the resident has been contacted, the next step is to determine whether a field check is needed. Typically, a field check is not needed on routine maintenance items such as a request to sweep a bike lane. Field checks, however, are required for requests involving other improvements such as the installation of signs and bike racks. Once the field investigation is completed and a determination is made to make an improvement, a work instruction is filled out and electronically sent to the appropriate city crew. The crews then do the work and electronically notify the bicycle program that the improvement has been completed. Bike Spot Safety Program staff then call the resident who originally made the request to complete the loop.

### BROWARD COUNTY, FLORIDA

The importance of institutionalizing good design practices is brought home by the experiences of a few localities in Florida and probably other states. These jurisdictions attempted a retrofit measure to create more space for bikes and eliminate the bike-unfriendly seam between the pavement and the gutter pan by paving over the seam to the curb face. Initially, the treatment seemed successful. As the pavement aged and shifted, the lateral seam returned, however, as well as cracks in the asphalt at expansion joints in the gutter pan. In addition to the seams reappearing, the asphalt gutter gives the impression that this is usable riding space and encourages inexperienced cyclists to ride in the gutter too close to the curb. Because the effectiveness of this fix degrades over time, this treatment should only be considered as a short-term fix (five years or less), and even then as a last resort. (The placement of an edge stripe will help delineate the gutter and may reduce gutter riding.) Other considerations: In areas with heavy rains, paving over the gutter pan may reduce the drainage capacity of the gutter. Also, additional care needs to be taken during resurfacing to prevent asphalt from covering the drainage inlets.

Information provided by Mark Horowitz, Bicycle Coordinator, Broward County Dept. of Planning and Environmental Protection

## EVALUATION AND RESULTS

Eliminating road hazards for bicyclists reduces the number of locations where bicyclists can fall or be diverted into the path of motor vehicles. However, Seattle has not been able to draw a direct cause and effect relationship between the Bike Spot Safety Program and institutionalization program and a reduction in crashes or an increase in bicycle ridership.

## CONCLUSIONS AND RECOMMENDATIONS

The Bike Spot Safety Program is the single most important program administered by the Seattle Bicycle Program to improve safety. Additionally, residents appreciate the quick turnaround on the initial phone call and don't

Gaps are minimized, but metal surfaces of this railroad crossing may be slippery when wet.

Relatively small bumps in a road or path surface may be enough to cause a bicyclist to lose control.

mind waiting a few months for an improvement as long as they know when it is coming. In many cases, they are delighted just to have someone who listens and responds to their concerns. The program has won many friends by making a special effort to give priority to requests from persons with disabilities. The program is also popular with elected officials and other decision-makers since it generates thank-you letters and phone calls. Something is always occuring on the street, which demonstrates that "something" is being done. Finally, it helps the city defend itself against liability claims since it can be demonstrated that there is a safety program which quickly responds to maintenance concerns.

The results of the program to institutionalize good design practices into standard plans and specifications, have been equally successful. In almost all cases, streets are being re-built in a more bicycle-friendly design as a matter of routine accommodation. This is true of both public and private projects. One of the keys to success is to make sure that on private projects the city inspectors know the design requirements and are willing to stay on top of the contractors to make sure they do it right.

## COSTS AND FUNDING

One key to the Bike Spot Safety Program's success has been to work with existing maintenance programs that pay for many of the bike spot projects. For example, Seattle has a "Pothole Ranger" program where a crew does nothing but respond to pothole requests. The bike spot program simply adds a few requests to this existing program. The Bike Spot Safety program spends a minimum of $200,000 per year. Since individual improvements are relatively cheap, the amount dedicated to the program is flexible. More money means more improvements. In lean years when funds are scarce, fewer improvements are completed.

## CONTACT

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PORTLAND, OREGON #2

# A Tale of Portland Bridges

## BACKGROUND

There are 10 bridges spanning Portland's Willamette River, which cuts through the heart of Portland and provides social, economic, and recreational benefits. The Willamette River bridges connect the city's east and west sides—on the west side is Portland's vibrant and economically critical downtown and on the east side are light industries, emerging business districts and pedestrian and bicycle-friendly neighborhoods. The bridges simply are critical for mobility (see map, figure 1). They include five local bridges providing downtown access (Hawthorne, Morrison, Burnside, Steel and Broadway), three other local bridges (Ross Island, Sellwood, and St. Johns), and two limited-access freeways (Fremont and Marquam). Multnomah County is responsible for five of the bridges, the Oregon Department of Transportation (ODOT) for four, and the Union Pacific Railroad for one. The city of Portland is responsible for installing signs, striping, and facilitating access to all bridges.

Eight bridges (all but the limited-access freeways) provide some level of pedestrian and bicycle access (see table 1). In the early 1990s, a year-long partial closure of the Hawthorne Bridge galvanized cycle advocates to press for access during the closure. At the same time, the city embarked upon a major program to engage cyclists and potential cyclists in a dialogue about ways to increase cycling as a means of transportation. Overwhelmingly, improvements to the bridges' approaches and spans were seen as the highest priority because of the poor bicycle and pedestrian conditions.

At the time, the eight non-freeway bridges were a major barrier for pedestrian and bicycle travel. Bicyclists and


Mia Birk[1], Principal, Alta Planning + Design
With assistance from Jeff Smith, City of Portland Transportation Options



Figure 1. Key Portland Bridges.

pedestrians shared narrow sidewalks, and all bridges had access problems, such as the following:

- Cyclists having to cross motor vehicle ramps with no markings or yield control.
- Lack of bikeway facilities on approaching congested streets and structures.
- Conflicts between bicyclists and pedestrians on narrow sidewalks and other points.

On two bridges (Sellwood and Steel), the sidewalks were so narrow that bicyclists were supposed to walk their bikes (which they rarely did) through conflict areas. On several of the bridges, bicyclists could theoretically use auto travel lanes. On one downtown bridge (Burnside) this required sharing the relatively narrow 3 m (10 ft)–wide outside travel lanes on a six-lane span. On three other downtown bridges, sharing the travel lanes was (and still is) a danger-

Broadway Bridge, 1992: Westside, westbound. Bike signal, no bike lanes.

ous undertaking given the narrow lane widths, traffic volume and speeds and sight distance. On three non-downtown bridges, sharing lanes meant bicycling on slippery grating (not a good option in rainy Portland).

These problems translated to low bicycle and pedestrian use of the bridge. Surveys of cyclists found the number-one problem cited was bridge facility quality and access. In response, Multnomah County, ODOT and the city of Portland collaborated on an ISTEA-funded study called the Willamette River Bridges Access Project (WRBAP). Consultants CH2MHill identified over $15 million in potential bicycle, pedestrian, and ADA improvements. The city and county subsequently implemented many of these via grants from ODOT, ISTEA, and through routine city of Portland, Multnomah County, and ODOT bridge and approach maintenance work.

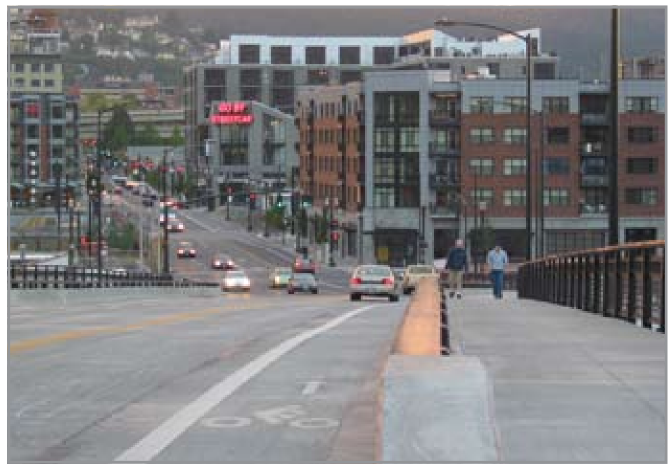
## COUNTERMEASURES

Over $12 million worth of improvements have been implemented, primarily on four of the downtown bridges—Hawthorne, Burnside, Steel, and Broadway. Preliminary design for improvements on the fifth downtown bridge—Morrison—is underway as of fall 2002. Limited improvements were suggested for the Sellwood, St. Johns, and Ross Island bridges; no major improvements have resulted. The measures implemented on the four main bridges are shown in the photos below and described for each bridge in table 1.

The measures include:

- Improvements to off-street facilities (widening sidewalks on Hawthorne, sidewalk in-fill in approach areas, replacement of slippery sidewalk surface on both Hawthorne and Broadway, addition of shared-use path on Steel).

Broadway Bridge, 2002: Westside, westbound. New bike signal splits bike movements.



Bike lanes on approaches and connecting streets.

- Striping bike lanes, signs (on the bridge span on Burnside, and on most approaches and access streets).
- Focusing on safety at conflict areas (closure of on-ramp from Naito to Hawthorne Bridge, reconstruction of conflict areas on approaches to Hawthorne and Broadway, blue bike lane implementation in conflict zones on approaches to Broadway and Hawthorne).
- Redesigning sidewalk ramps to meet ADA (all bridges).

It should be noted that many of the improvements were made in conjunction with other bridge upgrade or reconstruction projects; thus costs for specific bike and pedestrian improvements are not always available. Also note that the City used blue pavement areas in bike and motor vehicle conflict areas on the approaches from the eastside for two bridges (Broadway and Hawthorne). Blue bike lanes as a safety technique are discussed in the City of Portland publication, *Blue Bike Lanes for Cycling Safety* (City of Portland, 1997).

Table 1. Bridge countermeasures, costs, funding sources

| Bridge | Owner[2] | Status Before | Measures Implemented | Cost | Funding Source |
|---|---|---|---|---|---|
| Hawthorne* | Multnomah County | Cyclists and pedestrians sharing 1.8 m (6 ft)–wide sidewalks. No bike lanes and minimal sidewalks on approaches. Bicyclists shared roadway or used sidewalks to access. Problematic interaction between cyclists and motor vehicles in several areas. | Sidewalks widened to 3 m (10 ft) on each side. Bike lanes striped on all approaches. Sidewalk in-fill on approaches. Curb ramps rebuilt to meet ADA. Eastbound approach, Westside: First ramp from Naito Parkway closed, eliminating conflict area. Second ramp reconfigured to force motorists to stop and give cyclists and pedestrians priority, separate bike and pedestrian crossing areas. Blue bike lanes introduced in conflict zones on east side. | Sidewalk widening: $1.2 million<br><br>Other changes: $200,000 | ODOT Bike/Ped Grants, TEA-21 STP funding |
| Burnside* | Multnomah County | Bikes and pedestrians on 3 m (10 ft)–wide sidewalks. Bike access via surface street without bike lanes. | Deck restriped with bike lanes by removing one travel lane in non-peak direction | $20,000 | Local transportation funding |
| Steel* | Upper Deck: Multnomah County. Lower Deck: Union Pacific Railroad | Bikes and pedestrians sharing about 1.5 m (5 ft) sidewalk on south side, upper deck. Some cyclists on roadway. | New 3.7 m (12 ft) bike and pedestrian path added to lower deck, along with new shared-use path (Eastbank Esplanade) and bike lanes on eastside approaches. “Bikes on roadway” signs on upper deck. | $10 million | ISTEA & TEA-21 Enhancements, local tax increment financing |
| Broadway* | Multnomah County | Bikes and pedestrians on 3 m (10 ft)–wide sidewalks with slippery surface. No bike lanes on connecting surface streets. Approaches with numerous ill-defined conflict areas. | Sidewalk surface replaced (sidewalk width same). Bike lanes added to all connecting surface streets and ramps. Conflict areas on approaches modified and defined (by blue bike areas in two cases). | $300,000 | Multnomah County & Portland transportation funding |
| Sellwood | Multnomah County | Bikes and pedestrians on 1.2 m (4 ft)–wide sidewalk on one side. Very constrained. Access from eastside via surface street without bike lanes. Access from Westside via shared use path. | None. Bridge to be rebuilt within 20 years | | |

| Bridge | Owner[2] | Status Before | Measures Implemented | Cost | Funding Source |
|---|---|---|---|---|---|
| St. Johns | ODOT | Bikes and pedestrians on narrow 1.2 m (4 ft)–wide sidewalks.Access horrible via major highway. | None. ODOT studying restriping potential. | | |
| Ross Island | ODOT | Bikes and pedestrians on 1.2 m (4 ft)–wide sidewalk on one side. Very constrained. Access from westside near impossible. Access from eastside via crowded surface streets without bike lanes. | Bridge rebuilt, but bikes & pedestrians still share narrow sidewalk. No improvements made. | | |
| Morrison* | Multnomah County | Bikes and pedestrians on narrow sidewalks. Very constrained. Dangerous conflict areas at highway ramps. | Preliminary design study underway as of fall 2002 | $250,000 | TEA-21 |
| [2] On all bridges, approaches, signing, and striping controlled by the city of Portland | | | | | |
| * Connects eastside to downtown Portland. | | | | | |

## EVALUATION AND RESULTS

The city of Portland collected bicycle counts on the bridges over time, as shown in figure 2 and table 2. These counts are based on the daily peak two-hour period, and thus primarily reflect commute trips. The counts show an enormous increase over time in bicycle use on the four main bridges, while in comparison, counts for the bridges without bicycle access improvements remain extremely low. Recreational trips have increased enormously as well. Joggers and cyclists frequently use the Hawthorne and Steel bridges and their connecting paths as a downtown exercise loop during the day and on weekends.

A clear link can be made between the increased bike use and improved facilities on the four bridges discussed. On the Hawthorne, Burnside, and Broadway bridges alone, bike use went up 78 percent in the 1990s, compared with a 14 percent increase in the population and an 8 percent increase in motor vehicle use on these bridges. The following results should be noted:

- On the Burnside Bridge, bike use tripled from 300 daily cyclists to about 1,000 once the improvements were made.
- On the Hawthorne Bridge, many improvements were made over a multi-year period. The most significant jump in use occurred in 1999 after the sidewalks were widened, from about 2,400 cyclists to over 3,100—a 32 percent increase in one year.
- On the Broadway Bridge, a 54 percent increase in cycling occurred the year after the major improvements were made.
- On the Steel Bridge, bike use went up 220 percent after the Steel Bridge Riverwalk and Eastbank Esplanade opened in May 2001.

Table 2. Bridge Bicycle Traffic

| | before 1990 | 1990–92 | 1993–94 | 1995–96 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|
| Hawthorne Bridge | 830 | 1445 | 1920 | 2040 | 2025 | 2471[3] | 3154[4] | 3125 | 3675 |
| Burnside Bridge | 300[1] | 600[1] | 995[2] | 1065 | 1375 | 905 | 920 | 1075 | 965 |
| Broadway Bridge | 495 | 755 | 715 | 950 | 1205 | 1854[5] | 1476[6] | 1405[7] | 1625[7] |
| Steel Bridge | | 215 | 220 | 350 | 475 | 350 | 360 | 410 | 1312[8] |
| Totals | 1825 | 3015 | 3850 | 4405 | 5080 | 5580 | 5910 | 6015 | 7577 |
| Ross Island Bridge* | | | | 100 | | | 90 | | |
| Morrison Bridge* | | | | | 100 | | 100 | | |
| Sellwood* | | | | | 260 | | 315 | | |

Notes: counts are either from 24-hour hose counts, or from extrapolated 4 to 6 PM manual counts (estimated at 20 percent of total daily bicycle volume based on 24-hour video and manual verification). Where more than one count is available in a given year, counts are averaged. All counts taken in the summer months, on good weather weekdays.

* No significant bike and pedestrian improvements made.

[1] Burnside Bridge counts pre-1993 are estimates based on 7–9am counts.

[2] Burnside Bridge is restriped with bike lanes on-street.

[3] Hawthorne Bridge 1998 count was conducted on the Morrison Bridge Detour, as the Hawthorne was closed.

[4] Hawthorne Bridge reopens with widened sidewalks and access improvements.

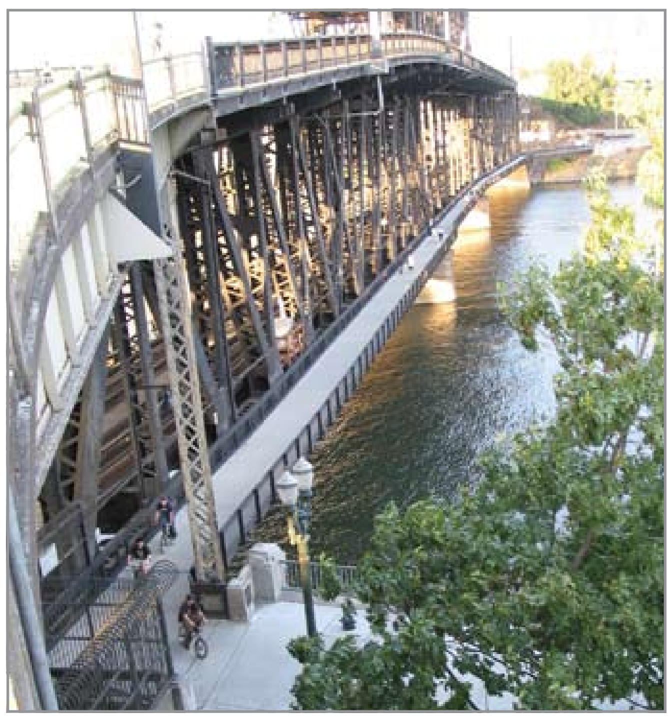
[5] Broadway Bridge sidewalks resurfaced, eastside approaches improved, westbound bike lanes added to Lovejoy Ramp.

[6] Broadway Bridge 1999 count conducted during Lovejoy ramp demolition.

[7] Lovejoy Ramp not yet open.

[8] Steel Bridge Riverwalk opens.

Before: Steel Bridge, upper deck. Bicyclists and pedestrians sharing one 1.5m (5 ft) sidewalk with guardrail.



After: Steel Bridge Riverwalk on lower deck. It's a cantilevered 3m (10 ft) shared use path connecting to paths.

Before: Eastbound Hawthorne Bridge access to sidewalks—bicyclists make sharp turn, yield to motorists.
Note 1.8 m (6 ft)–wide sidewalks.


Hawthorne: Bike lanes added on all approaches. Bike lanes added to all connecting streets: SW Main, SW Madison, SE Hawthorne, SE Madison.


After: Eastbound Hawthorne Bridge access to sidewalks—bicyclists proceed straight, motorists yield,
Note 3.2 m (10.5 ft)–wide sidewalks.

Blue bike lane on eastbound viaduct at off-ramp. Used at areas where motorists cross bicycle lane.

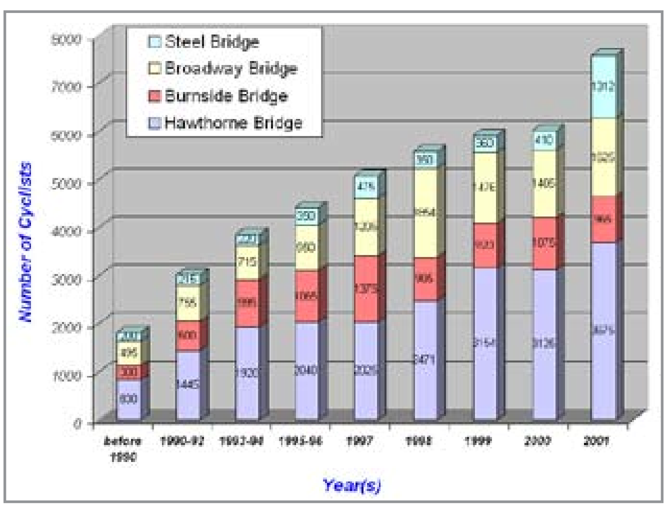



Figure 2. Bridge bicycle traffic on four main Willamette River bridges.

## CONCLUSIONS AND RECOMMENDATIONS

This decade-long effort has been a major factor in Portland's increasing bicycle use because of the crucial links these bridges provide into downtown. It also has been positive for pedestrians and people with disabilities, for several reasons:

- Bike and pedestrian conflicts have either been largely eliminated through the installation of on-street bike lanes, or reduced through the provision of more or alternative space.
- All curb ramps have been upgraded to meet ADA standards.
- Missing sidewalk connections have been installed.
- Pedestrian-motorist conflict areas at approaches were improved.

The most dramatic and expensive improvements have had the most significant impact. Relatively low-cost improvements such as the blue bike markings in conflict zones, bike lanes on certain approaches, and signs were not as significant to increasing bike use as were the major cost items, such as providing a new shared-use path, widening the sidewalk, and replacing sidewalk surfaces and approaches. For example, bike use on the Burnside Bridge tripled when bike lanes were installed in 1993 (at a cost of $20,000), but has remained flat since that time at less than 1,000 daily cyclists. In comparison, bike use on the Hawthorne Bridge tripled to more than 3,000 daily cyclists because of the much-improved sidewalks and access improvements (at a cost of more than $1.3 million). Similar increases were seen on Broadway Bridge (a cost of $300,000) and Steel Bridge (a cost of more than $10 million) following improvements.

A key to the heavy and increasing concentration of bicyclists on the Hawthorne, Steel, and Broadway bridges as opposed to the Burnside and other bridges is that on these three bridges' spans, bicyclists are off-street on either wide sidewalks or shared-use paths, with bike lanes on the approaches. In addition, the city added bicycle lanes to all streets connecting to the Hawthorne, Steel and Broadway bridges, overcoming a major hurdle in getting people to the bridges. In contrast, on the Burnside Bridge, cyclists operate in striped bicycle lanes adjacent to traffic, which is uncomfortable for some cyclists. And, there are no connecting bike lanes on the approaches or connecting streets.

## COSTS AND FUNDING

The total cost of bridge improvements to date is over $12 million, funded through a variety of sources (see table 1 above).

## CONTACT

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[1] Mia Birk was the Bicycle Program Manager for the City of Portland from 1993–1999. Currently she is a Principal with the Portland's office of Alta Planning + Design, a firm specializing in bicycle, pedestrian, and trail planning and design.

# Lighting and Advance Warning of Bicyclists in the Knapps Hill Tunnel

## BACKGROUND

The Knapps Hill tunnel is located on U.S. 97A in the North Central region of Washington State. U.S. 97A is a scenic route that parallels the Columbia River north from Wenatchee through the resort city of Chelan on the south shore of Lake Chelan. This route offers views of wildlife including deer, bighorn sheep, eagles and an occasional moose, making it an attractive ride for the weekend biker and large bicycle groups. The Knapps Hill tunnel was originally constructed in 1936. The tunnel is approximately 214 m (700 ft) long on a 6 percent grade and, unfortunately, only 7.6 m (25 ft) wide. The steep grade and narrow width of the tunnel meant that slower moving bicycles would be in the driving lanes during their ride through the tunnel.

## COUNTERMEASURES

The tunnel had no illumination until 1957 when a contract was let to place fluorescent lights through the length of the tunnel. The original bicycle/pedestrian warning system

Greg Morehouse, WSDOT North Central Region



may have been installed at the same time, but is thought to have been in place at least by 1967. The system consists of a push button at each portal that activates flashing beacons on a "PED OR BIKES IN TUNNEL" sign located in advance of each end of the tunnel. The flashing beacon operates for a period sufficient for the bicyclist to travel through the tunnel. The shoulder was widened to allow bicyclists to pull off the road safely to activate the push-button. The system has been modified since the original was installed but remains basically unchanged. In 1988, the illumination system was upgraded with 400-watt, high-pressure sodium luminaries. The upgrade also allows the internal tunnel lighting to adjust based on the ambient lighting conditions outside. This minimizes the blinding effects of driving into vastly different lighting conditions.

## EVALUATION AND RESULTS

No specific studies have been performed to evaluate these improvements, but adding flashing beacons for advanced warning and illumination systems are common components in our established safety standards.

## CONCLUSIONS AND RECOMMENDATIONS

This system is performing well for the current levels of bicycle and vehicular traffic, and there is no plan for an upgrade at this time. The tunnel structure itself is currently being retrofitted with a concrete liner that maintains the current width and stabilizes the rock behind the existing wooden structure. Any future upgrades for bicycle safety would more than likely involve moving the bicycle traffic to an alternate route.

## COSTS AND FUNDING

Information obtained from: http://inform.enterprise.prog.org/p22.html

The flashing warning system cost $5,000 to build and install in 1979. These costs were relatively low as a power supply was already in place to provide lighting on the tunnel. Had this not been the case, installation costs would have been significantly higher.

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**VANCOUVER, WASHINGTON** **#4**

# Back-in Diagonal Parking with Bike Lanes

## BACKGROUND

McLoughlin Boulevard, a minor arterial laid out at the turn of the century, was no longer serving the surrounding land uses and users well. Along segments, this arterial was wider than its traffic volume necessitated, especially in the area of Clark College. The segments under study had one to two wide lanes in either direction and often no parking or parking limited to parallel stalls (see figure 1). Complaints typically focused on problems with driver speeding, lack of bicycle facilities, strong parking demand in areas with limited supply, and long pedestrian crossing distances to reach transit stops. Complaints about conventional diagonal parking focused on the restricted line of sight parkers had when leaving a stall and the insecurity of bicyclists in cycling along zones with conventional diagonal parking.

Figure 1. Four lane configuration before back-in parking.

Diagonal parking in the City up to the point of this demonstration project was laid out conventionally by staff to allow drivers to enter 45-degree stalls head-in along some of the wider arterials. Research by the City in the 1970s documented the risk of vehicle-to-vehicle collisions when using head-in diagonal parking on an arterial street. To mitigate this concern, City engineers separated diagonal parking lanes from travel lanes with a full 3.7 m (12 ft) buffer lane for vehicle queuing (figure 2). The McLoughlin Boulevard corridor also lacked bike lanes, with the result that some bicyclists chose to ride on the sidewalk along this street (figure 3). Over time, this layout became less opportune as head-in diagonal parking facilities were difficult to combine with bicycle lanes. This demonstration project moved forward because of the desire of our Parks and Recreational Department for both additional on-street parking and enhanced bicyclist access to their facilities along a segment of McLoughlin Boulevard that lacked parking.

Todd Boulanger, Senior Transportation Planner, MURP, Vancouver, WA
Contributions by Ali Goudarz Eghtedari PE; John Manix PE, PTOE

Figure 2. Traditional diagonal parking with buffer lane, no bike lanes and incomplete sidewalks (1 block east of back-in zone).

Figure 3. Bicyclist access before bike lanes.



PHOTO 3: Bicyclist Access before Bike Lanes

In the treatment section, McLoughlin Boulevard:

- is a minor arterial,
- had two striped lanes in each direction and no parking,
- was identified as a facility with future bike lanes in the city's bike plan,
- had an ADT of 6,800 in 2000.

In a zone to the east of the demonstration area, McLoughlin Boulevard has head-in diagonal parking with a 3.7 m (12 ft) buffer lane (shown in figure 2).

This demonstration project had three objectives, to assess whether:

1. back-in diagonal parking would function as well as head-in diagonal parking in regard to safety and community acceptance,

2. back-in diagonal parking would allow bike lanes to replace vehicle buffer lanes for motorist maneuvering space, thereby improving bicyclist access, and

3. the narrower street cross-section devoted to motor vehicle travel would lower the 85th percentile speeds.

The existence of back-in diagonal parking in other cities was not widely known in Vancouver at the time of the original proposal in 2000. Staff became aware of this option in 1997 when bicycling in Seattle's Queen Anne district and from other cities (see figures 4–7). Interactions between parkers with motor vehicles, bicyclists and pedestrians were photographed and videotaped in other locations, although the combination with a bike lane was not observed during several annual observational visits. Other sections of Seattle used back-in parking along streets with very steep grades. Initial proposals were developed using photo simulations in Adobe Photoshop® overlaying photos of Seattle parked cars with Vancouver project sites.

Staff primarily relied on Seattle staff's written positive collision experience with this layout of parking,[1] as repeated literature review and research did not find many other examples to evaluate until the project was well underway. Soon after 2002, articles began to appear in the ITE Journal concerning renewed interest in back-in parking (Edwards, 2002) and concern about its rediscovery (Box, 2002). Over the last four years, staff has exchanged information with over 10 jurisdictions with back-in parking and those contemplating it. Through site visits and e-mail discussions, 23 communities in the US have been identified as having some form of back-in diagonal parking, and at least four of

Figure 4. Seattle—Merchants prefer the view.

KINGSBURY 03

Figure 5. Washington, DC—Back-in parking used on streets with bike lanes.

Figure 6. Seattle—back-in parking with neighborhood commercial land use.

Figure 7. Tucson standard for mixed-use downtown—bicycle and back-in angle parking.

those have combined back-in parking with bike lanes as of 2004 (see Appendix).

Initial treatment sites along McLoughlin Boulevard were selected during a Neighborhood Traffic Management planning process in 1999–2000. The initial parking concept proposal languished until a facility plan for a public swimming pool proposed tearing down a heritage house for parking lot expansion in Hough. Community support for back-in diagonal parking grew, as it would allow neighborhood associations to improve the surrounding parking supply while providing bicycle access to surrounding public facilities and protecting existing housing stock. The site of this demonstration was relocated one half-mile east of the original site, after a request by the Parks & Recreation Department for more parking in front of another pool guaranteed funding for the striping demonstration project. Additionally, engineering staff considered this site to be less politically risky for a long evaluation period as it had a greater supply of off-street parking, thus allowing drivers uncomfortable with back-in parking other parking options.

## COUNTERMEASURES

The demonstration project relied primarily on new bike lane striping, stenciling and signs to create back-in, diagonal parking stalls along a zone that did not have pre-existing parking. The pre-project lane configuration generally was four lanes with a striped center line for an 18.6 m (61 ft)–wide street (shown in figure 1) classified as a 'minor arterial' with 7,000 vehicles per day. The post-project lane configuration has added separate lanes for parking and bike lanes while removing one lane in each travel direction (see figure 8 and table 1).

Figure 8. After conversion—two lane configuration with back-in parking on one side.

The proposed addition of street textures for traffic calming and bulb-outs for reduction in pedestrian crossing distances could not advance until engineering evaluation of the parking demonstration was completed and additional construction funding was found. The project was initiated in the summer of 2002.

Time and understanding of the opportunities of this type of parking was important for many of the stakeholders in order for trust to develop. Initial interactions among stakeholders could be best summed up by one council member's comment on the idea; "cockamamie." Others suggested that it belonged downtown where more parking supply was needed and the speeds were slower. Support for the demonstration project was developed through repeated dialog with surrounding neighborhood associations and large institutional property owners, and then waiting for them to request project initiation at a later date. The bicycle community had guarded support for the project, as it provided 0.8 km (0.5 mi) of additional bike lanes in an area with many residences and civic facilities (two swimming pools, a college, a high school, and a recreational center). Outreach to other stakeholders (elderly recreation facility clients, students, bicyclists, transit riders, pedestrians, and parkers) was accomplished by posting information on the City Web site, holding neighborhood newsletter discussions and a televised council session, and the posting of flyers on windshields, bus stops, and sidewalk A-boards along the project area. Final institutional support for the project was found after the transportation manager visited Seattle and observed back-in parking in use. The project then advanced to City Council for final, though guarded, approval.

## EVALUATION AND RESULTS

This demonstration project has been evaluated using video analysis of vehicular interaction with parking (30 hours over six weekdays while college was in session), observational studies, feedback from users, review of collision rates and speed surveys, and review of citizen complaint files.

Table 1. Lane Configurations Pre- and Post-Project

| Lane Type | Bike Lane | Parking Lane | Travel Lane | Travel Lane | Parking Lane | Bike Lane |
|---|---|---|---|---|---|---|
| Before | None | None | 4.6 m (15 ft)* | 4.6 m (15 ft)* | None | None |
| After | 1.8 m (6 ft) | 4.9 m (16 ft) | 3.7 m (12 ft) | 3.7 m (12 ft) | 2.4 m (8 ft) | 1.8 m (6 ft) |
| Notes: Prior to 2002 there were two lanes in each direction. | | | | | | |

## DIAGONAL BACK-IN PARKING (FIGURE 9)

- Some drivers had difficulty backing into spaces when few cars were parked versus when stalls surrounded by other parked cars, as there was less spatial reference as to where the stalls were located while executing the turn unto a stall.

Figure 9. Driver backing into stall.

- A few drivers preferred to pull into a back-in space by looping in through empty adjacent stalls versus stopping in the bike lane and backing up into a stall—this behavior was not forecast before design.

- The 1.8 m (6 ft) bicycle lane was adequate to provide drivers space for reversing into the parking stall with traffic.

- Drivers that violated (drove through them without parking) the bike lanes and parking zones were typically leaving or entering the driveways nearest the parking zone versus drivers that were just driving through the zone.

- No drivers were observed violating the parking zone when cars were parked in it or when bicyclists were using the bicycle lane.

- Loading and unloading from parked vehicles is easier from the curb area (figure 10).

Figure 10. Easier unloading at the curb with back-in parking.

## VEHICLE TO PARKER CONFLICT (FIGURES 11 AND 12)

- No bike to parking or exiting parking vehicle conflict was observed on the video footage, but there were too few joint actions to judge this interaction between these street users.

- No vehicle to parking or exiting parking vehicle conflict was observed on the video footage.

Figure 11. Bicyclist's view along back-in parking zone.

Figure 12. Exiting driver's view of approaching traffic along back-in parking zone.

## BICYCLE TRAFFIC FLOWS

- Bicycle traffic increased from 1 to 6 percent of all eastbound vehicular traffic along the project area (tube counts pre- and post-project—10h00 to 11h00) during an average hour of use.

- Total bicycle traffic increased 235 percent from 17 bicycles (hose count—April 24, 2002) to as many as 44 bicyclists (video analysis—Oct. 16, 2002, 10h00 to 14h00, clear warm weather) after the bike lanes were added.

- Bikeway facilities provided more direct benefit than on-street parking facilities at this location (44 bicyclists versus eight drivers who parked during period with highest parking utilization—Oct. 15, 2002 video analysis).

- No recognized avoidance of back-in parking zone versus conventional parallel parking zone by either advanced (A type) or experienced (B type) bicyclists riding next to parked cars—and both zones had similar traffic flows (19 versus 25 riders on Oct. 15, and 19 versus 21 riders on Oct. 16).

### LANE CONFIGURATION EFFECT ON SPEEDS

The secondary objective of adding bike lanes and parking lanes was to reduce the traffic speeds along this corridor. The travel speeds along this section of McLoughlin Boulevard are historically higher than posted, causing concern among neighborhood leaders and other street users such as pedestrians and bicyclists, as identified during the Neighborhood Traffic Management planning process.

- The post-project travel speeds were not calmed. They increased slightly (see table 2). There is a visual break between the section west of the project area, which is a much more pedestrian-scaled, shared-use neighborhood. The project area, by contrast, is bordered by open-space land uses (sports fields) with few driveways and long blocks. In the next phase, enhanced pedestrian crossings with calming measures will be implemented.

Table 2. Eighty-Fifth Percentile Speed Pre- and Post-Project

| | East-Bound Traffic | West-Bound Traffic |
|---|---|---|
| Before | 35.1 mph | 36.7 mph |
| After | 38.5 mph | 38.3 mph |
| Notes: This street is posted as a 25 mph zone. | | |

### COLLISION HISTORY

- There were few collisions in both the pre- and post-time periods, so the project's influence on the collision rate along the parking zone is inconclusive. During 2000–2002 there were two collisions versus three collisions in the 2002–2004.

- All except one of the collisions in both periods involved two vehicles, where one vehicle turning left into a driveway failed to yield to oncoming traffic.

- Both periods had one injury reported closest to the parking zone. The entire bike lane zone (which extends beyond the parking project area) had a total of six injuries before the addition of the bike lanes and one injury after.

- None of the reported collisions or injuries involved a bicyclist or driver undertaking a parking or exiting parking maneuver.

Our office is currently working on extending this back-in parking and bike lane zone further to the west and the east for 2440 m (8000 ft) total, as requests for work are generated by property owners and neighborhood associations. Two projects are currently in the design stages. Both should be constructed during the summer of 2005.

## CONCLUSIONS AND RECOMMENDATIONS

Recommendations for future Vancouver projects included the following:

1. Widen the standard parking stalls from 2.7 m to 2.9 m (9 ft to 9.5 ft) or provide other stall position guidance (raised markers, etc.).
2. Adopt a supplemental back-in parking sign adapted from Salt Lake City (figure 13).
3. Adjust striping layout to add turn lane for west bound traffic into western entrance of parking lot (site specific).

Figure 13. Salt Lake City sign adapted for use in Vancouver.

This treatment has been very effective at balancing bicyclist access (increase in trips) while providing for growing parking demand. The adoption of recommendations #1 and #2 has met resistance from our maintenance crews ('another sign to stock' and 'if the drivers need the pavement markers, then there must be a problem with this type of parking…'). The proposed projects will be using the wider stall (2.9 m (9.5 ft)).

The use of photo simulations of the planned parking scenario was very helpful during the staff and public process stages, as few if any stakeholders had experienced this type of parking before or remembered doing so while visiting Seattle in the past (figures 14 and 15). This type of parking demands a lot of public discussion and process, more so than any other striping project we have typically under-

Figure 14. Simulation before back-in parking.

Figure 15. Simulation after back-in parking.

taken, especially since we were adding parking and not removing it. It would be ideal if a stakeholder group (business, engineers, residents, etc.) were able to visit a city with this type of parking before adopting it on a district-wide basis.

Vancouver plans to adopt the back-in form of diagonal parking along wider arterials where bike lanes are desirable and the surrounding land uses support pedestrian trips and shared uses. The use of conventional diagonal parking with bike lanes is not acceptable. Where bike lanes are required and back-in parking is not adopted, (low resident and business support) parallel parking shall be used. Back-in parking with bike lanes might be thought of as a kind of "road diet plus"—having parking and bike lanes but still keeping a narrower cross section to constrain car traffic. Road diets usually involve choosing between parking or bike lanes with the extra space going to center turn lanes.

## COSTS AND FUNDING

An original budget of $5,520 for signs, striping and traffic control was established. This cost was split between the Transportation Services and the Parks and Recreation departments (the parking was located in front of their recreation facilities and at their request). We are applying for the second portion of $100,000 Community Development Block Grant (Federal funds) money to fund pedestrian crossings. These funds join $80,000 funded for the striping and refuge islands.

## REFERENCES

John Edwards, Angle Parking Issues Revisited, 2001 *ITE Journal*, February 2002

Paul Box, Changing On-Street Parallel Parking to Angle Parking, *ITE Journal*, March 2002

## CONTACTS

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[1] "It is my understanding, the last research on accident history in the 1970s indicated a 3-1 ratio of more reported accidents occurring in relation to head-in parking spaces as distinct from back-in," wrote Billy Jack, City of Seattle to Todd Boulanger in 2001.

## CITIES WITH BACK-IN DIAGONAL PARKING

- Seattle, WA★
- Olympia, WA
- Tacoma, WA
- Vancouver, WA ★
- Everett, WA
- Portland, OR
- Salem, OR
- Ventura, CA
- San Francisco, CA
- Tucson, AZ
- Salt Lake City, UT
- Honolulu, HI
- Charlotte, NC
- Indianapolis, IN
- Montreal, QC
- Pottstown, PA★
- Plattsburgh, NY
- Knoxville, TN
- Birmingham, MI
- Marquette, MI
- Washington, DC★
- Arlington, VA
- Wilmington, DE

# Valencia Street Road Diet—Creating Space for Cyclists

## BACKGROUND

Bicycle lanes and wide curb lanes are common on-street facilities for accommodating and attracting bicyclists. As it is a goal of the city and county of San Francisco to encourage cycling as a viable transportation option, efforts are constantly made to find and create opportunities for the installation of bicycle facilities. However, with a population of about 780,000 people in a 47-square-mile space, San Francisco is a very dense and congested city where a variety of mode users compete for limited street space. While this reality is one reason that bicycling is a popular way to travel through the city, it also complicates the installation of bicycle facilities.

In order to implement the city's bicycle route network, motor vehicle lanes must often be removed to create space for bicycle facilities (often referred to as a "road diet"). San Francisco is a walkable city where mass transit is heavily used and elevated freeways are being torn down rather than constructed. The effects of such road diets on all road users must, however, be considered and sufficiently studied before final approval and implementation.

Although road diets have been implemented to create room for bicycle facilities on at least 16 streets throughout the city, this case study will focus primarily on the experience with Valencia Street, with passing reference to another road diet on Polk Street. Additionally, experiences with proposing and studying road diet projects in general will be shared as appropriate.

Michael Sallaberry, Assistant Transportation Engineer, San Francisco Department of Parking and Traffic

### VALENCIA STREET

Valencia Street is a 19.1 m (62 ft 6 in)–wide street through a shared-use area of mostly two- to three-story buildings with commercial at street level and residential units above, and metered on-street parking on both sides. The street lies in a grid pattern and is paralleled by four other north-south arterials. Before the project, the arterial was a four-lane street with an Average Daily Traffic (ADT) of approximately 22,000 vehicles per day. A motor coach transit line with a headway of 15 to 20 minutes travels along the street. There is a heavy pedestrian presence because the street is a popular area with restaurants, nightclubs, and a variety of shops. All intersections have signals. A photo of Valencia Street with four lanes before the road diet is shown below.

Figure 1. Valencia Street before road diet.

## COUNTERMEASURES

Though the bicycle community wanted a road diet performed along Valencia Street, the local department of transportation was not willing to reduce capacity along this important north-south corridor. Valencia Street can be used as a surface street alternative to the Central Freeway, which was damaged by the 1989 Loma Prieta earthquake. Eventually, after a series of community meetings and public hearings, the city Board of Supervisors voted on a resolution in November 1998 calling for the removal of two travel lanes and the installation of bicycle lanes and a median lane for left turns on a one-year trial basis. In March of 1999, work was completed on Valencia Street with the road diet performed from Market Street at its north to Tiffany Avenue to the south, a length of approximately 1.8 miles.

Please see figure 2 below for a picture of Valencia Street after the road diet.

Figure 2. Valencia Street after road diet.

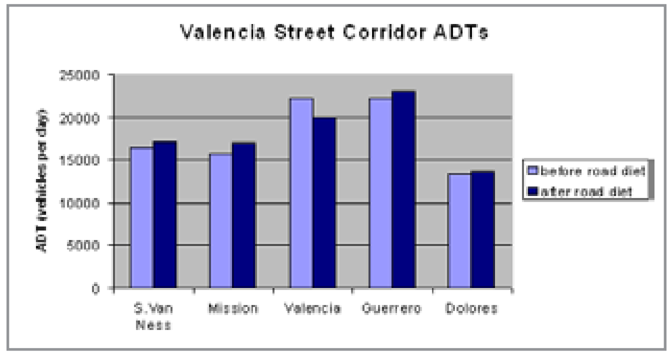
To minimize the loss of capacity along Valencia Street and reduce the impacts to parallel streets, changes were made to the signal timing along Valencia Street and Guerrero Street one block to the west. On Valencia Street, the green time was maximized for the Valencia Street split while still maintaining time for pedestrians crossing Valencia Street. On Guerrero Street, the signal offsets were modified to promote a smoother progression at 25 mph, as the speed limit was lowered from 30 mph to address citizen concerns along the primarily residential street. The speed limit change and signal timing modifications were intended to address speeding concerns and help mitigate the likely increase of traffic along Guerrero Street.

## EVALUATION AND RESULTS

Before the work was started, baseline data were collected for use in a before-after report evaluating the road diet. As the project was done temporarily for a one-year trial period, the results of the report would be presented at various public hearings with the project to be voted on by the Board of Supervisors. If the project were rejected, the street would be returned to its previous four-lane configuration.

Traffic volumes were recorded along Valencia Street and the four parallel arterials surrounding it to determine if there was spillover traffic from Valencia Street and where it went. The counts were taken using pneumatic devices laid across the roadway that automatically counted vehicles. The counters were installed at the same location on all five streets.

After determining the green times for Valencia Street, it was predicted that 10 percent of Valencia Street traffic would divert to parallel streets after the road diet was performed. Following is a table showing before and after ADTs for the five roadways along the corridor. As expected, Valencia Street traffic volumes dropped by 10 percent.




Collision data were also collected to determine if safety was improved with the new design. As the trial was for one year, it was difficult to come to any statistically significant conclusion for the before-after report. However, as it has now been a few years since the installation of the bike lanes, the collision data analyzed include a larger sample size.

The table below summarizes the collision data results. The values in the table are average monthly collision totals for each respective collision type, and not rates.

Table 1. Collision Data for Valencia Street, Before vs After Road Diet*

| | Before 1/95-12/98 | After 3/99-12/01 | Percent Change |
|---|---|---|---|
| Total Collisions | 5.9 | 4.7 | -20 |
| Midblock Collisions | 1.1 | 1.4 | 27 |
| Intersection Collisions | 4.9 | 3.4 | -31 |
| Bicycle Collisions** | 0.67 | 1.0 | 49 |
| Pedestrian Collisions | 0.83 | 0.53 | -36 |
| * Collisions per month | | | |
| ** Bicycle collisions not included during 1996 and 1997 due to lack of reporting so the before period reflects only 1995 and 1998 data. | | | |

Total collisions declined by 20 percent, though the overall drop was less dramatic when one considers that the ADT along Valencia Street dropped by approximately 10 percent. Also, a signal upgrade project was completed along Valencia Street in 1997 that increased signal visibility and helped reduce the overall collision rate. Thus, it is difficult to come to any definite conclusions regarding the effect of this road diet on overall collision patterns along Valencia Street.

Although bicycle collisions increased by approximately 50 percent, the increase was outpaced by the 140 percent rise in ridership along the street. This net decrease in collision rate for cyclists mirrors the increased comfort cyclists report feeling along the street.

Collisions involving pedestrians dropped by 36 percent. This could be viewed as a byproduct of the traffic calming effect people along the street have anecdotally observed. With lower speeds and fewer lanes, motorists are able to avoid collisions with pedestrians more easily. According to anecdotal accounts, pedestrian volumes on Valencia Street have increased the past few years as the street has thrived commercially and attracted even more foot traffic.

Bicycle counts were taken along Valencia Street before and after. Ideally, counts also would have been taken on parallel streets to determine how much of the rise in cyclists along Valencia Street was attributed to new cyclists or to cyclists transferring from parallel routes. Also, a number of counts should have been taken to come up with an average that better accounts for fluctuations in cycling volumes that occur with time of year, weather conditions, etc.

A bicycle count taken on Valencia Street prior to the road diet showed 88 bicyclists per afternoon peak hour. After the road diet, a count yielded 215 bicyclists per hour, a 140 percent increase. As no counts were taken on parallel streets before the road diet, it is difficult to know what percentage of these cyclists were new cyclists or cyclists from parallel streets. Speaking with cyclists, however, it is clear that many were new cyclists willing to try bicycling once they saw the bike lanes installed.

Public response was recorded using a hotline voicemail system that was advertised on two signs installed prominently along the roadway. The number of e-mails and letters submitted were also considered. Care must be taken to ensure that the source of public input is considered. For instance, do 200 form letters sent as part of a mail in campaign outweigh 20 individually written letters? Regardless, the ability to directly hear from the public was instrumental in understanding how various people responded to the changes and what successes or problems were associated with the changes.

Public response to the road diet project was supportive. A hotline was advertised along Valencia Street on two prominent signs directly after the road diet. From the 286 recorded calls, 259 were supportive of the project while 27 were opposed. Of letters and e-mails received, 39 supported the project while three did not. A postcard campaign led by the local bike coalition yielded 484 supportive post cards and four not supportive.

As this was the first road diet studied in San Francisco, there were some data that could have been collected for a more complete study but were not. They include: transit travel time and delay data, travel time and delay data for motorists, double parking observations, and spot speed surveys. Other data that could have been collected for a very thorough before-after study could include: noise levels, cyclist compliance with laws, and surveys of residents, merchants, cyclists, motorists, and pedestrians.

## CONCLUSIONS AND RECOMMENDATIONS

Although the project was initially controversial within the local department of transportation and some members of the community, the general consensus is that the project is a success. Bicycling along the street has increased dramatically and has made the street the second most heavily used bicycle route in the city. Collision rates for cycling have dropped on the street. The merchants association has shown support for the road diet that has made the street seem like more of a destination rather than through arterial. Although some traffic has spilled over to adjacent streets, it is likely that much of that traffic is through traffic with no intention of stopping along the street anyway. Thus, merchants' fears that less traffic meant less business were not substantiated, in general.

With public outreach initiated by the bicycle coalition and mandated by the nature of a one-year trial, giving stakeholders plentiful opportunities to be involved in the process was an important aspect of the project's success. Also, the use of a trial allowed everyone to see how the project operated in real life, especially useful for skeptics. It is important to have a trial of sufficient length to allow any changes in traffic patterns to come to an equilibrium. One year is a good length, with six months as a possibly sufficient length of time. With any trial, the process should be made clear to thecommunity so that there are no misguided expectations.

As this was the first trial road diet in the city, some data was not collected that would have been helpful. The effect on transit was not sufficiently studied. Travel time and delay studies for both transit and motor vehicles would have been helpful. Also, bicycle counts on parallel streets would have provided a better picture of where the increase of cyclists originated. While speed data would be helpful on road diet projects in general, the nature of Valencia Street is such that speeds are so variable given the short blocks, the changing traffic levels, the presence of double parking, etc. that collecting consistent before and after data would have been difficult.

Although the road diet created significantly more work when it was designated a trial, it was worthwhile to study and thoroughly discuss the project. Since the Valencia Street project, the city government and public has been generally more receptive to the idea of road diets. One example of a road diet whose approval was made more likely by Valencia's success was Polk Street, a similarly controversial project.

Polk Street is a 13.6 to 15.1 m (44 ft, 9 in to 49 ft, 9 in)-wide street with metered on-street parking on both sides. Like Valencia Street it travels through a shared-use area and lies in a grid pattern with one and two-way parallel arterials. Before the project, the street was a three-lane street with two lanes serving the heavier southbound direction. Depending on which section of Polk Street, the ADT ranged from 11,000 to 16,000 vehicles per day. A motor coach transit line with a headway of 10 to 20 minutes travels along the street and pedestrian presence is significant. Nearly all intersections have signals. Polk Street was installed as a six-month trial and also underwent a review of a before-after report. As with Valencia Street, the road diet on Polk Street was also eventually approved as a permanent installation.

## REFERENCE

*Valencia Street Bicycle Lanes: A One Year Evaluation,* Michael Sallaberry, San Francisco Department of Parking and Traffic, December 14, 2000

## COSTS AND FUNDING

For paint and sign work, and labor spent writing the report, the road diet cost $130,000.

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# Shoreline Park Expansion Project—Provision of Bicycle and Pedestrian Enhancements

## BACKGROUND

A segment of Shoreline Drive, designed and constructed as a California Department of Transportation (Caltrans) facility, provided excess vehicle capacity that was atypical of a Santa Barbara street. Furthermore, with only a 1.5 m (5 ft) sidewalk, this coastal connection between residential neighborhoods, Leadbetter Beach Park and the Santa Barbara Waterfront, was inadequate for the thousands of pedestrians accessing the Waterfront each week. Pedestrians commonly stepped into the street or onto the coastal bluff top to avoid one another on the sidewalk. Finally, bicyclists riding the existing bike path which terminated to the east of the project were frequently observed riding on the sidewalk or riding the wrong way on the street.

Road diet created off-road space for bicyclists and pedestrians to connect an ocean-front park with a marina and shopping district.

This project's goals reflect those in the Local Coastal Plan, the Shoreline Master Plan and the Circulation Element of the General Plan. These are: reducing the speed on the roadway and improving the transition for pedestrians and bicyclists between Shoreline Park and Leadbetter Beach Park.

This roadway segment, with no intersections or driveways, carried 8,600 average vehicle trips per day (ADT). The already existing two-lane portion of Shoreline Drive contiguous with the project carried slightly less traffic (8,400 ADT) and operated at a Level of Service (LOS) B during peak times with no roadway link delays, with the exception of the occasional left-turning vehicle. The project section of the roadway was expected to operate at the same LOS B or better because there are no opportunities for left turns in the project section of the roadway.

No changes were proposed to entering lane configurations at any intersections connected to the project. Therefore, the LOS at Shoreline Drive's intersections with Loma Alta Drive and La Marina Drive, which operated at LOS A and B respectively during the afternoon peak weekday hours and weekends, were not expected to change.

Drusilla van Hengel, PhD. Mobility Coordinator, City of Santa Barbara

The new section of the roadway was anticipated to operate at slower, safer speeds. At two lanes in each direction, the project section of the roadway was signed for a maximum speed of 35 mph and experienced 85th percentile speeds of 37 mph eastbound and 40 mph westbound. Because the roadway was wide and invited speeding, speed spiking occurred above 50 mph.

The primary objective of the project was to provide increased capacity for pedestrians and bicycles. Therefore, alternatives to the project also had to meet this objective. Because of public demands to retain the roadway's capacity while still improving the pedestrian facility, two alternatives were considered that would have allowed the existing four-lane roadway to remain: widening the existing sidewalk and constructing a Class 1 bike path to the south (toward the ocean); and constructing a new, wide sidewalk and Class 1 bike path on the north side of the existing roadway (toward the coastal bluff).

Four lanes seperated by a median provided excess vehicle capacity. Space was needed for bicyclists and pedestrians.

The alternative to construct the project to the south was determined to be infeasible because of coastal resource and environmental impacts. The existing sidewalk runs along a coastal bluff and cliff with drop-off varying from 4.6 m (15 ft) to 13.7 m (45 ft). Below the cliff lies the beach and the Pacific Ocean. Staff of the Coastal Commission stated that construction of retaining walls on the beach to widen the sidewalk and construct a Class 1 bike path would not receive staff support and most likely would be defeated by the Coastal Commission.

The second alternative was to construct a new sidewalk on the north side of Shoreline Drive. Although the cost would be significantly higher than the proposed project, a 2.4 m (8 ft) sidewalk could be constructed in this location. However, there was inadequate width for a bike path without extensive retaining walls. A coastal bluff about 12.2 m (40 ft) high lines the north side of Shoreline Drive, within the project area. Beyond the bluff are privately-owned residences and three condominium complexes. The city's experience with other sidewalks that are across the street from the beach is that they are less desirable by the public compared to beachside walkways. Therefore, the city did not pursue this alternative.

## COUNTERMEASURES

In spring 2004, the city of Santa Barbara modified and improved this half-mile, four-lane section of Shoreline Drive by providing pedestrian enhancements and bicycle facilities for novice cyclists, as well as landscaping that allows pedestrians to enjoy the ocean while separated from motor vehicles. The excess road capacity on the ocean side of the existing median was converted to meet the demand placed on the segment by pedestrians and bicyclists. Both directions of mixed-flow motor vehicle traffic now travel on the north side of the existing median as a two-lane road with an uphill Class II bike lane. The existing eastbound travel lanes, with a tremendous ocean view, were converted to a 3.4 m (11 ft) bikeway, a 4.6 m (15 ft) parkway, and an expanded pedestrian promenade within the portion of Shoreline Drive that is south of the existing median between Loma Alta and La Marina Drive. A midblock pedestrian crossing is provided and the existing sidewalk was substantially widened to create a promenade. The Class I bikeway is separated from the walkway by turf.

## EVALUATION AND RESULTS

The project was constructed in spring 2004 and had not yet been evaluated at the time this case study was written. Two obvious results of the project are the elimination of wrong-way bicycle riding on the street and increased capacity for pedestrians. A beaten path adjacent to the widened sidewalk on the new turf indicates that many pedestrians are using the grass for walking or jogging as well. Finally, the project eliminated the opportunity to pass slower cars, as motorists driving at excess speeds are forced to slow down when trailing other motorists driving at or below the speed limit.

## CONCLUSIONS AND RECOMMENDATIONS

Although early planning and engineering design efforts were difficult because of the lack of public support for change in the area, especially the lane reduction, overall

Two lanes on one side of original median were converted to a two-way off-road bikeway and a pedestrian facility.

public response to this project has been favorable since its opening. In addition to the increased capacity for bicyclists and pedestrians, the lane reduction had some effect on lowering vehicle speeds, which may allow the city to reduce the speed limit in this area.

## COSTS AND FUNDING

This project was funded through the Coastal Resources Enhancement Fund, the California Resources Agency, Transportation Enhancement Funds and the City of Santa Barbara.

| Source | Funds |
|---|---|
| Coastal Resources Enhancement Fund | $50,281 |
| California Resources Agency | $273,295 |
| Transportation Enhancement | $570,000 |
| City of Santa Barbara | $228,719 |
| Total Cost | $1,122,295 |

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# Bicycle Treatments on a Former Pedestrian Mall

## BACKGROUND

This paper describes a unique street project in downtown Eugene, OR. The city staff and the community have moved up a "learning curve" during the past decade in regard to on-street treatments for bicyclists and motorists sharing the same lanes. This project presented an opportunity to combine very narrow lanes and other design elements in a way that resulted in a truly slow-traffic, pedestrian-oriented street in the heart of downtown.

In 2002 a three-block section of Broadway in downtown Eugene, OR, was reconstructed and reopened to vehicular traffic. This portion of Broadway had been part of the downtown pedestrian mall created in the early 1970s. Two other street segments were previously rebuilt and reopened to traffic—a two-block section of Olive Street in 1992, and two blocks of Willamette Street in 1996.

While there was widespread agreement in the community that the pedestrian mall had failed to achieve the goal of revitalizing downtown Eugene, all three street reopening projects were somewhat controversial, and each project went forward only after winning approval at a city-wide election. Now that all portions of the former mall have been converted to pedestrian-oriented streets with slow-moving auto traffic, the overall results have been received favorably. However, the mix of vehicle and bicycle traffic on each street has been the topic of much discussion and feedback. Experience with the Olive and Willamette Street projects led the project team to modify the street design for Broadway, and the results appear to be more agreeable to most of the bicyclists, pedestrians and motorists using the street.

Dave Reinhard, former Transportation Engineer, City of Eugene, OR
Diane Bishop, Bicycle and Pedestrian Coordinator, City of Eugene, OR

Over the past three decades Eugene has developed an extensive system of bikeways. The network includes off-street paths, on-street striped lanes on busy streets, and designated bike routes on selected neighborhood streets to help provide continuity. Within the downtown area several of the busiest one-way streets have bicycle lanes but there are still some gaps in the network, leading to increased use of sidewalks as well as bicycling on unstriped streets. City ordinances required bicyclists to dismount and walk their bikes on the former pedestrian mall, though enforcement was minimal. For these reasons, when the decision was made to begin converting segments of the mall to reopened streets, city staff recognized the opportunity to enhance the downtown bicycle network by providing for bicycles on these street segments.

### EARLIER STREET DESIGNS

The designs for Olive and Willamette Streets were developed with significant input from the general public as well as major stakeholders such as downtown businesses. Early on, it was decided that on-street parking should be provided and the curb-to-curb street width should be as narrow as possible to maximize pedestrian space on the sidewalks and discourage speeding and excessive through traffic. Each street segment was designed as a two-way, two-lane cross-section. The designs also made use of techniques such as brick crosswalks; and, on Willamette, raised mid-block crosswalks to enhance pedestrian visibility and discourage high speeds. Lane Transit District buses also use Olive and Willamette Streets for several bus routes connecting to the central downtown Eugene station, so the design needed to accommodate buses as well as emergency vehicles.

The general treatment for bicycles on both Olive and Willamette could be described as a sort of hybrid "mixing" of vehicles and bicycles without using striped bicycle lanes. Each of the two-block segments begins or ends at a signalized intersection with a three-lane cross section that includes a left-turn pocket. In the middle of each segment (where these two streets cross Broadway) the street narrows to a minimal 6.7 m (22 ft) width for about 45.7 m (150

Earlier Olive Street design (4.3 m (14 ft) lanes along parking, 3.4 m (11 ft) lanes approaching Broadway) is not favored by bicyclists.

ft). In between, each street widens to provide parking bays on each side, generally 2.1 m (7 ft) in width, and the travel lanes are widened up to 0.9 additional meters (three additional feet) to provide wider lanes for the mix of autos and bicycles. The overall concept is thus a blend in which cars and bikes share the same lanes at each end and the middle, along with wider lanes in between where cars can pass bikes when the volume and speed of the auto traffic makes this feasible, such as off-peak times of the day.

As with many situations where a compromise is used to provide "the best of two worlds," the design used for both Olive and Willamette ends up being the worst of both worlds in the opinion of Eugene's bicycling community. Widening the travel lanes for several hundred feet tends to produce the unintended effect of "anti-traffic-calming," particularly at off-peak periods when the volume of auto traffic does not provide enough congestion to prevent higher speeds. Some cyclists report that it feels as if certain motorists intentionally intimidate the cyclists. The overall result is that many cyclists feel uneasy or unwelcome on these two streets. (One other outcome is the continued heavy use of the adjacent sidewalks by many cyclists, which is unfortunate given the good intentions embodied in the design of each street for mixed traffic.)

For these reasons, the design of Broadway was approached in a different way, as described in the next section of this paper.

## COUNTERMEASURES

The design for the three-block Broadway reopening project came together over a period of several months in the fall and winter of 2001–2002. The process involved an unprecedented degree of interaction and cooperation among city staff and private design consultants, many of whom have their businesses along this stretch of Broadway or within a block or two. This enabled the group to use a process that came to be known as a "rolling charrette" in which 10 to 20 people at a time would walk slowly from one end of the project to the other, discussing issues and design options, and seeking agreement on the key design features for Broadway. After several of these rolling charrettes and many other informal and formal opportunities for input and dialog, the following major features emerged:

### NARROW LANES

Travel lanes as narrow as 3 m (10 ft) would be used throughout the length of the three-block segment of Broadway. Unlike Olive and Willamette Streets, travel lanes would not be widened to provide for side-by-side motorists and cyclists. Instead, the expectation of very slow-moving vehicular traffic would be reinforced by having cars and bikes use the same space.

### RAISED MEDIAN ISLAND

This feature, which was abandoned for the earlier designs of Olive and Willamette Streets, was re-introduced based on its overall success and widespread popularity on several older segments of Broadway and Willamette just one block away from the mall. A raised median island about 1.2 m (4 ft) in width was viewed as having several advantages. It provides more space for landscaping, thereby reducing the glare and related drawbacks to the added "hardscape" of the newly built street. By planting trees and shrubs in the median, the motorist's view down the street is interrupted. The overall effect tends to reinforce the notion of moving slowly down a narrow street, rather than being able to see uninterrupted pavement several

Raised median islands narrow the street and offer a safe pedestrian refuge.

blocks ahead. The median provides a safe landing spot for pedestrians, who are thus encouraged to cross at multiple locations, not just intersections. And the median provides a left edge for each travel lane that helps visually narrow the lane, encouraging slower speeds.

## VARIATIONS IN PAVEMENT HEIGHT AND TEXTURE

The design for Broadway uses different colors and textures of paving materials, as well as raised crossings, much more extensively than Olive or Willamette. Each block of Broadway features a mid-block crossing raised to the full height of the curb (though with a gradual transition for motorists and cyclists, to avoid a speed hump effect). The intersection of Broadway and Willamette is raised 15.2 cm (6 in) and the portion of Broadway just east of Willamette is paved in brick and raised to the height of the adjacent brick plaza, extending the raised intersection into an at-grade street section. In addition to its traffic calming effect, this enhances the use of the street as an extension of the plaza on those occasions when the streets are closed for major events.

Raised crossing, pavement color changes, street furniture at edge of street encourage slower speeds.

At-grade intersection and street section blend in with adjoining outdoor plaza.

The new Broadway — 10 ft lanes, median islands, and parking bays.

## JUDICIOUS USE OF STOP SIGNS

Before the reopening of Broadway, the two locations where Olive and Willamette Streets cross Broadway were not stop-controlled. The fact that Broadway was only a pedestrian "street" meant that warrants for stop control were not met. This led to a number of complaints by pedestrians who felt cars were going too fast, or that too many motorists would not stop for pedestrians at these crossings. During the design process for Broadway, city staff estimated that the traffic volumes after completion of the project would warrant all-way stop control at the two new four-way intersections, along with the intersection of Broadway and Charnelton at the west end of the project. (The intersection of Broadway and Oak Street at the project's east end is controlled by a traffic signal, since volumes are much higher on Oak Street, a minor arterial). The presence of stop signs at regular one-block intervals is one more feature that tends to reinforce slow speeds along Broadway, and to some extent on Olive and Willamette now that traffic on those two streets must stop at Broadway.

## EVALUATION AND RESULTS

The combined visual effect of all these features provides significant reinforcement for the concept of a slow-moving, very pedestrian-oriented street. As a motorist, one tends to travel slowly and somewhat uncertainly down Broadway, perhaps because it looks so different from a typical street. It feels okay to be there only if you are going slowly enough to allow for surprises and to share the space with others who are going even slower than you.

Speed studies conducted mid-block at two locations in this three-block project indicate favorable results. The 85th percentile speed was 17 mph at one location and 18 mph at the other. Highest speeds were 23 mph. This compares favorably to the speed studies of Willamette and Olive streets at the completion of their openings where, even with raised mid-block crossings on Willamette, the 85th percentile speeds were 20 mph on Willamette Street and 22 mph on Olive.

Informal feedback from other city staff, downtown businesses, bicyclists, and the general public seems very supportive of the overall design and the specific techniques used to provide a safer and slower mix of auto and bicycle traffic. Some of this positive feedback may relate more to the favorable impression most of the community has about the look and feel of the new street. However, the general impression and community "buzz" about a project are important aspects of the project's effectiveness and public acceptance of innovative design features.

## CONCLUSIONS AND RECOMMENDATIONS

### PUBLIC INVOLVEMENT

Encouraging participation by private sector consultants, key stakeholders, and interested public as full participants in the design of the project from the beginning can be a powerful tool for gaining acceptance and moving forward with strong support for the project. By the time the city Planning Commission reviewed and approved the design concept, nearly all the issues had been resolved and the various stakeholder groups all strongly supported the project as presented. Many property owners believed the opening of Broadway to automobiles was critical to their success. Their interest helped sustain the forward movement of the project.

### TRAFFIC CALMING

Getting the motorists to slow down so bicyclists can share the space and pedestrians feel safe when crossing the street appears to depend on narrowing the travel lanes as much as possible. The lanes need to be narrow in an actual, physical sense (e.g. 10 or 11 ft wide), and they need to look and feel narrow to motorists. The look and feel can be achieved by a combination of narrow lanes along with conspicuous edges (e.g. use of a median island) and design elements like trees and shrubs at the edges and in the median to eliminate the look of a long straightaway. Other components of the design included parking bays along both sides of the street, minimizing the pavement markings; lane lines and signs along the street, to avoid the look and feel of a major traffic artery; and raising the major intersection of Broadway and Willamette to meet the grade of the adjacent public plaza and create a speed table.

Parking bays, raised intersections, narrow lanes help calm traffic.

### CONTINUING UP THE LEARNING CURVE

While it appears the city has developed a winning design in the case of Broadway, this example also serves to illustrate that there are probably other still-undiscovered "templates" for street designs that can meet these kinds of objectives. The best approach involves being open to experimentation and recombining various design techniques to achieve the best mix of outcomes. Broadway seems to reinforce the notion that the two best ways to provide for bikes on streets are a) striped lanes with adequate, separate spaces for cyclists and motorists, or b) very narrow lanes shared by bikes and autos. However, there are likely to be situations in Eugene and other locations where wider, shared lanes work better, or some other combination of features should be tried, especially in view of the needs of transit and emergency vehicles. Each project provides an example that can be copied or borrowed from to create even better designs for future projects.

## COSTS AND FUNDING

Total cost of the project was $2.1 million, including preliminary and construction engineering. Landscaping, irrigation, and street furniture accounted for about $185,500. Accommodating an existing brick outdoor plaza at the center of the project and incorporating it into the street design increased the project cost considerably. A breakdown of project costs is available upon request.

Generally the city assesses a certain portion of a project's cost to adjacent property owners. Since this area had previously been a street before it became a pedestrian mall, a second assessment was not possible. However, the business owners along the project were anxious for the conversion back to a city street and donated $200,000. The county provided $1.6 million in road funds and the city of Eugene paid the balance from former Commercial Revitalization Loan funds.

Street furniture, bicycle racks, and landscaping were considered part of the cost of the project.

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# Bike Lane Safety Evaluation

## BACKGROUND

Phoenix, AZ, is the sixth largest city in the United States with a population of 1.32 million and an ideal climate for cycling. In the mid-1980s Phoenix had a very small system of bike facilities, consisting of only 75 miles, including off-street paths, signed bike routes, and a few miles of on-street bike lanes.

## COUNTERMEASURES

In 1987, the City Council approved an aggressive bicycle system of 700 miles of bike lanes, bike paths, and signed bike routes to be installed over the years. The plan included providing many new miles of bike facilities as well as upgrades to existing facilities. Funding for new bike facilities increased from $300,000 per year to $500,000 per year in fiscal year 2000–2001. By 2000, Phoenix had developed over 450 miles of bike facilities, including over 222 miles of on-street bike lanes. While many of the on-street bike lanes have been installed on collector streets, bike lanes are also provided on arterial streets. Furthermore, the standard cross-section for new arterial streets built in Phoenix was modified to include on-street bike lanes.

Michael J. Cynecki, P.E., Traffic Engineering Supervisor, City of Phoenix Street Transportation Department

## EVALUATION AND RESULTS

Traffic engineering staff wanted to determine if the new bike facilities were associated with an increase in bike crashes with motor vehicles. In addition to wanting to learn more about the how, where, and why of all bicycle crashes, staff wanted to determine how many collisions occurred in the on-street bike lanes and how these crashes were occurring. There was also a desire to know if younger children were involved in the bike-lane collisions on busy arterial streets.

A comprehensive manual review of all police reports involving bicyclists on Phoenix streets in 2000 was conducted to determine where bike collisions occurred and the age of the bicyclists in the crashes. Additional data was collected to determine the classification of the street where the crash occurred and if a bike facility existed on that street. The police report was further reviewed to determine if the bicyclist was riding on the sidewalk, along the street or in an on-street bike lane, or crossing the street when the collision occurred.

This analysis was, unfortunately, limited to collisions between bicyclists and motor vehicles on the public right-of-way based on the Arizona Department of Transportation (ADOT) Accident Location Identification Surveillance System (ALISS) computerized database. Bike crashes with fixed objects, other bicyclists, or pedestrians are not in the state database, nor are private property crashes. Furthermore, non-injury bike crashes below the reporting threshold ($1,000) are not in the statewide computerized collision database.

About two percent of the 36,400 vehicle collisions reported in Phoenix during 2000 involved a crash between a motor vehicle and a bicycle. While this may not seem like many, this resulted in 682 bike collisions with motor vehicles. Thus, a motor vehicle or bike collision was reported every 12.8 hours on Phoenix streets, roughly two per day. Of the reported collisions, 35 (five percent) involved no injury, 532 (78 percent) involved 'minor' or 'moderate' injuries, 107 involved a serious or incapacitating injury (16 percent), and eight (one percent) resulted in a fatality. The number of total and fatal vehicle or bike crashes in Phoenix remained relatively stable over the five years of the study period, but peaked in 1999, as shown in the table below:

Motor vehicle/bicycle crashes
reported in Phoenix (1996–2000)

| Year | Total Bike Crashes | Fatal Bike Crashes |
|---|---|---|
| 1996 | 683 | 9 |
| 1997 | 743 | 9 |
| 1998 | 760 | 6 |
| 1999 | 811 | 9 |
| 2000 | 682 | 8 |

During these same five years, Phoenix population increased about 15 percent from 1.15 million in 1996 to 1.32 million in 2000. The total number of reported collisions increased about 13 percent from 32,200 in 1996 to 36,400 in the year 2000.

## WHICH BICYCLISTS ARE MOST COMMONLY INVOLVED IN MOTOR VEHICLE COLLISIONS?

The crash data revealed that bicyclists ages 11 to 20 were most frequently involved in motor vehicle collisions (32 percent). This age group had double the number of crashes of the next highest 10-year age group. A vast majority of bicyclists involved in collisions with motor vehicles are males (81.5 percent), and this is relatively consistent among all age categories. This largely reflects that more bicyclists are males.

## WHO IS AT FAULT IN BIKE COLLISIONS WITH MOTOR VEHICLES?

Fault in the collision was determined based on the comments of the investigating police officer (Figure 1). The investigating officer could designate either the motorist or the bicyclist or both were at fault in the crash. The inexperience or errrors made by bicyclists is evident by the police report results, which indicated that bicyclists were partially or entirely at fault in nearly 79 percent of the collisions with motor vehicles, with the motorists involved in an unsafe action in 43.5 percent of the crashes. This disproportionate blame for collisions largely being attributed to bicyclists reflects the young age of bicyclists involved in many crashes. It also indicates a need for more training and education on the rights and duties of bicyclists. In some instances, the police officers may not fully understand the traffic laws as they apply to bicyclists in the right-of-way, which may result in an erroneous designation of fault.

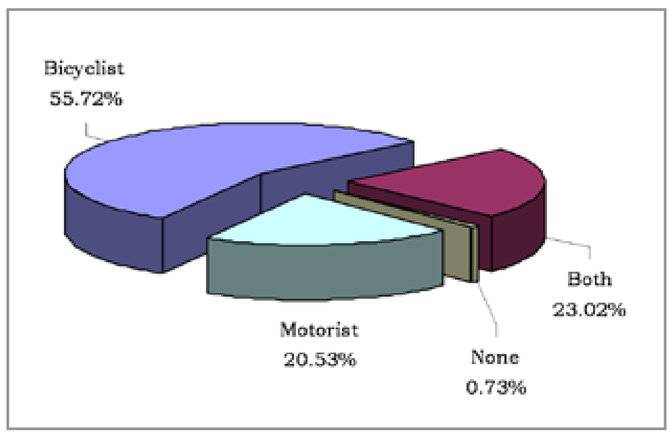


Figure 1. Police designation of fault in bicycle-motor vehicle collisions.

## HOW DID THE BIKE CRASHES OCCUR?

Figure 2 shows the breakdown of bicycle collision types in Phoenix. Angle crashes comprised 38 percent of reported bike collisions, with 27 percent involving right-turn motorists, and 25 percent involving vehicles entering or leaving private driveways.

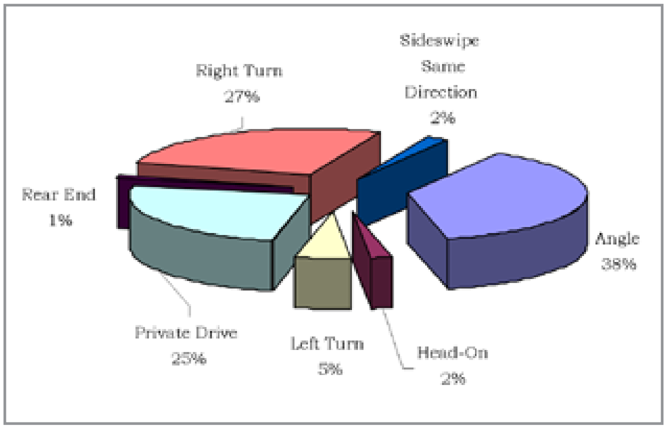


Figure 2. Type distribution of reported bicycle-motor vehicle crashes.

## WHERE DID THE BIKE CRASHES OCCUR?

The classification of street where each bike crash occurred (local, collector, or arterial street) was identified. Figure 3 shows that only 10 percent of reported bike crashes occurred on local streets, which are the overwhelming majority of the streets in Phoenix (74 percent). These are the safest streets for bicyclists because of lower speeds, narrower street crossings, and fewer conflicting motor vehicles. Fifty-five percent of the bike crashes occurred on arterial streets, which comprise only about 15 percent of Phoenix streets. Collector streets comprise about 11 percent of our total streets but were the location of 35 percent of the reported bike crashes.

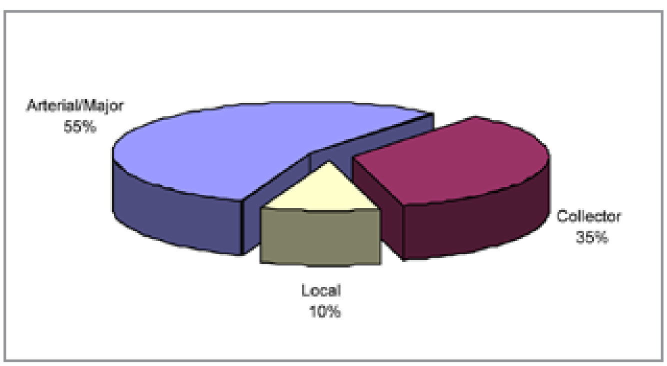


Figure 3. Street classifications of bicyclist collision locations.

The police reports were reviewed to determine if the bike crashes took place on streets with designated bike facilities (on-street bike lanes, striped shoulders, or signed bike routes). Of the 682 crashes with motor vehicles, 95 percent of the crashes occurred on streets with no designated bike facilities. Figure 4 shows where the bicyclist was riding when struck. About 40 percent of the bike/motor vehicle crashes occurred in the crosswalk area, with a similar percentage of bicyclists hit when riding in the street outside of a crosswalk or bike facility (bike lane, striped shoulder or signed route). Almost 18 percent of the bicyclists were struck while on a sidewalk. Many of the bicyclists struck crossing the street rode off a sidewalk into the street and were in the crosswalk when hit. Less than 2 percent of the bicyclists were struck while riding in an on-street bike lane, and a smaller percentage of bicyclists were struck while riding in a striped shoulder (not signed as a bike lane).

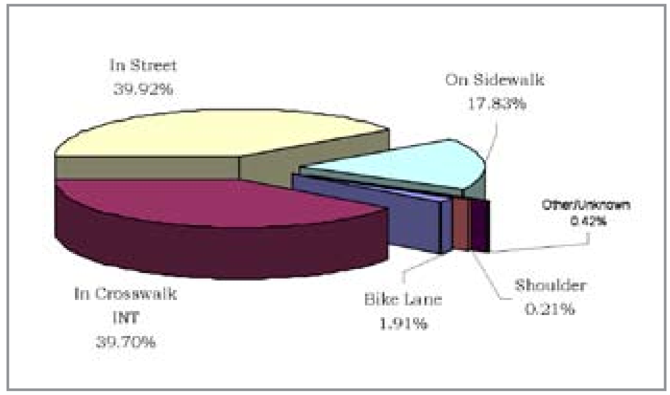


Figure 4. Bicyclists riding location when bicycle-motor vehicle crashes occured.

The actions of bicyclists involved in crashes is illustrated in Figure 5. Slightly more than half of the bicyclists struck were attempting to cross a street. For those bicyclists not crossing the street, the most common action was a bicyclist who was riding in a sidewalk 'against' traffic (22.6 percent). While riding in either direction on a sidewalk is legal in Phoenix, motorists generally do not expect bicycle traffic coming from the 'wrong' direction, especially when turning out of a driveway or side street. Most drivers are looking to their left for approaching traffic and do not expect traffic coming from their right. Generally the speeds of bicyclists on the sidewalk do not provide motorists

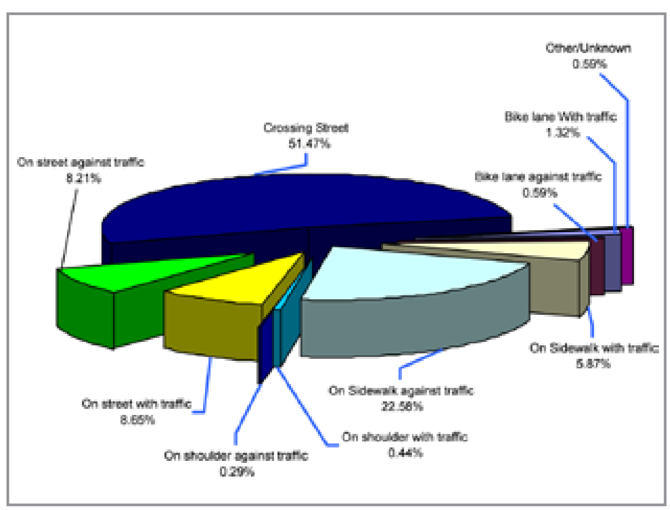


Figure 5. Pre-crash riding direction and position of bicyclists involved in crashes with motor vehicles.

much time to react. Only 5.8 percent of bicyclist-motor vehicle crashes involved cyclists riding on the sidewalk in the same direction as motor vehicle traffic.

State law requires bicyclists, when in the street, to obey the traffic laws established for motor vehicles and ride with traffic (ARS 28-812). About 8.7 percent of bicyclists were struck when riding in the street with traffic, and about the same percentage were riding in the street against traffic (not in bike lanes). Very few bicyclists were struck in on-street bike lanes (about 1.8 percent of total bike crashes), with 1.3 percent riding with traffic and 0.6 percent riding illegally against traffic.

A special analysis was conducted to further identify where the on-street bike lane crashes occurred, how they occurred, and the age of the bicyclists. There were 13 bicyclist crashes in on-street bike lanes during 2000. Of these, five occurred at midblock locations and eight occurred at intersections. The age of bicyclists struck while riding in bike lanes ranged from 16 to 70 years old, with the median age of 38. With the exception of the 16-year-old bicyclist, all other bicyclists struck in bike lanes were adults. Six of the bike-lane crashes occurred on arterial streets while seven occurred on collector streets. Three of the crashes involved 'wrong way' bike riding in the bike lane. All but two of the bike-lane crashes involved collisions with motorists turning into or out of driveways or side streets. The other two bike-lane crashes were rear-end collisions where the motorist struck the bicyclist from behind. Three of the bike-lane crashes occurred during nighttime conditions, and in two of these collisions the investigating officer noted that the bicyclist did not have a front headlight (in violation of State law when riding at night). None of the on-street bike lane crashes involved alcohol, but one did involve a hit-and-run motor vehicle.

## CONCLUSIONS AND RECOMMENDATIONS

The Phoenix bike program has been highly successful in preserving more space in the right-of-way for bicycle travel and identifying desirable bicycle travel routes. While the population of Phoenix is growing, the number of crashes involving bicyclists in 2000 was virtually the same as five years earlier, despite an increase in the interim years. The number of fatal crashes involving bicyclists has remained unchanged.

The most common safety problems for bicyclists involved crossing streets, riding the 'wrong way' on sidewalks, colliding with right-turning motorists, and crashing into motor vehicles entering or leaving driveways. These problems should be addressed through bicyclist training and bicyclist/driver education, as well as police enforcement of unsafe bicyclist and driver actions.

The results of the study indicate that the new bike facilities in Phoenix, particularly on-street bike lanes, are not associated with motor vehicle or bicycle safety problems. Furthermore, there is not a problem with inexperienced children being encouraged to ride in busy streets with on-street bike lanes, resulting in crashes. Observation confirms that the bicyclists who use on-street bike lanes along arterial streets are mostly adults, while children most commonly ride on neighborhood streets. Because so many of the bike crashes occurred on arterial streets outside of bike lanes, the addition of bike lanes along arterial streets may result in safer conditions for bicyclists. This is especially true where the curb lane of the arterial street is only 12 ft wide, which is not conducive for a bicyclist and a motor vehicle to "share" the lane.

Phoenix has actively promoted bicycling as an alternative transportation mode that is healthy, non-polluting, and does not rely on fossil fuel. These activities will continue. There is a need to quantify the amount of bicycle travel throughout the city and monitor usage.

## COSTS

This evaluation of police reports for all bike/motor vehicle crashes in Phoenix was made possible through an internship program within the Street Transportation Department. Tim Cook, who was completing his Bachelor's Degree at Arizona State University, accomplished the analysis. The cost of the study was approximately $7,000.

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# Establishing Bike Lanes — Chicago's Streets for Cycling Plan

## BACKGROUND

In 1992, Mayor Richard M. Daley's Bicycle Advisory Council adopted Chicago's *Bike 2000 Plan*. A key recommendation was to "develop a network of a minimum of 300 miles of bikeways" including on-street bike lanes, signed routes, wide curb lanes, and bike paths. This case study will focus on how 100 miles of bike lanes have been established as of October 2004 in Chicago, presenting seven strategies to help other jurisdictions successfully establish bike lanes.

Bike lane next to parking. Chicago's *Bike Lane Design Guide* provides designs for various cross-sections.

## COUNTERMEASURES

### 1) PLANNING

Chicago's first bike lanes were established in the mid 1990s with minimal public and political consultation and without a comprehensive plan. Some locations were criticized. Chicago's Bicycle Program Coordinator, soon after he was hired, secured $125,000 to hire a professional consultant to prepare a plan identifying the best streets for bicycling in Chicago. This *Streets for Cycling Plan* identified a network of 150 miles of bike lanes and 300 miles of signed routes. Critical success factors include the following:

- Proposed bikeways were "field tested" by bicycle to ensure the best streets were selected.
- All streets proposed for bike lanes were measured to ensure they were wide enough for bike lanes with minimal effect on traffic movements. Bike lanes were primarily accommodated on streets by reducing travel and parking lane widths.
- Only streets with traffic controls at all major intersections were considered, to provide safe crossings for cyclists.

Nick Jackson, Director of Planning, Chicagoland Bicycle Federation
Ben Gomberg, Bicycle Program Coordinator, Chicago Department of Transportation

### 2) PROMOTION

Preparation of the *Streets for Cycling Plan* was very inclusive, involving thousands of cyclists, presentations to thirty-five Chicago Aldermen and twenty-five senior CDOT staff, and even front-page coverage in the *Chicago Tribune*. The process was dynamic and widely known, with a result that the plan was largely supported upon its completion.

### 3) FUNDING

Any plan is only as good as its implementation. Funding is critical.

Fortunately, perhaps in part because of the "buzz" while developing the *Streets for Cycling Plan*, the City of Chicago was able to secure $3.825 million of federal Congestion Mitigation and Air Quality (CMAQ) funds for implementation.

### 4) STAFF

With the federal funding, Chicago was able to hire three full-time consultants to help with establishing the network of bicycle lanes: an urban planner to arrange political and community support, a designer to prepare pavement marking plans, and a "bikeway technician" to perform detailed site visits and coordinate construction. In addition, two student interns were hired to work with the program and assist as needed. The designer and bikeway technician were Chicagoland Bicycle Federation employees who were passionate about improving conditions for cycling. The Chicagoland Bicycle Federation is a nonprofit organization dedicated to improving the bicycling environment of the region.

### 5) MAP

More than one million copies of a map featuring the *Streets for Cycling Plan* were published. The *Chicago Sun-Times*, at no cost to the city, publishes the map every year as an insert in its Sunday edition following Bike to Work Day in June. Copies were also distributed throughout the Chicago Transportation and Planning Departments. Laminated (display) maps were mailed to 100 local engineering and planning firms with a letter from the transportation department's commissioner asking them to consider the recommended routes in their projects.

### 6) RESURFACING PROGRAMS

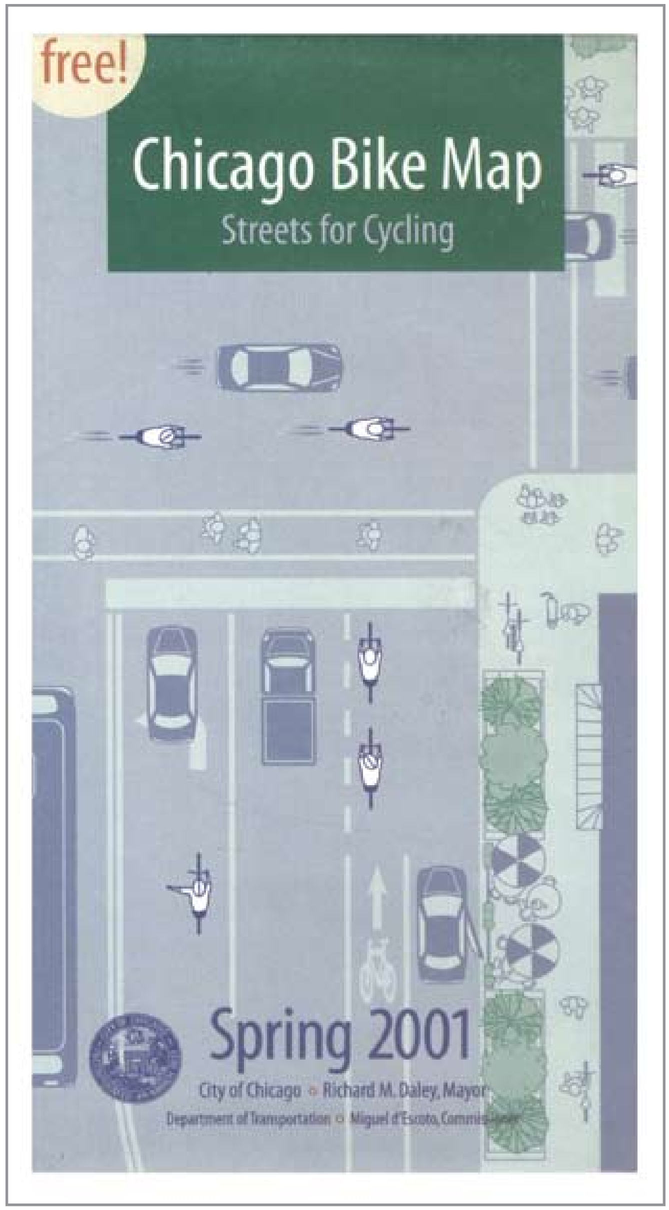
Every year in Chicago more than 50 to 75 miles of roads with poor pavement are resurfaced. Each year, thanks to the bikeway technician's efforts in reviewing the bicycle network included in this program, five to 10 miles of new or upgraded bike lanes are established during resurfacing. Advantages include costs being absorbed by the resurfacing agency and excellent (vs. potholed) pavement for bicycling. Ribbon-cutting ceremonies are often staged, and letters are written to acknowledge the efforts of the resurfacing agency to help ensure their continued support.

Additionally, Chicago streets are frequently repaved after utility or construction work (e.g., sewer main repair, fiber optic cable installation). Bikeway technicians arrange for new lanes to be striped or existing lanes upgraded as a condition of approval for this work.

### 7) ENGINEERING OUTREACH

A plan will only be implemented if engineers and planners embrace it. Education and outreach are especially important since most agencies and their staff have little experience planning and designing for bike lanes. Two Chicago strategies:

- Staging three *Bicycle Facility Tours* a year for engineers and planners to see that bike lanes work. Are they worth staging? Consider what one participant stated: "I'm going to include bike lanes in my project now that I see that they work. Thanks for getting me on a bike for the first time in years."
- Developing comprehensive design guidelines with typical cross-sections, intersection configurations, and specifications for line types and bicycle symbols. Guidelines are compiled in the *Bike Lane Design Guide* and distributed for engineers' reference. Plans are underway to follow-up these guidelines with a 2-hour interactive training session.




More than 1 million copies of the *Chicago Bike Map* have been published.

## EVALUATION AND RESULTS

Results of our efforts are evaluated by the miles of bike lanes established, the partnerships developed, the changes in awareness among engineering and planning staff in advocating for bike lanes, and the changes in bicycling on Chicago's streets with bike lanes.

The following table illustrates the results of partnerships with other agencies to install bike lanes from 2000-2004:

| Implementing Agency | Division | Program | Miles of Bike Lanes |
|---|---|---|---|
| Chicago Department of Transportation | Bureau of Traffic | CMAQ | 40 |
| | Bureau of Highways | ASRP | 17 |
| | Bureau of Highways | Reconstruction | 2 |
| | Bureau of Signs and Markings | Request | 5 |
| | Bureau of Bridges and Transit | Streetscape | 2 |
| | Bureau of Underground | Utility | 1 |
| City of Evanston | Collaborative project with Evanston Department of Public Works and Chicago Department of Transportation | Resurfacing | 1 |
| Illinois Department of Transportation | Local Roads | Resurfacing | 5 |
| | | Subtotal | 72 |
| | | Pre-2000 | 31 |
| | | Total | 103 |

Over 100 miles of bike lanes have been established in Chicago to date with 32 of those miles established through partnering and at minimal cost. Eight *different* agencies have established bike lanes as part of their resurfacing or road reconstruction projects. The federal CMAQ program has been so successful that another $1,500,000 was recently awarded to guarantee completion of the project and establish colored bike lanes, signed bike routes, and upgrade existing bike lanes to higher standards. Engineers now typically ask bicycle program staff about installing bike lanes as part of their projects, even if the streets were not included in the *Streets for Cycling Plan*. The bike lane tours have turned engineers and planners previously hesitant about bike lanes into advocates for bike lanes on future projects. And, most importantly, bike use on Chicago's streets continues to grow.

## CONCLUSIONS AND RECOMMENDATIONS

The *Streets for Cycling Plan* was a valuable tool in creating partnerships to diversify the funding of construction of a bike lane network. Through the *Streets for Cycling Plan*, bicycle facilities are now incorporated in the multi-year planning for infrastructure improvements.

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http://www.ChicagoBikes.org

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CAMBRIDGE, MASSACHUSETTS #10

# How Hampshire Street Pavement Markings Influence Bicycle and Motor Vehicle Positioning

## BACKGROUND

Bicycle lanes have been established on city streets throughout the United States as a way of improving conditions for cycling and ensuring that motorists understand that bicyclists belong on the street. Multiple surveys have shown that bicyclists strongly prefer marked bicycle lanes when traveling on urban streets (figure 1). Some people have raised a concern about whether bicycle lanes are more likely to put cyclists at risk of coming in conflict with motorists opening car doors into the path of the cyclist. Although motorists parking a car are responsible for not opening a car door unless it is safe to do so, the reality is that many motorists have not been well educated about this. Attention has thus focused on whether pavement markings have an impact on bicyclist safety by influencing whether bicyclists ride closer to parked cars.

The purpose of this study was to determine how pavement markings influence where bicyclists and motorists position themselves on the road, particularly with regard to how far bicyclists travel from parked cars. The research examined the effects of sequentially adding the component markings that constitute a bike lane on Hampshire Street in Cambridge, MA. Hampshire Street has on-street parking and a substantial number of cyclists who travel on it. The street had just been repaved, offering the ideal opportunity for testing a variety of pavement markings. The study looked at what impacts the various markings had on parked motor vehicles, traveling motor vehicles and traveling bicyclists.

Figure 1.

Cara Seiderman, Transportation Program Manager, City of Cambridge
Ron Van Houten, Professor, Mount Saint Vincent University, Halifax, Nova Scotia, CA

### PREVIOUS RELATED RESEARCH

Research on bicycle facilities has often focused on examining bicycle lanes installed on roads without on-street parking (Harkey & Stewart, 1997; Harkey, Stewart, & Stutts, 1999). Several studies have shown that drivers make fewer wide swerves or close passes when passing bicyclists on streets with bicycle lanes (Kroll & Ramey, 1977; McHenry & Wallace, 1985) and have found that bike lanes reduced the percentage of encroachments by motorists into the next lane and resulted in less variation in the wheel path for bicycles and motor vehicles (McHenry & Wallace, 1985). McHenry and Wallace (1985) also found that motorists swerved less when passing cyclists when there was a marked bike lane.

Harkey and Stewart (1997) found that bicycle lanes as narrow as 0.9 m (3 ft) provide sufficient space for bicycles and motor vehicles to interact safely and that lanes of 1.2 m (4 ft) worked best. They also found that a stripe separating motor vehicles and bicycles produced fewer erratic maneuvers by motorists. Hunter, Stewart and Stutts (1999) discovered that there was more wrong-way cycling and more sidewalk riding at wide curb lane sites than at bicycle lane sites and that more cyclists obeyed stop signs at locations with bicycle lane sites. These studies involved comparisons of existing sites and did not involve comparisons of cyclist and driver behavior before and after facilities were installed.

One recent study did look at streets with on-street parking. The San Francisco Department of Parking & Traffic engaged Alta Planning & Design to study the effects of "shared use" markings on cyclists' and motorists' road position, cyclists' riding behavior, and bicycle/motorist conflicts. The report, *San Francisco's Shared Lane Pavement Markings: Improving Bicycle Safety*, (February, 2004) concluded that the markings increased the distance of cyclists from parked cars as well as the distance between cyclists and passing vehicles. One of the marking types, the "bike and chevron," significantly reduced the number of wrong-way riders.

## COUNTERMEASURES

Hampshire Street in Cambridge was the chosen location for implementing the series of pavement markings. Hampshire Street is 13.4 m (44 ft) wide, with parking on both sides of the street, an average daily traffic (ADT) of about 15,000 and bicycle volumes of 120 to 150 in peak periods.

The pavement marking treatments were implemented sequentially. First, data was gathered when the street was newly repaved and the only markings were a center line and crosswalks. Then, edge lines were established 3.7 m (12 ft) out from the curbs, creating 3 m (10 ft) travel lanes, and data collected with this measure. Then, bicycle symbols and arrows were put to the right of those lines, and data collected. Finally, inner lines were established, creating 2.1 m (7 ft) parking lanes, 1.5 m (5 ft) bicycle lanes and 3 m (10 ft) travel lanes. Figures 2–5 show these treatments.

The work was done between April and October of 2003.

## EVALUATION AND RESULTS

Data measured were the distance cars parked from the curb, the distance bicyclists rode from the curb, and the distance traveling motor vehicles drove from the curb. The data on bicyclists and moving motor vehicles were gathered by videotape. The data on parked cars were gathered in the field. Data were collected at each stage of the implementation, so there were four sets of data collected: baseline, line alone, line with symbol, and full bicycle lane.

Surveys of bicyclists and motorists also were administered. An intercept survey of bicyclists and motorists was conducted during the baseline and final treatment condition.

Figure 2. Only center lane markings.

Figure 3. Edge lines installed.

Figure 4. Edge lines with bicycle symbols and arrows.

Figure 5. Inner lines added.

All intercept surveys were conducted at traffic signals on Hampshire Street. After the signal turned red, the research assistant or volunteer approached the stopped cyclist or driver and said, "Good morning/afternoon. I am doing a survey for the City of Cambridge and have a few brief questions to ask you. It will take less than a minute. May

I proceed?" If the potential respondent refused, the surveyor approached the next person. There were few refusals. Cyclists who agreed to participate were asked to stay against the curb, out of the line of traffic. The baseline bicyclist survey (n = 117) had participants rate their comfort level on a five-point scale; how often they cycled on a five-point scale; and what they would change to improve cycling on Hampshire Street (an open-ended question). During the after survey (n = 123; 115 were scored for the rankings), cyclists were again asked to rate their comfort level on a five-point scale; how often they cycled on a five-point scale; if they noticed street markings on Hampshire Street over the course of the past few months (yes/no); and to rank each of the four conditions with "1" being most preferred and "4" being least preferred.

The baseline survey was administered to 129 motorists, and 120 received the "after" survey. The motorist survey asked drivers whether they were aware of bicyclists while driving on Hampshire Street; what about the street made them aware of bicyclists (an open-ended question); and how often they drove on Hampshire Street (five-point scale).

The three pavement marking treatments—an edge line demarcating the travel lane, the edge line and bicycle symbols, and a full bike lane—were all effective at influencing bicyclists to ride farther away from parked cars than when no pavement markings were present. Here are some details.

### PARKED VEHICLES

With the installation of the lane line (treatment 1), motorists parked significantly farther from the curb in both directions. The motorists moved in with each additional marking and in the end, there was no statistically significant difference between where motorists parked in the baseline condition and the full bike lane condition.

### BICYCLE POSITION

When one looks simply at an *average* position, the cyclists did move further away from parked cars in all circumstances, but only by a couple of inches—not as significant as might be hoped. However, the critical evaluation is the effect of the treatments on the *distribution* of where cyclists rode. Under all test markings, the distributions narrowed so that there were fewer outliers on either side (which is why the average did not change dramatically) (Van Houten and Seiderman, 2005). Most importantly, cyclists who were riding the closest to parked cars in the baseline condition moved further away, so the percentage of people riding more than 0.6 or 0.9 m (2 or 3 ft) from parked cars went up significantly.

The data also needed to be adjusted to account for the placement of the parked cars. At first blush, it looked as though the "line only" marking had the most influence on cyclist position, with the highest percentage of people riding more than 2.7 or 3 m (9 or 10 ft) out from the curb. However, when the data were adjusted to account for the change in where cars were parked, the three interventions became more equal in their impact of how far cyclists were from the parked cars.

There was also a difference among the locations, particularly between the locations near the signalized intersection and those near unsignalized intersections. The influence of the markings was greater on the cyclists near the former, because they started out closer to the parked cars. At the end of the study, the locations were similar as to where cyclists were riding.

### MOVING MOTOR VEHICLES

The data revealed that the treatments had little effect on driver wheel path. Because Hampshire Street is relatively narrow and is busy at rush hour, when the data was collected, there may not have always been room for drivers to move into the opposing lane. The data on the mean distance between bicyclists and through vehicles show that the distance between bicyclists and the nearest through vehicle was greatest during baseline and significantly less at three of the four sites during the lane line alone condition. Since bicyclists were moving toward the travel lane with successive treatments, this finding is consistent.

### SURVEY DATA: CYCLISTS

Because this is a commuter route and because data were collected during commuting periods, it is not surprising that the vast majority of riders rode their bikes on Hampshire on a daily basis, and virtually all respondents rode at least several times a week. It was therefore reasonable to expect them to be aware of the various interventions.

Rider comfort ratings, on a five-point scale, averaged 3.4 during baseline survey and 3.3 during the after study survey—not statistically significant. Ratings in this range fall between neutral and fairly comfortable. When respondents were asked (in an open-ended question) what they would change to improve bicycling on Hampshire Street, by far the most common response was to "add a bike lane."

During the after study survey, 80 percent of cyclists indicated they had noticed the markings. When asked to rank the various conditions from 1 (most preferred) to 4 (least preferred), cyclists ranked the full bike lane the highest (average rank of 1.25), the lane line plus bike symbol next (average rank 1.97), followed by the lane line alone (average rank of 2.95), and then no markings at all (average rank 3.78).

Another way of looking at this is to summarize which of the options were chosen as riders' first preferences. Eighty-two percent of the respondents chose the full bike lane, and 8 percent chose the line with bike symbol. Since the latter is also a bike lane, 90 percent of the respondents prefered a bicycle lane.

### SURVEY DATA: MOTORISTS

Most drivers in both surveys drove on Hampshire on a daily basis. A similar percentage of drivers in both surveys responded that they were aware of cyclists on Hampshire (86 percent of the baseline respondents and 84 percent of the end of study survey respondents—not statistically different).

When asked, "What about this street makes you aware of bicyclists?," motorists during baseline responded most frequently "nothing" (68 percent). After all of the treatments had been introduced the most frequent response was "bike lanes" (42 percent) and the second most frequent response was "I see them (the cyclists)."

## CONCLUSIONS AND RECOMMENDATIONS

This study shows that all three pavement marking options encouraged cyclists to ride farther away from parked cars. The bicycle lane was the most effective at keeping cars parked closer to the curb and encouraging cyclists to ride in a consistent position at intersections. Given that cyclists prefer marked lanes and have indicated that they make them feel welcome on the street, and that motorists do notice them, bicycle lanes can be seen as a preferred and positive way of providing for bicyclists in the transportation network.

## COSTS AND FUNDING

This research was funded by the city of Cambridge. The project cost approximately $25,000 for the research effort, plus staff time, including markings done by staff and most of an intern's time for about six months.

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## ACKNOWLEDGMENTS

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# Raised Bicycle Lanes and Other Traffic Calming Treatments on Ayres Road

## BACKGROUND

This paper describes an unusual design for a street improvement project in Eugene, OR. City staff and the community have moved up a "learning curve" during the past several decades in regard to on-street treatments for bicyclists in combination with traffic calming techniques. This project presented an opportunity to combine a number of design features in a new way on a suburban collector street.

In 2001–2002 the city of Eugene, OR, fully improved Ayres Road, a collector street in the northern suburban part of the city, using a number of unconventional design techniques. Ayres Road is a half-mile long collector street in a developing residential neighborhood, and the only street that provides a usable east-west connection between two north-south major collectors—Delta Highway North on the west, and Gilham Road on the east.

Ayres Road is similar to many other collector and minor arterial streets the city has inherited from Lane County through annexation. It was a two-lane, narrow oil mat roadway with no curbs, drainage, or sidewalks. The roadway functioned reasonably well for many years in its rural setting, but was not adequate to serve the suburban residential development called for in the city's adopted land use plan. The city began efforts to design an improved cross-section in the early 1990s when residential development began to accelerate on adjacent farm land. The project was delayed a number of years because of other projects having a higher priority for scarce funds and an extended public involvement process over the proposed design.

Dave Reinhard, Transportation Consultant (formerly City of Eugene Transportation Engineer, Division Manager)

Over the past three decades Eugene has developed an extensive system of bikeways. The network includes off-street paths, on-street striped lanes on busy streets and designated bike routes on selected neighborhood streets to help provide continuity. The classification of Ayres Road as a major collector street and the need for bicycle connectivity in the area led to a decision to incorporate on-street striped lanes in the design for the street reconstruction project.

In addition, Eugene has developed a number of strategies over the past decade to incorporate traffic calming features in street improvement projects. Experience with a number of techniques in various settings, in retrofit examples as well as new construction, helped shape the public input and the decision-making by city staff on the Ayres Road project. The project provided an opportunity to combine a number of bike-friendly components with proven traffic calming features in a unique way.

### EARLIER STREET DESIGNS

During the 1970s and 1980s a number of collector and arterial streets in Eugene were improved to upgrade the cross-section from a two-lane asphalt mat to an urban section including curbs, gutters, and sidewalks. In a few cases, multi-lane streets were built to respond to existing or forecasted traffic volumes, but the majority of projects were built as two- or three-lane streets, the latter using a striped center continuous two-way left turn lane. In some cases parking was retained on one or both sides of the street, and in nearly all cases, on-street, striped bicycle lanes were included in the project. Therefore a somewhat typical, default cross-section of three lanes and bicycle lanes became the norm for upgrading former county roadways to urban standards in developing areas of the city.

In the early 1990s, several active neighborhood associations began petitioning the city for relief from excessive traffic speeds on collector streets in residential areas. The city went through a process of initial experimentation with speed humps, evolving to the use of other techniques

A typical 1970s–80s 3-lane urban street with on-street bike lanes used in Eugene.

that have proven more acceptable to emergency service providers. As these projects were carried out in retrofit situations in older neighborhoods, interest also began to grow rapidly in incorporating traffic calming features as part of the design of major street improvement projects. Public perception shifted, and the earlier "default" design of two lanes, a center turn lane, bike lanes and (usually) no on-street parking came to be viewed as a very unattractive design that encouraged speeding and diminished neighborhood livability.

In response to these issues, city staff began modifying design practices to incorporate traffic calming features in major improvement projects. Several projects were built in the 1990s that included some or all of the following:

- narrower lanes (more use of 3.4 m (11 ft) lanes than 3.7 m (12 ft) or wider)
- raised median islands
- chicanes or similar curves introduced into the alignment of otherwise straight sections of street
- provision of on-street parking, either continuously or in intermittent parking bays
- use of setback sidewalks and extensive street tree plantings between curb and sidewalk, instead of curb-side sidewalks

A more recent (1990s) design with chicanes and wide curb and gutter for bike lane (example from Terry Street).

As the city gained experience with these types of design features, they were incorporated in the major update of design standards and guidelines, adopted in 1999. While some of the traffic calming features still generate controversy, the improved look and feel of major street projects has met with a high level of public acceptance.

### BICYCLES LANES VS. TRAFFIC CALMING

The greatest disappointment with the "new" street design was that by continuing to include on-street bicycle lanes, the overall look and feel of the street still gave the perception of a fairly wide roadway that did little to discourage speeding. To provide a safe place for cyclists on streets with moderate to heavy vehicular traffic, an additional 3 to 3.7 m (10 to 12 ft) of pavement width was being added, which tended to cancel out the visual enhancement brought about by the other features such as narrower lanes, medians and landscaping.

As part of the updated design standards mentioned earlier, the city revisited its practice of requiring on-street bike lanes on all street classifications other than local streets. The new standard established a category for collectors through residential areas, termed the "neighborhood collector." This street type calls for mixed, slow-moving bike and auto traffic, rather than requiring striped lanes on these lower-volume streets. However, on-street bicycle lanes are still the standard for major collectors and all arterial streets in Eugene. Since Ayres Road is a major collector, the city faced a challenge to come up with a design that would achieve the best balance of competing objectives—such as the goal of a bike-friendly design along with one that discourages traffic speed.

## COUNTERMEASURES

The design for the Ayres Road major improvement project evolved over a period of nearly 10 years. In about 1991 city staff initially proposed a typical three-lanes-plus- bicycle-lanes cross section. Residents of the area protested that this would result in too wide a street and increased traffic speeds in the neighborhood. The process was put on hold for several years due to other priorities, but occasional discussions took place with residents and local developers who were carrying out subdivision projects on land adjacent to Ayres Road. Eventually the city initiated a series of meetings and design charrettes with representatives of the adjacent residential neighborhoods and other interested stakeholders. The design that emerged from this process included the following elements:

## NARROW LANES

Travel lanes as narrow as 3.2 m (10.5 ft) would be used on Ayres Road.

## CHICANES

Horizontal curves with bulb-outs and centerline changes on a fairly straight segment of roadway would be used to discourage high speeds.

## RAISED MEDIAN ISLANDS

Oval-shaped, raised median islands were used to interrupt the center line and create a "veer" to the right, then back to the left as the island tapered and then vanished at the far end. The islands also provide space for landscaping, which helps reduce the glare and related drawbacks to the added pavement of the newly built street. By planting trees and shrubs in the median, the motorist's view down the street is interrupted and the overall effect tends to reinforce the notion of moving slowly down a narrow street, rather than being able to see uninterrupted pavement a long distance ahead. The median islands provide a safe landing spot for pedestrians, enabling them to cross at multiple locations, not just intersections. Also, where a median island runs along the left edge of the travel lane it helps visually narrow the lane, encouraging slower speeds.

## RAISED INTERSECTIONS AT ENTRANCES TO MAJOR SUBDIVISIONS (MEADOWVIEW AND RIVER POINTE)

The intersections were raised to full curb height in order to provide a visual cue as well as a tactile message that helps discourage speeding in these areas. The raised intersections were an important design component in order to prevent the image of Ayres Road simply being a new and improved road race course from one end to the other.

## RAISED BICYCLE LANES

The most unusual and controversial design feature is the use of raised bicycle lanes. City staff knew of this technique being used in Europe, and after a great deal of internal discussion, decided to use this feature on Ayres Road. The primary reason for using raised bicycle lanes instead of the conventional on-street lane at normal street grade was the desire to provide a very strong, visible, right-hand edge to the vehicle travel lanes. Eugene's experience on many other streets has been that on-street bike lanes tend to be seen as another 1.5 to 1.8 m (5 to 6 ft) of pavement on each side of the road. Even though most motorists don't physically occupy this space when driving along tangent sections, most use it when they create their own transitions on curved road segments.

Vehicles tend to intrude into bike lanes on curved roadways (Crescent Avenue).

The additional space also adds to the image of a wide roadway where it feels OK to drive fast. Since the raised bicycle lane is constructed of concrete and has a left edge that is beveled up to a height of half the normal curb height, it adds a very visible edge to the travel lane that a normal, striped bike lane does not provide. The 4:1 slope of the left edge is very forgiving for both bicyclists and motorists who get too close to the edge, but is visually nearly as powerful as a vertical curb.

Raised bike lane and other traffic calming features utilized on Ayres Road.

## ISSUES IN DESIGN, CONSTRUCTION, AND OPERATIONS

### Design

When it was decided that a raised bike lane would be a design feature for the Ayres Road improvement project, several design issues became apparent right away: how wide and elevated should the riding surface be, how wide and at what slope should the beveled edge or transition surface be, what type of material should it be constructed of, and how should transitions at accessible ramps and intersections be designed. The only information on raised bike lanes available at the time came from the Oregon Bicycle and Pedestrian Plan, which was limited to a photo of one constructed in Switzerland and a cross-section sketch showing how the raised bike lane separates bicyclists from motorists and bicyclists from pedestrians. No details or dimensions were specified in the plan. The photo as well as the sketch depicted a raised bike lane constructed of asphalt concrete, the same material used in the motor vehicle travel lane, with a sloping concrete ribbon separating the two. The city's desire was to have at least 1.4 m (4.5 ft) of bicycle-riding surface, the same accommodated by a wide curb-and-gutter option that is used as a bike lane. It was also decided that the raised bike lane would be constructed of concrete because a narrow lane of asphalt concrete would be hard to construct and to maintain. The design of the beveled edge determined how high the raised bike lane would be, and it was based on how well it would deter casual intrusion by motorists but still be traversable by motorists and bicyclists alike. Designers chose to use a 4:1 beveled edge with a transition width of 30.5 cm (1 ft) (a 7.6 cm (3 in ) rise in a 1 ft run). The treatment at intersections became a challenge also. At one intersection, the raised bike lane continues around the curb return, which brought up accessibility requirements. At this location, it was decided to transition the beveled edge near the curb return from a 4:1 slope to a straight grade all the way to the bottom of curb. This choice complies with accessibility guidelines and seems to satisfy riding conditions as well.

Transition design for accessible ramp locations.

Water ponding created by asphalt paving created challenges around curb return.

At another intersection, the raised bike lane transitions to a standard on-street bike lane at the curb return. This option did not introduce any riding or accessibility issues, but it did bring up constructability issues for the asphalt paving operation.

**Construction**

When the design of the raised bike lane was completed, the city did not specify how it would be constructed. As it turned out, the contractor who was awarded the project elected to extrude the raised bike lane as is done for most curb and gutter installations. However, this proved to be more complicated since it was untried with no similar projects to use as an example. The first challenge for the contractor came when the company asked for a shoe from the extruding machine manufacturer based on the city's design. The manufacturer stated that its machine was not designed to handle that much concrete volume (three times as much) through a shoe and therefore would not provide one. At that point, the contractor elected to fabricate a shoe on his own and take his chances. It eventually worked, after minor modifications with the structural supports, but several yards of concrete were wasted because the extruding machine operators were learning how to control the operation. The finished product did not fully meet city specifications and the surface smoothness for ride-ability was less than desired. Nevertheless, the City chose to accept it since the end product did not seem to present safety hazards. Had the contractor chosen to construct the raised bike lane by using traditional wood forms, it would likely have met specifications, but would probably have been more costly, mostly due to labor expense.

Another challenge for the contractor was the narrow curvilinear travel lanes. Most paving contractors have large highway type mechanized pavers, but a narrow mechanized paver would have provided better results in this application. As a result of the contractor using a standard 3 m (10 ft)–wide paver, the end product had many undesirable surface conditions (poor cross slope, poor longitudinal slope, raveling, flushing, etc.) in the final lift of the asphalt concrete.

**Operations**

A few operational considerations must be kept in mind when choosing a raised bike lane — street sweeping, road drainage, and driveway access. The final version of Eugene's raised bike lane requires two passes for the city's 2.4 m (8 ft)–wide street sweepers. The first pass is done along the raised bike lane, which pushes all of the debris to the bottom of the beveled edge. The second pass is along the bottom of the beveled edge. Another operational consideration is to be aware that the road drainage is along the joint, which can reduce the life of the asphalt pavement and create long-term maintenance headaches. The last operational consideration, driveway access, was addressed during the design phase, but had to be re-evaluated after construction. During the design phase, it was determined that no special consideration would be given for vehicle access at driveways. However, because the raised bike lane was constructed out of specification (a rise of 10.2 cm (4 in) to as much as 11.4 cm (4.5 in) in 30.5 cm (1 ft) run), some homeowners complained that their vehicles were "bottoming out" during ingress and egress. Based on this information, the City elected to have each driveway access location reconstructed using the same design parameters done for accessible ramps, i.e., the beveled edge dropped out at driveways.

## EVALUATION AND RESULTS

The combined visual effect of all these features provides reinforcement for slower vehicle speeds on Ayres Road. Motorists who use the street, especially those not already familiar with it, are greeted with a set of visual cues that imply, "something is really different about this street," and are probably more likely to proceed somewhat slowly and cautiously. At the same time, the raised bicycle lanes, median islands and other features help bicyclists and pedestrians feel relatively safe and at home as users of the street.

Informal feedback from motorists, bicyclists, neighborhood residents and the general public has been mixed. A number of initial comments during the construction of the project and immediately afterward were critical, partly because the street looked so different from other typical Eugene streets, not to mention very different from the narrow Ayres Road that this project replaced. As people have gotten more used to the street and some of its visual newness has worn off, public reaction seems to be cautiously supportive or at least neutral. City staff continues to receive comments about how unusual the street looks, but there is also a growing acknowledgment that the design does help slow down traffic. In general, feedback from the bicycling community has been positive.

Before 1992, Ayres Road was under county jurisdiction, and like most roads that did not have formal speed studies conducted, operated under basic rule — up to 88 km/h (55 mph) dependent upon road and weather conditions. When the road was transferred to the city in 1992, a speed study was completed, which resulted in a speed zone of 56 km/h (35 mph). After the reconstruction of Ayres Road, the posting was changed to 40 km/h (25 mph), which more closely reflects the traffic calming design features and the average speed of vehicles.

Ayres Road speed zone history

| | 1992 | 2002 (Post Reconstruction) |
|---|---|---|
| Average Speed (mph) | 36 | 26 |
| 85th % Speed (mph) | 39 | 29 |
| Maximum Speed (mph) | 46 | 37 |
| Posted Speed (mph) | 35 | 25 |

## CONCLUSIONS AND RECOMMENDATIONS

### PUBLIC INVOLVEMENT

As with many other projects, the process of arriving at a final design for Ayres Road reinforces the notion that it's generally better to approach the neighborhood and major stakeholders at the beginning, with no preconceived design proposal, and let the public help develop the design. Only by struggling with the choices and trade-offs in the design process can the public come to appreciate the difficult task city staff and consultants face in designing a street to meet a number of conflicting goals and objectives. Additionally, staff cannot assume that citizens are able to fully understand engineering plans and drawings. Illustrations and 3-D pictures may be necessary to convey the "look and feel" of a design element, particularly one that is unique to an area.

### TRAFFIC CALMING

Getting motorists to slow down so bicyclists can share the space and pedestrians feel safe when crossing the street appears to depend on narrowing the travel lanes as much as possible. The lanes need to be narrow in an actual, physical sense (e.g. 3 or 3.4 m (10 or 11 ft) wide), and they need to look and feel narrow to motorists. The look and feel, in turn, can be achieved by a combination of narrow lanes along with conspicuous edges (e.g. use of a center island), introducing curves and chicanes, and design elements such as trees and shrubs at both the edges and in the median, to eliminate the look of a long, straight road. Use of speed tables or raised intersections at strategic locations is also a key element of traffic calming, especially when there are very few intersections or other interruptions to continuous traffic flow along the street.

### BIKE LANES THAT COMPLEMENT TRAFFIC CALMING

The most significant new feature in the Ayres Road design was the use of raised bicycle lanes. This enabled the city to meet the objective of a safe facility for bicyclists along a moderately busy roadway, while at the same time avoiding the pavement-widening effect of the typical on-street bike lane. The strong visual edge provided by the left edge of the raised bike lane helps reinforce the narrow travel lanes and discourage excessive speeds.

### CONTINUING UP THE LEARNING CURVE

While it appears the city has developed a successful design in the case of Ayres Road, this example also serves to illustrate that there are probably other undiscovered "templates" for street designs that can meet these kinds of objectives. The best approach involves being open to experimentation and re-combining various design techniques to achieve the best mix of outcomes. Each project provides an example that can be copied or borrowed from to create even better designs for future projects.

## COSTS AND FUNDING

The total construction costs for the reconstruction of Ayres Road came to just under $1 million. The unit costs for each of the bid items compared well with other local projects similar in size and nature despite the innovative design treatments utilized. The raised bike lane component came in at $15 per lineal foot as compared to the City's standard curb and gutter with asphalt street section at $13.50 per lineal foot. A majority of the project costs were funded by Transportation System Development Charges (a.k.a. transportation impact fees) but about 20 percent of the project costs were paid by abutting property owners through assessments.

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# Floating Bike Lanes in Conjunction with Part-Time Parking

## BACKGROUND

The Embarcadero is a waterfront arterial in San Francisco that replaced a freeway heavily damaged by the Loma Prieta Earthquake of 1989. The roadway varies from four to six lanes (two to three in each direction) and now handles weekday traffic volumes of 40,000–50,000 vehicles per day.

After the roadway was constructed and while the area along the waterfront continued its evolution, it was determined in some areas that there was a need for on-street parking during non-peak traffic periods. During peak periods, there would be a tow-away restriction to uncover a third travel lane in each direction. While the accommodation of bicyclists was intended along the length of the roadway, there was a problem with how to stripe or designate space for cyclists to use along the sections with part-time parking.

One option was to stripe two rows of shared lane markings along each direction of the roadway, one along the curb to show where cyclists would ride when there was no parking allowed and the other farther away from the curb when parking was allowed. This was rejected on the basis that two rows of bicycle specific markings would be confusing to road users. Also, it generally is desirable to explore options which give cyclists their own striped space on the roadway before accepting shared lane markings in narrow lanes.

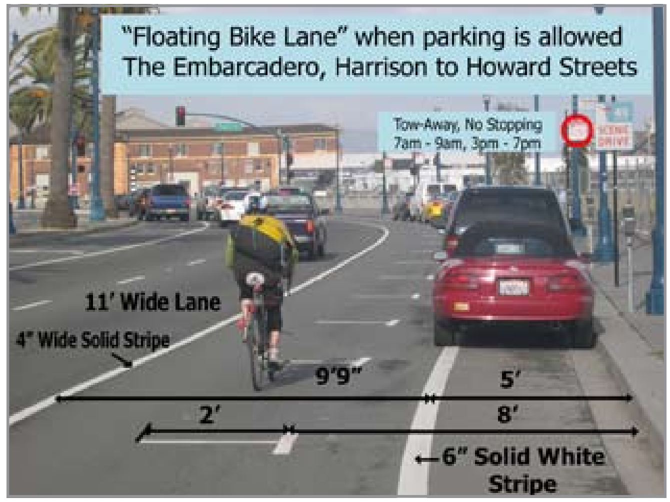


Figure 1. Cyclist using space between parked cars and first lane.


Figure 2. Northbound Embarcadero floating bike lane during tow-away.

## COUNTERMEASURES

To give cyclists a designated space along the section of roadway with part-time parking, the design shown in figures 1 and 2 was chosen. When parking is allowed, cyclists use the space between the parked cars and the solid 10.2 cm (4 in)–wide white stripe, a space about 2.1 m (7 ft) wide depending how close cars park to the curb. When parking is not allowed, as shown in Figure 2, cyclists move to the right and use the 1.5 m (5 ft)–wide shoulder. Motorists are able to use the third lane,

Michael Sallaberry, PE, Associate Transportation Engineer, San Francisco Department of Parking and Traffic

Figure 3. Cross-hatching at beginning of part-time bike-parking lane, northbound Embarcadero.

which at 3 m (10 ft) wide is narrow, but wide enough to accommodate the generally slower traffic speeds one would expect during peak hours.

Before this design, there was some trial and error along the way. The 10.2 cm (4 in) solid white line shown 4.5 m (15 ft) from the curb in Figure 1 initially was farther out at 4.7 m (15 ft, 6 in) and broken, like a typical lane line. While this allowed for a 3.2 m (10 ft 6 in) motor vehicle lane when no parking was allowed, it also created a wider space alongside the parked cars when parking was allowed. The space looked like a typical travel lane but actually was too narrow to accommodate traffic. The result was that motorists used the space and sideswiped parked cars, filling the space intended for cyclists.

To make the space between the first 10.2 cm (4 in)–wide lane line and the parked cars seem less like a travel lane to motorists when parking is allowed, the 10.2 cm (4 in)–wide white line was moved closer to the curb face. It was also made solid to discourage crossing and make the lane seem less like a travel lane. The parking T's, initially 2.1 m (7 ft) from the curb, were relocated to be 2.4 m (8 ft) from the curb and painted with longer stems. The placement was meant to further narrow the space by encouraging people to park their cars farther from the curb while the longer stems were to make the space seem less like a travel lane. And finally, cross hatching was added in the 3 m (10 ft) space at the beginning of the floating bike lane sections to further discourage motorists from using the space when parking was allowed (see figure 3). While this was meant to make the space narrower and less attractive to motorists when parking is allowed, it still remains wide and attractive to cyclists.

Would these efforts to make the space less attractive to motorists when parking was allowed result in the space not being used by motorists when parking was restricted and they were expected to drive in the third lane? From


Figure 4. Merge sign, southbound Embarcadero at beginning of part-time bike-parking lane.

observations, motorists use the 3 m (10 ft)–wide third lane as intended when parking is not allowed. The theory is that while it does not look like a conventional lane, motorists, especially when traffic congestion reaches certain levels (such as during peak hours), will use whatever reasonable space is available to them. An analogy is that the design works as a pressure release valve with the unusual-looking third lane used only when traffic levels reach a certain level.

Use of signs associated with this unusual arrangement has been minimal. While it was tempting to place signs along these stretches to explain what is going on, initial sign designs were too complicated or incomplete. Though signs always were an option if the roadway lane markings were not sufficient, it was determined that signs explaining the part-time use of the space were not necessary. The only signs pertinent to the design are the tow-away signs (circled in Figure 1) and the merge sign used in the southbound direction (figure 4). There, three full-time lanes enter the section with the floating bike lane, and the three lanes narrow to two travel lanes when parking is allowed. Bike route signs are also along this area.

There have been some calls to install bicycle markings on the street. But as mentioned earlier, two sets of markings would be necessary for cyclists as they shift from one space to another, resulting in a confusing arrangement.

Cyclists tend to stay to the right, so when there is no parking allowed, they naturally ride in the 1.5 m (5 ft)-wide shoulder. When parking is allowed, they ride in the space between the parking and the 10.2 cm (4 in) solid white stripe.

## EVALUATION AND RESULTS

While there has not been a quantitative evaluation of the design, observations indicate the space is now working as intended. Feedback from cyclists, motorists, and employees of the Port of San Francisco along the Embarcadero has been utilized throughout the process. Initial feedback and observations yielded the modifications to the design, while the good feedback and lack of negative feedback have reflected observations that the design essentially works. The primary comment heard now is that there should be pavement markings for cyclists, but the potential confusion caused by trying to mark a shifting space would likely outweigh any benefits.

The design result of this trial and error process to accommodate cyclists along a roadway with part-time parking is shown in Figures 1 and 2. If this approach of creating shifting bike lanes is used, the key is to not make the space between the parked cars and the first 10.2 cm (4 in) lane line too wide. With the 10.2 cm (4 in) lane line initially 4.7 m (15 ft 6 in) from the curb, the space was wide enough to attract motorists when parking was allowed. This 4.7 m (15 ft 6 in) width resulted in sideswipes with parked vehicles and motorists in the space intended for cyclists. Another key is to ensure that traffic levels are reasonably accommodated when parking is allowed so that there is less temptation to try to use the space intended for cyclists.

## CONCLUSIONS AND RECOMMENDATIONS

Based on observations, generally good feedback from cyclists and lack of significant negative feedback, the current design is considered effective. While not perfect, with its slightly confusing, unorthodox design, it successfully accommodates cyclists, part-time on-street parking, and motorists needing additional capacity during peak hours. It does so with minimal signs, leading one to conclude that while the design is unorthodox, it uses fairly predictable road-user behavior to its advantage. Cyclists naturally tend to stay to the right, and motorists will use a space even if it is not clearly for their use if traffic congestion reaches certain levels and the space is reasonably accommodating.

## COSTS AND FUNDING

Costs of the final design are typical of basic striping and signage projects. However, the amount of re-striping and trial and error did add to the final cost. Costs were not tracked.

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# Incorporating a Bicycle Lane through a Streetcar Platform

## BACKGROUND

Bicycle lanes on NW Lovejoy Street in Portland have long serviced an important bicycle connection between Northwest Portland and Portland's inner eastside. Northwest Portland is Oregon's most densely developed residential area, includes many shared-use developments and is a gateway to one of the city's industrial employment districts. One edge of the district is also one of Portland's fastest redeveloping shared-use neighborhoods. The neighborhood is connected across the Willamette River to Portland's inner northeast neighborhoods via the Broadway Bridge. The eastside neighborhoods are similar, though not as dense as those on the west, and host many commercial establishments, including the thriving Lloyd District.

The introduction of a streetcar line on NW Lovejoy presented a difficult problem for maintaining bicycle facilities on the street. (Bicycles are not allowed on streetcars.) A streetcar platform at the intersection of Lovejoy and 13th extends to the edge of the travel lane. The streetcar tracks run parallel to the platform and 45.7 cm (18 in) from the curb face. Through cyclists were faced with the potential of a dropped bike lane and 45.7 cm (18 in) of clearance between the parallel tracks and an 27.9 cm (11 in) curb exposure. One consideration was to drop the bicycle lane and implement an out-of direction detour that involved an uncontrolled left-turn onto a busy arterial without bicycle facilities.

## COUNTERMEASURES

The solution eventually adopted was to carry the bicycle lane up onto the streetcar platform. We did several things to slow cyclists entering the platform—the on-street lane runs into an area of heavily brushed concrete and the mouth of the ramp entering the platform is narrow and enters the platform at a moderate angle. We made sure to distinguish this area from the rest of the platform to alert pedestrians to the presence of cyclists. The bike lane area on the platform is marked with two bike stencils and is bordered with brick. It also has a different texture than the other areas of the platform. At the end of the platform the bike lane rejoins the street.

Roger Geller, Bicycle Coordinator, City of Portland, Oregon

Street level bike lane is diverted to behind a street car platform.

## EVALUATION AND RESULTS

The facility has been operating for some time with neither incident nor complaint. A more challenging test will

View of bike lane and street car platform.

come when a nearby multi-story residential development is completed and the use of this streetcar platform grows. Another challenge for the platform could be the proposed development of a supermarket, which could dramatically increase cyclists' use of the platform and the street.

## CONCLUSIONS AND RECOMMENDATIONS

The innovative placement of the bike lane has operated well so far. More will be learned as nearby development takes place.

Bicyclists travel behind the transit stop platform to reduce potential conflicts with stopped streetcars and passengers.

## COSTS AND FUNDING

Project costs are unknown, as changes were part of a larger street improvement project. The platform was to be built as part of the street car project. Additions to adapt the platform to a bikeway involved brickwork, markings and ramp and were not costly.

## CONTACT

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LAKE COUNTY, FLORIDA #14

# Red Shoulders as a Bicycle Facility

## BACKGROUND

A scenic road in Lake County, Florida, is the subject of this evaluation. Lakeshore Drive is about 8 km (5mi) in length and lies between Mount Dora and Tavares, a pair of communities located about 56 km (35 mi) northwest of Orlando. The road is under both city and county jurisdiction, although maintenance is performed by the county. The location is popular with bicyclists and walkers. Lake County has some hilly terrain and is frequented by bicyclists riding for physical fitness or preparing for races. Bicycling groups from the Orlando area often ride on Lakeshore Drive as part of longer bike rides. The route is also used extensively during the Mount Dora Bicycle Festival each fall.

In the early 1990s, the road was slated to receive shoulders. Residents who feared that speeds would increase with the addition of shoulders opposed the project. The Florida Department of Transportation (FDOT) suggested that painting the shoulders might be a treatment that could be adapted from Europe. Even though the travel lanes would remain at approximately 2.9 m (9.5 ft), adding shoulders would physically widen the cross-section. The painting of the shoulders was intended to make the road appear no wider than before.

Figure 1. View of the red shoulders.

The 1.8 m (1.1 mi) treated section of road has a 56 km/h (35 mph) speed limit and is primarily a two-lane rural roadway with about 1,700 vehicles per day. There are two main intersections along the section where the shoulders have been painted red. In one area a railroad divides the road into two one-lane sections. At the end of this section a roundabout has been added, with the railroad extending through the roundabout and the colored shoulders ending at the entry to the roundabout. Several more intersections (stop-sign-controlled) intersect Lakeshore Drive along the red shoulder section.

## COUNTERMEASURES

In the summer of 1996, a 1.8 km (1.1 mi) section of the road was widened with 0.9 m (3 ft) shoulders. The shoulders were colored red with a paint that is used on tennis courts (figure 1).

William W. Hunter, Senior Research Scientist,
UNC Highway Safety Research Center

## EVALUATION AND RESULTS

The evaluation examined several items. The treatment produced a non-slippery surface that maintained its appearance rather well for some time after the initial painting. The most obvious discolorations occurred at locations with frequent motor vehicle traffic, such as mail trucks stopping at mail boxes.

The Lake County Department of Public Services collected speed data before and after the addition of the red shoulders to determine if motor vehicle speeds had changed. Videotape was taken of bicyclists traveling along the roadway at sections with and without red shoulders. Besides determining whether the shoulder was used by bicyclists, the lateral positioning of bicyclists being passed by motor vehicles was determined, along with the amount and severity of vehicular encroachment into the opposing lane of travel. If encroachment occurred, conflicts between the passing and oncoming motor vehicles were recorded. In addition, any conflicts between motor vehicles and bicycles were recorded. Also, the Lake County Department of Public Works developed a questionnaire that was administered to bicyclists riding along Lakeshore Drive to obtain feedback concerning the red shoulders.

Evaluation of the red shoulders considered a variety of issues. Major findings are highlighted below:

- Full-time bicyclist use of the shoulder tended to be around 80 percent, and another six percent used the shoulder partially.

- The frequency of motor vehicles encroaching over the center line when passing a bicyclist was greater at the site without red shoulders.

- The severity of encroachment was fairly evenly split between minor, moderate, and severe at the red shoulder site. Almost 93 percent of the encroachments were severe at the site without red shoulders.

- There were no motor vehicle-to-motor vehicle conflicts when passing a bicyclist at the red shoulder site, and there were eight (four minor and four serious) at the site without red shoulders.

- Bicyclists positioned themselves about the same distance (about 0.5 m (1.5 ft)) from the edge of pavement on both the red shoulder and non-red shoulder sites.

- The spacing between bicycles and passing motor vehicles was statistically significantly greater (about 0.1 m (0.6 ft)) at the site without red shoulders.

- Mean and 85th percentile speeds showed little difference before and after the placement of the red shoulder.

- Survey responses showed that 80 percent of the respondents thought the red shoulders resulted in no change in the speed of cars and trucks. More than 85 percent responded that there was more space between bicycles and passing motor vehicles with the red shoulders in place, even though actual measurements of spacing distance showed greater clearance between bicycles and motor vehicles on the section of roadway without red shoulders. A final survey response showed that almost 80 percent thought the red shoulders made them feel safer than ordinary unpainted shoulders. Thus, bicyclist comfort level was increased by installing the red shoulders.

## CONCLUSIONS AND RECOMMENDATIONS

The red shoulder section of roadway not only has been well received but also has functioned well in an operational sense. The comfort level of bicyclists appears to be greater on the red shoulder section, which matches the results of a recent Federal Highway Administration study focused on the development of a bicycle compatibility index (BCI), a means of measuring the "bicycle friendliness" of a roadway (Harkey, Reinfurt, Knuiman, Stewart, and Sorton, 1998). In this study the variable with the largest effect on the index was the presence of a bicycle lane or paved shoulder. In other words, the presence of a bicycle lane or paved shoulder increased the comfort level more than any other factors.

Use of the shoulder was quite high. Riders who did not use the red shoulder tended to be part of a group, where the typical placement was to have one or more following cyclists riding to the left of lead cyclists for safety purposes. In addition, cyclists in pairs often rode abreast so they could converse. Children also had a tendency to be partial users of the red shoulders, with a tendency to cross back and forth across the road.

Perhaps the most important evaluation parameter was the speed of motor vehicle traffic before and after the placement of the red shoulders. The primary intent of the red shoulders was to create a visual sense of no widening of the road, which would lead to no increase in traffic speed. This appears to be the case. One could speculate that the general curvy alignment of the roadway could also have a bearing on this result; however, the section of the roadway where the red shoulder was installed is relatively straight.

## COSTS AND FUNDING

The cost of painting the 1.8 m (1.1 mi) section of red shoulders (in both travel directions) was approximately $6,600. The widening and resurfacing costs amounted to $173,000.

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The modification (red shoulders) that is the subject of this case study is not compliant with the *Manual on Uniform Traffic Control Devices*, nor is it currently being considered for inclusion. Accordingly, it is imperative that any jurisdiction wishing to utilize red shoulders (or any other non-approved traffic control device) should seek experimental approval from the Federal Highway Administration. For information on how to do so, please visit this Web site: http://mutcd.fhwa.dot.gov/kno-amend.htm.

FORT LAUDERDALE, FLORIDA #15

# Conversion of 14-foot-wide Outside Lanes to 11-foot Travel Lanes with a 3-foot Undesignated Lane

## BACKGROUND

In the early 1990s, the City of Fort Lauderdale redesigned SR A1A, the famous Fort Lauderdale "strip." It went from a three-lane cross-section with head-in parking on the ocean side and a narrow sidewalk on the commercial side to a four-lane divided roadway with a 4.3 m (14 ft)–wide outside lane and 2.4 m (8 ft)–wide sidewalks on both sides. Shortly after the completion of the initial redesign, the city began receiving complaints about bicyclist and pedestrian conflicts on the beach side sidewalk. While the typical section included a "bicycle facility," only the proficient bicyclist was comfortable mixing with traffic in the 4.3 m (14 ft)–wide outside lane. As the complaints continued to rise, the city began requesting that the Florida Department of Transportation (FDOT) add 1.2 m (4 ft) bicycle lanes. There was considerable discussion between the city of Fort Lauderdale, the FDOT and the Broward County Bicycling Advisory Committee about reducing the outside travel lanes to 3 m (10 ft) and putting in 1.2 m (4 ft) bicycle lanes. It was decided to try 0.9 m (3 ft) marked bicycle lanes (Figure 2) next to 3.4 m (11 ft) travel lanes. During discussions, concerns were raised that there might be increases in wrong-way riding and turning conflicts at hotel driveways.

## COUNTERMEASURES

A 0.9 m (3 ft) bike lane was incorporated into the wide outside lane (figure 1). Because this was a pilot project, the existing edge stripe was left in place. Standard bicycle lane pavement markings and signs were added to identify the lane as a bicycle facility.

Mark Horowitz, Special Projects Coordinator IV, Bicycle Coordinator, Broward County Dept. of Planning and Environmental Protection

Figure 1. SR A1A with a 0.9 m (3 ft) marked bike lane. Substandard width lanes are no longer marked or designated as a bicycle facility.

## EVALUATION AND RESULTS

The project was evaluated by several means. The local bicycle coordinator tested the facility by bicycle; members of the County's Bicycling Advisory Committee and FDOT Staff conducted observations of the bicyclists on the sidewalk and in the undesignated lane, and surveyed bicyclists using the undesignated lane. In addition, the complaints regarding bicycle and pedestrian conflicts received by the city decreased.

Overall, the evaluation of the facility was positive. The on-bike test by the bicycle coordinator found that while the stripe did provide an additional measure of traffic control and bicyclist comfort level increased, it was the minimum width that should be striped. The observations of bicycle ridership showed a decrease in sidewalk riding and conversely an increase in bicyclists riding in the street. The bicyclist surveys revealed that the majority of bicyclists were glad the lane was present but thought it was too narrow. Before the installation of the lane, the club cyclist typified the bicyclist in the street. After installation, cyclists with a wider variety of experience levels were using the 0.9 m (3 ft) lane. In this instance the concerns about an increase in wrong-way riding were not validated. However, this is

Figure 2. Along US 1 an existing 4.2 m (14 ft) outside lane was converted to an 3.3 m (11 ft) travel lane next to 0.9 m (3 ft) undesignated lane, or urban paved shoulder.

most likely because the major attraction to the area is the beach, and there was a significant amount of wrong-way riding on the beach side before the installation. Additionally, wrong-way riding did not increase on the opposite side of the street, nor was there an increase in turning conflicts at the numerous hotel driveways.

While this test was successful, the FDOT ultimately decided to reduce the widths of all four travel lanes to 3.2 m (10.5 ft) and put in a 1.2 m (4 ft) marked bike lane.

## CONCLUSIONS AND RECOMMENDATIONS

The test of the 0.9 m (3 ft) bike lane was successful. It reduced bicyclist and pedestrian conflicts on the sidewalk and increased the bicyclist's comfort level when riding in the street. The predicted negative impacts of increased wrong-way riding and increased conflicts with turning vehicles did not materialize in this instance.

This design has been slightly modified from the original test and does not include bike lane pavement marking or signs. It is now being used by both the FDOT and Broward County Public Works with about 75 km (47 mi) in place in Broward County. Figure 2 shows U.S. 1 in Fort Lauderdale with a 4.3 m (14 ft)–wide outside lane that has been converted to a 3.4 m (11 ft) travel lane with a 0.9 m (3 ft) undesignated lane.

Broward County has included the 0.9 m (3 ft) undesignated lane in its Land Development Code as a design alternative when right-of-way is constrained. Broward County's Traffic Engineering Division has made a special effort to stripe a 0.9 m (3 ft) undesignated lane on existing 4.3 m (14 ft) outside lanes. The University of North Carolina Highway Safety Research Center is studying the conversions.

Undesignated lanes are in place or planned for use throughout Broward County on major arterials as well as collectors with ADTs ranging from 25,000 to 45,000 cars per day. As was observed in the original evaluation, the undesignated lane is used by bicyclists of all abilities (figure 4). Because of the 0.9 m (3 ft) width, the design should not be referred to as a bicycle lane but as either a 0.9 m (3 ft) undesignated lane or an urban shoulder.

Because this type of facility provides better direction for the motoring and the bicycling public but does not meet current standards, bicycle signage and pavement markings are not used. Additionally, this facility type has been referred to as an undesignated lane or urban shoulder. It should be noted that referring to this facility as an urban shoulder has occasionally created some confusion during the striping process and has resulted in the lane being placed to the right of a dedicated right turn lane instead of to the left. Additionally, care needs to be taken during the striping process. A slight drift to the right when applying the stripe could easily result in a 0.8 m (2.5 ft) lane.

## COSTS AND FUNDING

During new construction the installation cost is slightly more than placing an edge stripe. The cost in Broward County to convert a 4.3 m (14 ft) wide lane to an 3.3 m (11ft) travel lane with a 0.9 m (3 ft) undesignated lane is approximately $0.37/ft to stripe the lane. Removal of the edge stripe is approximately $1/ft. Broward County has chosen not to remove the existing edge stripe.

## REFERENCES

AASHTO, *Guidelines for the Development of Bicycle Facilities* Federal Highway Adminstration

*Manual on Uniform Traffic Control Devices*, 2000 Edition

## CONTACTS

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**TUCSON, ARIZONA** **#16**

# Preferential Transit-Bicycle-Right-Turn Lanes on Broadway Boulevard

## BACKGROUND

Broadway Boulevard is a major, six-lane divided arterial roadway in Tucson, Arizona, that carries over 30,000 cars per day. All of the lanes were constructed between 3.7 m (12 ft) and 4.3 m (14 ft) wide, except the curb lanes which were constructed between 6.7 m (22 ft) and 7.3 m (24 ft) wide with no parking allowed. Originally, the plan intended the curb lanes to be wide enough to facilitate turns into and out of the numerous driveways along the strip shopping corridors without impacting through traffic along the arterial. The wider curb lane was designed to allow drivers to position their vehicles next to the lane stripe when traveling straight ahead and only pull closer to the curb when turning right into the business driveways, keeping the faster lanes clear. In addition, the wider curb lane was intended to assist public transit vehicle operations by giving them an opportunity to travel more slowly and stop frequently for passengers in relative safety next to the curb and not impact the main flow of traffic.

A combination bus, bicycle, and right-turn lane was separated from a former 6.7–7.3 m (22–24 ft) multi-use, wide curb lane.

Richard B. Nassi, Transportation Administrator, City of Tucson
Shellie Ginn, Bicycle Coordinator, City of Tucson

Unfortunately, the actual operation of the wider lanes did not fulfill their design intent. After the construction of the road system, a series of crashes occurred involving right-turning vehicles entering the driveways and colliding with the slower-moving public transit vehicles. In addition, there was no clear area for bicyclists to ride. The wide lane did not provide enough guidance to less-skilled drivers and a number of drivers failed to position their vehicle properly as they began their turn. Approximately 20 percent of these crashes involved turning vehicles and public transit vehicles.

## COUNTERMEASURES

The problem was studied and reviewed by transit and traffic practitioners and the decision was made to divide the wide curb lane into two lanes. The wide outside lane was divided and the new curb lane was striped as a priority *BUS and RIGHT TURNS ONLY, EXCEPT BIKES*, lane. This treatment provided clearer direction as to how the lanes were to be used and where drivers should position their vehicles when turning into driveways. Transit vehicle operators can operate in the curb lane, away from the faster through traffic lanes, thus reducing the potential for crashes as they stop to board or disembark passengers.

## EVALUATION AND RESULTS

The splitting of the wide curb lane worked very well and eventually was included in the design of other streets with wide curb lanes. The system now has been in operation for over 22 years throughout Tucson on about 22.5 km (14 mi) of arterials. The reoccurring sideswipe, rear-end and turning type crashes fell to very low levels, Transit management also noted that the lanes helped in other areas in addition to service and safety. Sun Tran, the local transit agency, indicated the priority lane seemed to increase bus driver morale and ultimately made their jobs easier. Equally important, the preferential transit/bike lane provided a means of making the city's transit system more visible to the community, especially in a time of energy conservation, and encouraged alternate modes of transportation.

## CONCLUSIONS AND RECOMMENDATIONS

The priority transit lane striping worked as expected and the reoccurring crashes fell to low levels. The lanes have now been in operation, city-wide, for approximately 22 years. Once the lane system was installed in other portions of the city, crash involvement between transit vehicles and other motor vehicles was reduced.

The operation is transferable to other jurisdictions with similar roadway geometric and land use patterns. The mixing of the various transit and bicycle modes has not proven to be a problem. The separation of the turning vehicles, faster through vehicles and the transit vehicles solved the safety problems.

## COSTS AND FUNDING

The project was funded under the City of Tucson maintenance budget. The cost for markings and signs is minimal—in the range of approximately $100 per sign, posted approximately every fifth of a kilometer (eighth of a mile), and painted pavement diamond adjacent to each sign.

## REFERENCES

The stripes and signs of the preferential Transit-Bicycle lane can be found in the Federal Highway Administration's *Manual on Uniform Traffic Control Devices*.

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MADISON, WISCONSIN #17

# Taming the Urban Arterial

## BACKGROUND

The one-mile downtown segment of University Avenue is a major arterial roadway that cuts through the heart of the University of Wisconsin campus. In view of the significance of University Avenue to local pedestrian and other traffic circulation on the University campus, as well as to the broader community traveling to and through downtown Madison, there was a broad-based community input and review process engaging local officials and the public that considered the safety and accommodation needs of pedestrians, bicycles, and motor vehicles along this corridor before selection of the recommended design cross-section and reconstruction in 1983.

Before reconstruction, there were three eastbound through traffic lanes, a curb lane designated for buses, bicycles and right turns only, plus a 3.4 m (11 ft)–wide contraflow bus lane, which eastbound bicycles were also permitted to share. Roadway facilities and infrastructure were out of date and in poor condition. Accommodations for buses, bicycles, and pedestrians were considered inadequate. Numerous design concepts, alternatives, and cross-sections, especially for accommodating eastbound bus and bicycle traffic, were developed for the University Avenue corridor that also included consideration of the parallel one-way Johnson Street. A detailed safety review and conflict analysis was conducted before the selection of a design cross-section. The selected cross-section provided for complete reconstruction within the existing right-of-way and included relocation of eastbound bus traffic to West Johnson Street. This made it possible to increase the spatial accommodations for pedestrians and bicyclists while minimizing the number of conflicts between motorized and non-motorized traffic.

Arthur Ross, Pedestrian-Bicycle Coordinator
Tom Walsh, Traffic Engineer
City of Madison Traffic Engineering Division

University Avenue at Park Street – Before condition with curb bicycle, bus and right turn only lane. Lane to left of concrete divider is a contraflow bus lane.

## COUNTERMEASURES

The countermeasures/improvements implemented include the following:

- 2.4 m (8 ft)–wide westbound bike lane adjacent to a 4 m (13 ft)–wide bus and right turn only curb lane
- 2.4 m (8 ft)–wide exclusive eastbound contraflow bike lane and barrier median between this lane and westbound through traffic lanes.
- Expansion of 1.8 m (6 ft)–wide pedestrian walkways to between 2.4 m (8 ft) and 3 m (10 ft).
- Barrier railing between sidewalks and roadway to prevent midblock pedestrian crossings.
- Wider and enhanced pedestrian crosswalk markings including zebras at the most desirable crossing locations
- Signal timing improvements to provide progressive traffic flow and reduce bicycle and motor vehicle conflicts
- Widened barrier median at intersections to provide refuge for left-turning bicyclists

Two views of University Avenue at Park Street today.

## EVALUATION AND RESULTS

University Avenue traffic conditions have changed over the past 20 years. Average weekday motor vehicle traffic volume increased from about 22,000 vehicles per day in 1980 to 32,000 in 2001. The total number of buses was reduced by the elimination of the contraflow bus lane, but westbound bus traffic has remained stable at about 50 buses per hour in peak hours. The combined eastbound and westbound bicycle lane volumes increased from an average weekday low volume of 25 and high volume of 6,310 in 1980 to an average weekday low volume of 3,198 and high volume of 12,749 in the year 2002. (Low bicycle counts typically are in January when students are on break and weather is cold and snowy; high bicycle counts typically are in September when University classes resume after the summer break.) Pedestrian volume is extremely high, although no counts are available. The University Avenue corridor is located in the heart of the University campus, with an enrollment of more than 40,000 students. The number of pedestrian users along and crossing University Avenue likely exceeds the number of motor vehicle users on a typical day when classes are in session.

The corridor improvements resulting from reconstruction include:

- Fewer conflicts between pedestrians on widened sidewalks.
- Fewer conflicts between westbound buses and bicycles that played leapfrog prior to reconstruction.
- Fewer conflicts between westbound bicycles and motor vehicles through separation of space for bicycles versus through and right-turning motor vehicles (creation of space for each purpose/user).
- Eastbound bus and bicycle conflicts were eliminated through relocation of bus traffic to the parallel Johnson Street arterial.
- Reduction in travel delay and intersection cross-traffic conflicts through progressive signal timing for both westbound traffic and eastbound bicycle traffic.
- Traffic signals were removed from one low-volume intersection in the corridor, resulting in improved signal progression for westbound traffic.

As they approach the 20-year design life of the University Avenue reconstruction project, local officials look back on the project as a major success, especially in view of the large volume of multi-modal uses and the larger-than-expected increases in traffic volume in the corridor, which still has few problems. There have been few complaints or irresolvable problems, and the safety record is very good with no remarkable issues. The primary conflicts or concerns have to do with turning traffic, both left- and right-turning traffic conflicts as well as conflicts with pedestrians at intersections. The limited number of private driveways and the relatively low volume of turning traffic at most intersections along the corridor have contributed to the good safety record.

## CONCLUSIONS AND RECOMMENDATIONS

Local officials conclude that improvements were successful. It's likely that if the corridor were reconstructed today, the existing cross-section would not be changed significantly.

## COST AND FUNDING

Construction costs in 1983-1984 were approximately $1 million and were funded by the Federal Aid Urban System Program (predecessor to the Surface Transportation Program-Urban (STP-U)). Cost sharing was 70 percent Federal, 30 percent local cost match.

## REFERENCES

*ITE Journal*, February 1986 article entitled "Unique Roadway Design Reduces Bus-Bike Conflicts." Also City of Madison Traffic Engineering project and location files.

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# Contraflow Bicycle Lanes on Urban Streets

## BACKGROUND

Cities that have extensive one-way street systems can be very frustrating for cyclists to maneuver, especially because they often are more affected by major detours or out-of-the-way travel than motorists, both because the time difference is greater and because the alternative routes are often more stressful or less safe. In addition, because of the inherent greater flexibility of the bicycle, many cyclists will simply ignore the one-way restrictions and travel against traffic, particularly when traffic volumes and speeds on the preferred route do not present a deterrent.

There are some options available in looking at ways to accommodate cyclists on one-way street systems. Many cities and towns in Europe explicitly allow cyclists to travel in both directions on a one-way street. This usually occurs on very narrow streets with very slow traffic, typically in the core areas of older cities and towns. Another option is that specific designated facilities be created to permit travel in the opposite direction. The contraflow bike lane is a designated facility marked to allow bicyclists to travel against the flow of traffic on a one-way street.

There are, of course, safety concerns associated with contraflow bike lanes. Motorists and pedestrians do not expect bicyclists to be traveling in the opposite direction of traffic on one-way streets. However, contraflow bike lanes have been used successfully in some cities in the United States (Boulder, CO; Eugene, OR; Portland, OR; Madison, WI). Building on evaluation criteria developed for Eugene, OR, the city of Cambridge looks at the following conditions when evaluating a potential contraflow lane location:

Cara Seiderman, Transportation Program Manager, Cambridge, MA

Sign indicating contraflow bike lanes on Scott Street. Bike lane is highlighted with blue pavement.

- Safety is improved because of reduced conflicts;
- Bicyclists can safely and conveniently re-enter the traffic stream at either end of the section;
- The contraflow bike lane is short and provides direct access to a high-use destination point;
- There are no or few intersecting driveways, alleys or streets on the side of the proposed contraflow lane;
- A substantial number of cyclists are already using the street;
- There is sufficient street width to accommodate a full-dimension bike lane;
- The contraflow bike lane provides a substantial savings in out-of-direction travel compared to the route motor vehicles must follow;
- The contraflow bike lane provides a significantly improved travel experience for the cyclist (e.g., allows cyclists to avoid a high-volume, high-speed alternative route);
- Traffic volumes on the street are low.

In addition, the following features should be incorporated into the design of the street with the contraflow lane:

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

It is preferable also to have a separate bike lane in the direction of motor vehicle traffic, striped as a normal bike lane. Where the roadway width does not allow this, bicyclists will have to share the road with traffic.

Concord Avenue contraflow bike lane.

## COUNTERMEASURES

There now are four contraflow bicycle lanes in Cambridge: on Concord Avenue between Follen Street and Waterhouse Street (often referred to as "Little Concord Avenue"); on a portion of Waterhouse Street off of Mass. Ave (it is a very short stretch without much evaluation information so this will not be discussed here); on Scott Street between Beacon Street and Bryant Street; and on Norfolk Street south of Broadway. These contraflow lanes meet the criteria detailed above, although Norfolk Street was somewhat of an exception in that not many cyclists were riding against traffic on this street.

### 1. CONCORD AVENUE

In 1994, a major street renovation project created changes in the street pattern in the area of Arsenal Square. This route is a direct connection for east-west travel in the city as well as a main route from one part of the Harvard University campus to the main campus. Concord Avenue not only provides the most direct connection, but also allows cyclists to avoid riding on a street with major traffic and no space between the travel lanes and the parking lanes. It also allows cyclists to avoid riding in an underpass where cars reach speeds of up to 50 mph (the city speed limit is 30 mph).

Larger numbers of cyclists already were traveling in both directions on this one short block of a residential street to make the direct connection. There are only two driveways for single-family residences along the street.

A 1.5 m (5 ft) contraflow bicycle lane was created with two solid white lines, bicycle symbols and arrows at very frequent intervals. The reason for using white rather than yellow, which one normally would use to separate the directions of traffic, is because there is parking between the contraflow bike lane and the curb, so motorists needed to be permitted to pull over and park in the direction of travel. A stop sign for cyclists was put up at the end of the block so that cyclists would look for traffic before proceeding across the street.

Signs were installed on the approach to the intersection. The intersection is a non-conventional situation, more of a bend in the road than a real intersection. Motorists must proceed slowly. The street is a U-shaped one, only serving residents along the street, and has very low traffic volumes (under 1000 VPD).

### 2. SCOTT STREET

Sewer construction and roadway paving on this street offered the possibility of implementing traffic calming and other changes. Scott Street offers a direct connection between a minor arterial that is one of the area's most used bicycle travel corridors and Harvard University, Harvard Square, and other destinations. It is a wide one-way street


Sign indicating contraflow bike lane on Norfolk Street.

with little-used parking on both sides. A contraflow bike lane was marked and blue thermoplastic included to remind motorists to look for cyclists and not to drive in the bicycle lane. A sign was included, stating "Do Not Enter Except for Bicycles." Traffic volumes are less than 2,000 vehicles per day.

### 3. NORFOLK STREET

One block of this one-way street was striped as a contraflow lane to allow cyclists to avoid an arterial street without shoulders or bike lanes and with large traffic volumes, including trucks. A sign with a graphic representation of the contraflow lane was installed at the intersection entering the street. Blue thermoplastic was added to each end of the lane to call attention to its presence. Traffic volumes are below 2,000 vehicles per day.

## EVALUATION AND RESULTS

No formal evaluations have been done for these streets. City staff have observed the locations, Cambridge Bicycle Committee members, and members of the traveling public have offered comments, and we have performed before and after bicyclist counts for two of the streets. Cyclists are continuing to use the streets in both directions and are using the designated contraflow lanes.

On Concord Avenue, some cyclists have been observed riding in the contra-flow lane but in the direction of traffic, despite the extremely frequent occurrence of arrows. Anecdotal comments are that the lane has bike symbols, so it seemed to those traveling the wrong way that they were supposed to be in that lane.

On Concord Avenue, there is also a sight-line issue created by a combination of the angle of the street and a private property fence. Concerns were reported by regular users of the street and additional signs were put up to remind motorists to watch for bicyclists.

### SCOTT STREET COUNTS

Before and after counts were performed for cyclists riding on Scott Street. These showed an increase of cyclists riding against traffic (using the contraflow lane in the after counts). Given origins and destinations in the area, it would be expected that more people would be using the contraflow lane in the morning peak period, and this was affirmed in the data (see following table).

Before and After Scott Street Contraflow Lane Bike Counts

| | |
|---|---|
| AM Peak Hour | |
| Before | 20 peak, 16 traveling southbound (against traffic), 4 northbound (with traffic) |
| After | 34 peak, 30 traveling southbound (in contra-flow lane), 4 northbound (with traffic) |
| PM Peak Hour | |
| Before | 17 peak, 4 traveling southbound (against traffic), 13 northbound (with traffic) |
| After | 19 peak, 7 traveling southbound (in contra-flow lane), 11 northbound (with traffic) |

### CONCORD AVENUE COUNTS

Before and after counts are not exactly comparable because they were performed at different times of the year. However, the counts consistently showed that there were about the same number of cyclists in both directions of travel, before and after. Peak hour counts were about 62 cyclists (occurring at midday rather than morning or night, presumably because of the student population).

## CONCLUSIONS AND RECOMMENDATIONS

Contraflow bike lanes can be used successfully in circumstances similar to the ones described here if they meet the criteria outlined. There may be additional designs or circumstances that would merit testing as well.

Pavement markings and signs should be thought through carefully in the design. It is preferable to implement the lane when longer-lasting pavement marking materials can be installed (thermoplastic or in-lay tape). Otherwise, a strict maintenance program to keep paint highly visible will be required. Bicycle symbols and arrows should be created at frequent intervals (far more frequently than standard AASHTO recommendations). Consideration should be given to adding color (blue is most visible) in the lane. Signs should be installed wherever motorists would be approaching the street (at the beginning of the intersection and at any intersecting roads or major driveways).

Where there is room for bike lanes on both sides of the street, they should be included to clarify where cyclists should travel. If there is no room for a full bike lane, other pavement markings or signs should be considered to clarify direction.

## COSTS AND FUNDING

In general, the costs for implementing a contraflow lane are fairly straightforward and easy to calculate when they involve standard pavement markings and signs. The costs would increase somewhat from a standard bicycle lane because it is preferable to use more frequent bicycle symbols and arrows as well as more signs. Additionally, some signs might be custom-made rather than standard. Costs would increase if blue thermoplastic paint is used.

Sample costs for Cambridge in 2002:

| | |
|---|---|
| Thermoplastic Bike Symbols | $80 each |
| Thermoplastic Bike Arrows | $60 each |
| Inlay Tape Bike Symbols | $200 each |
| Inlay Tape Bike Arrows | $150 each |
| Blue Preformed Thermoplastic* | $10.00/square foot |
| *Not including installation—All others include installation | |

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# Left Side Bike Lanes on One-Way Streets

## BACKGROUND

More than 50,000 people (35 percent of commuters) travel to downtown Minneapolis each weekday by bus. Practically every street within the downtown grid is a bus route. Most of these buses stop at each block on the right side of the roadway, creating a potential hazard for bicyclists who tend to ride on the right side.

According to Census 2000 data, Minneapolis has one of the highest commuter and bicycle mode shares in the nation for a city of its size. Much of this success is attributed to more than 80 miles of on-street and off-street bikeways. During the mid 1990s, the City of Minneapolis decided to install a grid of east/west and north/south bicycle lanes in downtown Minneapolis to encourage bicycle commuting. Most of these facilities were proposed along one-way streets with high volumes of right-turn movements. Possible bicycle and bus conflicts along these routes greatly concerned city engineers and transit providers, especially after a bicycle fatality involving a bus occurred downtown.


Downtown Minneapolis bicycle lane routes.

## COUNTERMEASURES

In an effort to reduce potential bicycle and bus conflicts it was decided that bicycle lanes on one-way streets in downtown Minneapolis would be installed along the left side of the roadway for the following reasons:

- Better visibility—Drivers are better able to see bicyclists in the driver's side mirror than on the passenger side. There is also a large blind spot on the passenger side of most vehicles.
- Fewer rush hour parking restrictions—Rush hour parking restrictions create right-turn lanes and add capacity during peak periods. Having the bicycle lane on the left side ensures a consistent facility during all times of the day.
- Fewer truck conflicts—Since most loading zones are on the right side of the roadway, there are fewer delivery trucks crossing the bike lane on the left side of the roadway.
- Fewer door incidents—Since most commuters drive alone there are relatively few passenger doors swinging open. Having the bike lane on the left side considerably reduces a bicyclist's chance of being hit by a door.

Donald C. Pflaum, City of Minneapolis Public Works
Thomas Becker, P.E., City of Minneapolis Public Works

Left side bicycle lane on Portland Avenue.

Left side bicycle lane on Park Avenue.

- Fewer left-turn movements—There tend to be fewer left-turn movements on one-way streets than right-turn movements. Having the bike lane on the left side of the roadway reduces the number of a turn-related bicycle crashes.

Typical left side bicycle lanes along one-way streets in downtown Minneapolis can be found on 9th Street South, 10th Street South, 12th Street South, Park Avenue and Portland Avenue.

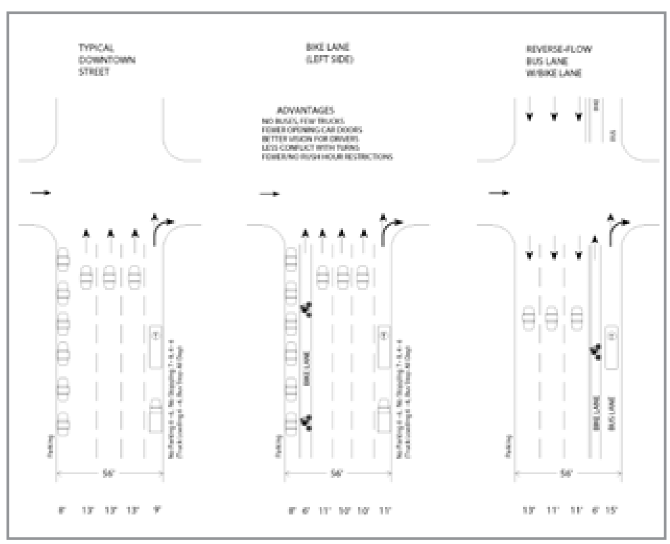
To facilitate the efficient movement of buses during peak periods and to improve air quality, reverse flow bus lanes were implemented along three north/south downtown one-way streets in the mid-1990s. An additional east/west one-way street was converted in 2000 to include a contraflow bus lane and bicycle lane on 4th Street South to accommodate buses and bicycles displaced from 5th Street South, which is the corridor in which Hiawatha Line Light Rail Transit vehicles was to begin operation in 2004. Reconfiguring these streets by removing a 3 m (10 ft) parking lane and an 3.4 m (11 ft) driving lane allowed for a new 4.6 m (15 ft)–wide reverse flow bus lane and a parallel 1.8 m (6 ft)–wide bike lane to be constructed. To increase visibility of the bicycle lane, a red seal coat treatment was applied to the bike lane in all of these corridors.

Perhaps one of the most controversial discussions when the 2nd and Marquette corridors were redesigned was deciding which direction to place the bike lanes. Although there is technical merit for either option, the decision ultimately was made by bicyclists. After considerable debate by the Minneapolis Bicycle Advisory Committee, the majority felt that it was better to ride in the same direction as buses since bus drivers are professional drivers and are less likely to hit a bicyclist from behind.

## EVALUATION AND RESULTS

The success of the left side bicycle lanes in downtown Minneapolis can best be gauged by observing how much the facilities are used, by examining bicycle crash trends, and by asking bicyclists their opinions. These outcomes were measured by examining accident records, performing a thorough downtown Minneapolis bicycle count, and by performing a survey with a reasonable sample size.

On September 10, 2003, the City of Minneapolis conducted a 12-hour cordon count, counting all people via all modes of transportation entering and existing downtown Minneapolis at 35 perimeter stations. There were 2,311 inbound bicyclists and 2,368 outbound bicyclists counted that day. In addition to the cordon count, over 30 volunteers took turns counting bicycles at four locations from 6 a.m. to 6 p.m. that day. These mid-block stations




Typical downtown cross-sections.


2nd Avenue looking north. Bicycles travel northbound in the same direction as buses. Buses are allowed to use the bike lane to pass other buses only in the event of a bus breakdown. Bicyclists making right turns may share the bus lane with buses. Marquette Avenue one block to the west is the mirror image of 2nd Avenue except that bicycles and buses travel southbound and general traffic travels northbound.


Eastbound bicycle lane along 4th Street South. Note that bicycles travel in the same direction of traffic. A bicycle lane will be installed along 3rd Street South to replace the westbound bicycle lane lost due to Light Rail Transit along 5th Street South. Since 3rd Street is a typical one-way westbound street with a proposed westbound bicycle lane, an eastbound bicycle lane on 4th Street was the most logical application.


Typical signs along 4th Street South.


Modified MUTCD approved sign along 4th Street South.

were set up between 6th Street and 7th Street along Hennepin Avenue, the Nicollet Mall, Marquette Avenue, and 2nd Avenue South. A total of about 1,475 bicycles were counted in these four corridors. About 350 bicyclists were observed using Marquette Avenue, 325 used 2nd Avenue South, 200 used the Nicollet Mall, and over 600 used Hennepin Avenue. In Minnesota it is legal for a bicyclist to ride with vehicular traffic, even if there is a bicycle lane present. It is also important to note that bicycles are prohibited on the Nicollet Mall weekdays from 6 a.m. to 6 p.m. by city ordinance.

About 75 percent of bicyclists who chose to ride in the Hennepin Avenue, Marquette Avenue, and 2nd Avenue corridors used the bicycle lane. Unfortunately, improper use of the bicycle lanes was common. About 35 percent of those who chose to use the bicycle lanes on Marquette Avenue and 2nd Avenue that day were wrong-way riders. Wrong-way use was considerably less on Hennepin Avenue since there are dedicated bicycle lanes in each direction. One phenomenon that was observed was that wrong-way riding was worse along Marquette Avenue in the morning peak hours and worse along 2nd Avenue in the afternoon peak hours. One theory is that South Minneapolis has more bicycle commuters than other regions of the city and that bicyclists will take the quickest, most direct route possible from their origin to their destination. Clearly some bicyclists do not want to go a block out of their way to get to their destination, even if their behavior is illegal. At the easterly cordon boundary it was also observed that one-third of all bicyclists either used the sidewalk or chose to ride against traffic on one-way streets, both of which are prohibited by law. Bicycles are not permitted on sidewalks in downtown Minneapolis to avoid conflicts with pedestrians.

Looking south along Hennepin Avenue at 7th Street.

Looking north at the same location. Approximately 50 percent of the crashes that have occurred at this intersection (and also at the intersections of 7th Street and 3rd Street) between 1998 and 2003 have involved a left-turning car and a bicyclist going straight ahead. To mitigate this problem, bollards with warning signs have been placed where left turns are permitted. Although the bollards have improved safety, they must be removed in winter to allow for easier snowplowing. The bollards also help keep vehicles from cutting into the bike lane. Over one-third of all bicyclists in Minneapolis bike year-round.

Bicycle crashes in Minneapolis tend to be directionally proportional to the volumes of bicycles in a corridor, vehicular speed, vehicular traffic volumes, and the number of turning movements in a given corridor. After evaluating types of crashes and crash locations from 1999 to 2003, it was found that the above statement is accurate throughout most corridors in downtown Minneapolis. Bicycle crash rates on 2nd Avenue and Marquette Avenue appear to be typical for a corridor of its functional classification and characteristics. Hennepin Avenue crash rates also appeared to be typical, but crash rates were higher at intersections where left turns were permitted. This problem was mitigated with additional signs to warn turning vehicles to yield to bicyclists traveling across an intersection. Many of the crashes that occurred on Hennepin Avenue, Marquette Avenue, and 2nd Avenue involved a driver or a bicyclist who was using the corridor improperly.

Although no scientific bicycle survey has been conducted citywide, more than 600 bicycle surveys were distributed to bicyclists and neighborhood groups throughout the city in November 2001. Of the 188 bicyclists who responded to the survey, more than 28 percent felt that safety concerns and fear of drivers is the most significant barrier in arriving at their destinations. The lack of trails and on-street bikeways ranked second with 17 percent of responses, and ranking third at 8 percent of responses was the poor maintenance of bikeways, roadways, and bridges. A number of those surveyed indicated the importance of the downtown bicycle lane system, but many felt uncomfortable using the left side bike lanes. Novice and even intermediate adult bicyclists found it especially difficult to safely get on and off the bicycle lanes along Hennepin Avenue. Many experienced bicyclists commented that they would rather ride with traffic instead of use the left side bicycle lanes because they felt unnatural and counterintuitive.

There are several gaps and discontinuities that remain in the Minneapolis bicycle lane system. Many of these gaps and discontinuities are programmed for funding within the next five years. In downtown Minneapolis many of these discontinuities and gaps occur at the perimeter. There is need to connect with existing bikeways systems near the University of Minnesota and in residential areas throughout the city. Experimental mid-block and intersection treatments are now being explored to better integrate left-side bicycle systems on one-way streets with right-side bicycle systems on two-way streets.

## CONCLUSIONS AND RECOMMENDATION

After evaluating the left-side bicycle lane concept in downtown Minneapolis and along the Park and Portland corridors over the last several years, City of Minneapolis engineers are satisfied with the left side bicycle lane system. No significant changes are planned for any of the corridors discussed in this analysis, however greater enforcement is needed to ensure proper use of the facilities. What is important to note is the left-side bicycle lane system in downtown Minneapolis was created to accommodate specific needs given unique conditions and circumstances. This concept is not a one-size-fits-all treatment and is not appropriate in some situations. Although many bicyclists do not like the left-side bicycle lane concept, left-side bicycle lanes create a safer environment for bicyclists by effectively providing separation from buses.

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## COSTS AND FUNDING

Standard bicycle lane striping and counterpart signs cost about $50,000 per mile to implement in an urban setting. Roadway configurations and seal coat/pavement treatments are extra and project costs widely vary. For example it cost $100,000 in 1996 to implement the Marquette Avenue/2nd Avenue restriping, signs, and seal coating project (3.2 km (2 mi) long). The 4th Street reverse flow bus lane project was part of a $900,000 mill/overlay project about 1.6 m (1 mi) in length. Annual bicycle lane maintenance costs in Minneapolis have been estimated at about $6.50 per linear meter ($2 per linear foot).

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# Curb Radii/Curb Revisions

## BACKGROUND

When streets intersect at an obtuse angle or have a large curb radius, motorists can make turns at relatively high speeds. By contrast, 90-degree intersections and corners with tight curb radii tend to slow motorists down. The problem with obtuse angles is particularly bad when a vehicle on an arterial street turns onto a residential street. Motorists turning right at high speed may cut off bicyclists traveling straight on the arterial street. Pedestrians crossing the residential street adjacent to the arterial may not expect high-speed turning traffic, or they may have their backs facing the turning cars.

Obtuse angle intersection allowed motorists to make high-speed turns.

## COUNTERMEASURE

The solution to this problem in Seattle has been to reduce the turning radius. Seattle routinely reduces the curb radii at locations that: a) are on routes used by school children or the elderly; b) are in neighborhood shopping areas with high pedestrian volumes; and c) are at intersections identified by the neighborhood as having a unique safety problem.

The goal is to slow down right turning motor vehicles. This solution works particularly well where motor vehicles are turning right, at an obtuse angle, from an arterial street onto a residential street.

When making curb radii revisions, consideration must be made for truck and bus traffic. A curb radius that is too tight may result in the truck or bus crossing the double yellow line or overriding the curb. This can damage the curb and pose a risk to pedestrians. However, when a truck or bus is turning onto a four-lane roadway (two lanes in each direction), it often is acceptable to turn into the second (inside) lane as long as the center double yellow line is not crossed. Such turns would not be acceptable in cases where truck traffic is very heavy or there is a double right turn.

Seattle has adopted the following guidelines for reducing curb radii:

- A curb radius of 3 to 4.5 m (10 ft to 15 ft) is recommended where residential streets intersect other residential streets and arterial streets.
- A curb radius of 6 m (20 ft) is recommended at intersections of arterial streets that are not bus or truck routes.
- A curb radius of 7.5 to 9 m (25 ft to 30 ft) is recommended at intersections of arterial streets that are bus or truck routes.

Peter Lagerwey, Pedestrian & Bicycle Program Coordinator, City of Seattle

## EVALUATION AND RESULTS

Reducing the curb radius is expected to reduce turning speeds and increase the comfort of bicyclists traveling straight through past this junction. Seattle has not conducted a formal study to determine if crash rates have been reduced.

Curb realignment reduced the turning radius, forcing turning vehicles to slow. Crossing distance was also narrowed.

## CONCLUSIONS AND RECOMMENDATIONS

While many transportation agencies have increased curb radii over the years, these changes have had the effect of increasing the turning speed of motor vehicles. This has made bicycling and walking less safe and less inviting. In many cases, turning radii have been unnecessarily increased on neighborhood and arterial streets where there is little or no truck or bus traffic. Seattle has found that reducing curb radii is a relatively cheap, effective and popular way to create a more bicycle- and pedestrian-friendly community.

## COSTS AND FUNDING

The costs of changing curb radii can vary considerably, depending on the amount of concrete and landscaping that is required and also on whether drainage grates and other utilities have to be moved or if there are other issues that need to be addressed. For example, it may be necessary to move a conduit for a signal or relocate utility poles and light standards. In Seattle, costs typically range from as low as $5,000 to as high as $40,000.

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# Combined Bicycle Lane/Right-Turn Lane

## BACKGROUND

In many bike lane retrofit projects, there is not enough space to mark a minimum 1.2 m (4 ft) bike lane to the left of a right-turn lane. This case study focuses on a combined bicycle lane/right-turn lane used in Eugene, OR, when right-of-way at an intersection was limited. There are standard options for installing or retrofitting bike lanes onto shared roadways. The American Association of State Highway and Transportation Officials *Guide for the Development of Bicycle Facilities* (1999) shows accepted ways of accommodating bike lanes at intersections. Placement of bike lanes in conjunction with right-turn lane lanes must be done carefully, in that conflicts result between straight-through bicycles and right-turning motor vehicles (Hunter, Stewart, Stutts, Huang, and Pein, 1999). In some cases where insufficient room exists, the bike lane is dropped prior to the intersection. The *Oregon Bicycle and Pedestrian Plan* (Oregon DOT, 1995) recognizes this limitation and states that when this occurs, "a right-turn lane may be marked and signed as a shared-use lane, to encourage through cyclists to occupy the left portion of the turn lane. This is most successful on slow-speed streets."

## COUNTERMEASURES

The City of Eugene, OR, has such a shared, narrow right-turn lane in place on 13th Avenue at its intersection with Patterson Street. The avenue leads directly into the University of Oregon campus and has considerable bicycle traffic (see figure 1—left side diagram). Near campus, 13th Avenue has a speed limit of 48.3 km/h (30 mi/h) and carries 6,000 to 8,000 vehicles per day.

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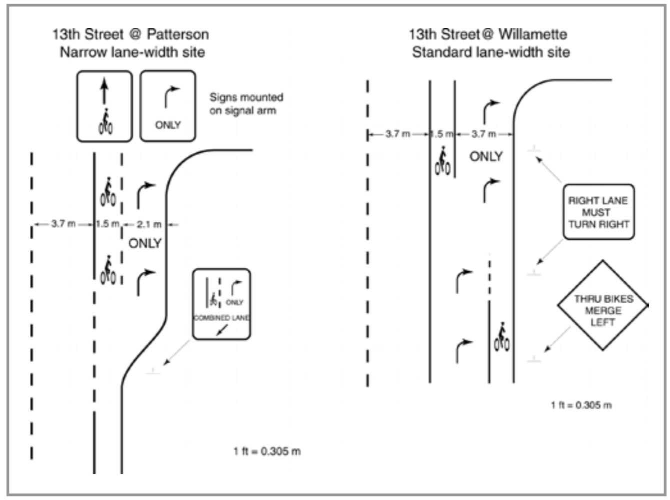


Figure 1. Narrow- and standard-lane views.

The left side of Figure 1 provides details for 13th and Patterson, which will be referred to hereafter as the narrow-width right-turn lane site. At this site, bicyclists usually approach the intersection in a 1.5 m (5 ft) bike lane at the edge of the street. At the intersection proper, the total right-turn lane width is 3.6 m (12 ft), which includes a bike lane (pocket) of 1.5 m (5 ft) and a 2.1 m (7 ft) space to the right of the bike pocket. The right side of Figure 1 provides details for 13th and Willamette, which will be referred to hereafter as the standard-width right-turn lane site. At this location, bicyclists also usually approach the intersection in a 1.5 m (5 ft) bike lane at the edge of the street. At the intersection proper, the total right-turn lane width is 5.2 m (17 ft), which includes a bike lane (pocket) of 1.5 m (5 ft) and a standard 3.7 m (12 ft) lane to the right of the bike pocket. Figure 1 also shows accompanying signs used at both intersections.

## EVALUATION AND RESULTS

The narrow right-turn lane described above was evaluated by comparing the behaviors of bicyclists and motor vehicle drivers at 13th and Patterson (an intersection that had the shared, narrow right-turn lane described above in



Figure 2. Videotaped bicyclists at the narrow-lane sites (above) and standard-lane sites (below).

place) with behaviors at 13th and Willamette (an intersection that had a standard-width (3.7 m (12 ft)) right-turn lane and accompanying bike lane (pocket) to the left of the right-turn lane). The intersection of 13th and Willamette is located about 0.8 km (0.5 mi) west of 13th and Patterson. These right-turn treatments had been in place for several years when this evaluation was done, and bicyclists were familiar with the movements.

It is important to note that bicyclists approaching on 13th at Patterson Street proceed straight ahead to the bike pocket at the intersection proper, in that the right-turn lane is "bulbed out." Bicyclists approaching on 13th at Willamette have to shift to the left to get in the bike pocket adjacent to the right-turn lane at the intersection (i.e., no "bulb out").

Approximately 600 bicyclists traveling through each intersection were videotaped during a three-week period in May 1998. Videotaping was done for two-hour periods at different times of the day and week to get a cross-section of bicyclists and to avoid recording bicyclists more than once. It is possible that some duplication occurred, but the number would have been quite small. Figure 2 shows the view from a video camera of oncoming bicyclists at both 13th and Patterson (the narrow-width site) and 13th and Willamette (the standard-width site). The videotapes were coded to evaluate operational behaviors and conflicts with motorists, other bicyclists, and pedestrians. Coded bicyclist variables included sex, age group, helmet use, whether a passenger was being carried, intersection approach position, position at the intersection, proximity of the bicyclist to motor vehicle at a red traffic signal indication, turning movements, traffic signal violations, and whether the bicyclist prevented a right-turn-on-red by following motorist. Coded motor vehicle information included type of motor vehicle beside the bicyclist at a red traffic signal indication, and motor vehicle type and position without a bicyclist present. We also coded whether any conflicts occurred. Conflicts between a bicyclist and a motor vehicle, another bicyclist, or a pedestrian were defined as an interaction such that at least one of the parties had to make a sudden change in speed or direction to avoid the other.

The technique worked well at the intersection locations evaluated in this study. More than 17 percent of the surveyed bicyclists using the narrow-lane intersection felt that it was safer than the comparison location with a standard-width right-turn lane, and another 55 percent felt that the narrow-lane site was no different safety-wise than the standard-width location. This is probably a function not only of relatively slow motor vehicle traffic speeds on 13th Street, but also because of the bike lane proceeding straight through the intersection at the narrow-lane site such that motorists crossing to the right-turn lane tended to have to yield. Bicyclists at the comparison intersection had to shift to the left to be positioned in the bike pocket next to the right-turn lane. It was also relatively easy for bicyclists to time their approach to the narrow-lane intersection and ride through on a green indication.

It was expected that bicyclists going straight through the narrow-lane intersection would position themselves either in front of or behind motorists. However, it was quite easy for bicyclists to ride up to the narrow-lane intersection and position themselves beside passenger cars or light trucks. The issue of the most appropriate position for a bicyclist at an intersection is not necessarily well understood or agreed upon. Positioning certainly can vary as a function of motor vehicle speed, traffic volume, turning movements, and a number of other variables. This evaluation pertains to a single location for this narrow-lane treatment, and it would be beneficial to compare bicyclist positioning choice here to what occurs at other intersection types, such as a shared through/right-turn lane with no bicycle lane or pocket.

Bicyclists at the narrow-lane site chose to position themselves in the adjacent traffic lane on a few occasions, usually the result of a heavy vehicle taking extra space. Sometimes bicyclists would shift to the right-turn portion of the lane if a heavy vehicle were in the through lane. Right turns on red by motor vehicles were rarely prevented when bicyclists were present at the front of the queue at the narrow-lane site. No conflicts between bicyclists and motor vehicles, other bicyclists, or pedestrians took place at either intersection.

The combined bicycle lane/right-turn lane design is shown in the *Oregon Bicycle and Pedestrian Plan* and has been reviewed, but not yet officially adopted, by the Oregon Department of Transportation's Traffic Control Device Committee. However, adoption is expected in the near future. For the present, favorable conditions for implementation appear to be on local streets with speeds of 48.3 km/h (30 mi/h) and traffic volumes of less than 10,000 vehicles per day. Adding a bulb-out to the combined bike lane/right-turn lane so that motorists move to the right and bicyclists continue in a straight line may also be a safer situation for bicyclists.

## CONCLUSIONS AND RECOMMENDATIONS

It is recommended that the design be implemented at other types of intersection locations (i.e., different motor vehicle approach speeds and approach configurations) and evaluated for effectiveness.

There are many intersections where using a minimum-width bike lane is not possible due to limited right-of-way. The use of a shared, narrow right-turn lane in combination with a bike lane in a limited right-of-way situation is a novel approach. This treatment could be applied in initial intersection design, when retrofitting a bike lane to an existing right-of-way, and when adding an auxiliary right-turn lane.

## COSTS AND FUNDING

Costs included the removal of paint (regular, not thermoplastic), new thermoplastic paint, a sign placed in the ground and another sign next to the signal head for about $1,500 in parts and labor. If traffic loops have to be moved, it would cost an additional $1,000 per lane.

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PORTLAND, OREGON #22

# Blue Bike Lanes at Intersection Weaving Areas

## BACKGROUND

Intersection and intersection-related locations account for 50 to 70 percent of bicycle–motor vehicle crashes (Hunter, Stutts, Pein, and Cox, 1996). In Portland, OR, both motorists and bicyclists had expressed concern about a number of locations where bicycles and motor vehicles came into conflict when motor vehicles turned, changed lanes, or merged across bike lanes at or near intersections. Colored pavement, raised crossing paths, and other measures have the potential to alert motorists and cyclists to these intersection conflict zones, thereby increasing yielding behaviors and reducing conflicts and crashes. Such treatments have been found to be effective in several European and Canadian cities (Pronovost and Lusginan, 1996; Jensen, 1977; Leden, 1977; Leden, Gårder, and Pulkkinen, 1998).

The 10 Portland sites selected for treatment and study were all sites with a high level of bicyclist-motorist interaction and a history of complaints. All were in areas with existing bicycle lanes. Prior to treatment, all of the bike lanes were outlined with dashed lines at the conflict areas. All except one of the sites also had in place traditional regulatory signs to alert motorists to "YIELD TO BIKES." The signs had been in place for some time and were in good repair. At one location, Hawthorne Bridge, where there was no yield sign for motorists, bicycles had been yielding to motor vehicles before the blue pavement and signs were added.

## COUNTERMEASURES

Each of the 10 sites were locations where the bicyclist travels through (straight ahead) and the motorist crosses

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Figure 1. Hawthorne bridge conflict area. Motorists exit right to an off-ramp, crossing the through bike lane that weaves left to cross the bridge. Example of a group 1 configuration.

the bicycle lane to: exit a roadway (group 1), move into a right turn lane (group 2), or merge onto the bicyclist's street from a ramp (group 3). (See figures 1–3 for examples.)

At all 10 sites, the conflict areas of the bicycle lanes were marked with light blue paint or with blue thermoplastic intended to highlight the conflict zone. The intent was to increase awareness and safe behaviors by both cyclists and motorists and yielding behaviors by motorists. Light blue was chosen because it doesn't have another meaning to motorists (as do red and green, sometimes used in other countries), can be detected by color-blind individuals, and usually is relatively visible in low-light or wet conditions. Additionally, blue was overwhelmingly favored by participants in a number of public presentations, as well as by bicycling professionals, and prior studies suggested that it would be an effective color.

The first sites were painted blue with glass beads applied to the wet paint at a total cost of $900. Unfortunately, within two to three months, the paint was worn away at some of the locations with higher traffic volumes. Therefore, at eight of the sites, a more expensive, thermoplastic, skid-resistant material was applied.

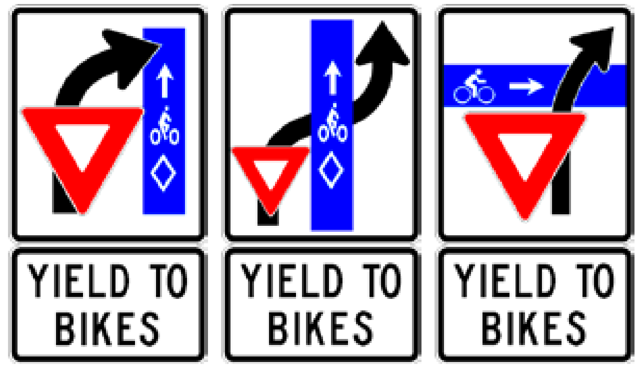

Figure 2. Motorists approaching Grand Avenue weave across a bicycle through lane to enter a right-turn- only lane on Madison Street. (Group 2 site)


Figure 3. Bicyclists approaching the Broadway Bridge travel straight, while motorists from Interstate Avenue entering Broadway cross the bike lane conflict area (outlined by the dashed striping). (Group 3 site)

At each location, one of several innovative "YIELD TO BIKES" signs was installed with a design appropriate for the particular motorist maneuver and configuration at that site (Fig. 4).

## EVALUATION AND RESULTS

Videotape analysis was used to compare before and after behaviors of both motorists and bicyclists in the conflict areas. Twenty hours of "before" treatment video data (two hours per site) and 30 hours of "after" data (two or four hours per site) were collected. Videotaping was performed at peak-hour ride times on days with good weather. Video data were compared with observations conducted before videotaping, and there was no evidence that the presence of the camera affected rider or motorist behavior. Each bicyclist traveling through a site




Group 1 - Exit right across bicycle lane | Group 2 - Lane change across bicycle lane | Group 3 - Entering roadway/merge across bicycle lane

Figure 4. Novel signs (non-MUTCD approved) used in conjunction with blue pavement marking to alert motorists and bicyclists of conflict areas and to warn motorists to yield to bicyclists.

was an observation, while each vehicle traveling through a site in the presence of a bicycle was also an observation. Videotapes were analyzed to code signaling, slowing and stopping, and yielding behaviors for both bicyclists and motorists, as well as head-turning or scanning behavior for bicyclists only.

Videotapes were also analyzed to code conflicts "before" and "after" treatment. Conflicts were defined as an interaction between motorist and bicyclist where at least one of the parties had to make a sudden change in speed or direction to avoid the other (a stringent definition).

Bicyclists' opinions on the treatment were solicited through an in-the-field, oral survey of 200 riders who had just traveled through one of the sites. A survey was also mailed to about 1,200 owners of vehicles who had been spotted driving through the same site as determined from license plate numbers. Responses were received from 222 of the vehicle owners. Additionally, city staff members performed test rides on wet treated surfaces to evaluate slipperiness. The sites were also informally evaluated for durability and wear of the markings.

As mentioned above, the painted markings did not last more than two months at high traffic locations. Almost a year after the thermoplastic treatments were applied, six of those eight locations showed little wear. One was in fair condition, and one was in poor condition because it may have been installed incorrectly. Thus, the higher cost for thermoplastic application may be offset by greater durability and lower maintenance costs. Neither the paint nor the thermoplastic was slippery, but neither material was as visible at night as had been expected.

## MOTORISTS

Motorist behaviors changed significantly in one or more ways at most sites. From the data pooled across sites, significantly more motorists slowed or stopped at the conflict area in the "after" period than in the "before" period (87 percent after compared to 71 percent before). Fewer motorists signaled their intentions after the blue pavement was installed (63 percent after compared with 84 percent before), but this result could partially be because the motorists yielded more frequently.

## BICYCLISTS

Most observable bicyclist characteristics (age group, helmet use, passengers carried) remained the same for the before and after periods, with the exception that there were 29 percent females before and 21 percent in the after period over all the sites. The percentage of bicyclists following the marked path through the conflict areas significantly increased over all sites from 85 percent before to 93 percent after the blue markings were added. Bicyclists slowing or stopping on approach to the conflict areas decreased from 11 percent to 4 percent after the treatment. Reduced slowing is interpreted to signify bicyclists' increased comfort in approaching the conflict areas.

Some desirable bicyclist behaviors decreased, however, after the treatment. Considerably fewer bicyclists turned their heads to check for motor vehicle traffic after the treatment than before (43 percent before, 26 percent after). Additionally, as with motorists, fewer bicyclists (4 percent) used hand signals to indicate their intended movement after the blue pavement was installed, although few bicyclists (11 percent) used hand signals in the before period either. It also should be noted that bicyclists would not be expected to signal at sites where they were riding straight ahead (all but two of the sites).

## MOTORIST AND BICYCLIST INTERACTIONS

A significantly higher percentage of motorists over all sites yielded to bicyclists after the blue pavement was installed — 92 percent in the after phase compared with 72 percent in the before period. Conflicts, as defined in this study, were infrequent in both periods, with eight coded in the before period and six coded in the after period. Conflict rates were therefore quite small — 0.95 per 100 entering bicyclists in the before period. This rate decreased to 0.59 per 100 after the blue pavement was installed.

There were differences by site and by type of site (group) in some of the outcomes noted above (for full report and analyses, see Hunter, et al. 2000). For example, after blue pavement was installed for the group 1 and group 3 sites described above, the percentage of bicyclists using the marked pathway increased significantly and the percentage of bicyclists slowing or stopping decreased significantly. Also, the percentage of motorists yielding to bicyclists increased significantly. Unfortunately, bicyclists turned to check for traffic less frequently at those groups of sites. In the group 2 sites, where motorists were shifting into a right-turn lane across a through bicycle lane (as opposed to entering or exiting the roadway), cyclists actually increased their scanning behavior and motorist signaling also increased significantly. The percentage of bicyclists using the painted area at the group 2 sites decreased after treatment, and motorist yielding did not change significantly at the group 2 sites.

## SURVEY RESULTS

The majority of bicyclists indicated the following:

- the pavement markings were no more slippery than before,
- motorists were yielding to bicyclists more than before,
- the treated locations were safer than before, and
- the markings increased motorist awareness of the conflict areas.

A majority of surveyed motorists noticed the blue markings and the signs. More motorists who noticed the signs also correctly interpreted that the blue pavement meant they should yield to cyclists. Nearly 50 percent of the motorists who responded said the treatment helped increase awareness of the conflict areas, while others expressed concern about creating a false sense of security for bicyclists.

## CONCLUSIONS AND RECOMMENDATIONS

These results suggest that colored bike lanes and accompanying signs may be one way to heighten both motorist and bicyclist awareness of some types of intersection and merge conflict areas, thereby creating a safer riding environment. Motorist yielding behavior increased overall and at six of 10 individual sites. Slowing by bicyclists approaching the conflict areas also decreased, signaling an increased comfort level among cyclists. Some of the treated areas still are in good condition, even five years after the thermoplastic markings were installed. Some are somewhat worn, but still functional. Others are greatly worn where traffic is heavy. The thermoplastic coloring seems to last two to three years in places with heavy traffic. Five years following installation, Portland's bicycle coordinator still has a high opinion of the value of the blue pavement markings. He has more sites identified for implementing this treatment when funds become available to install and maintain them.

More evaluations are needed of the use of this treatment as well as when and where such applications are appropriate, the effects and use of signs with markings, and the types of materials and colors that should be used. Additionally, bicyclists should be encouraged to continue their vigilance and scanning behavior after colored pavement markings are installed in conflict areas.

## COSTS AND FUNDING

| | | |
|---|---|---|
| Painted sites | materials and labor | \$900/10 sites |
| Blue thermoplastic sites | materials | 9,700 |
| | labor | 6,300 |
| Total: | | \$16,000/8 sites (1998) |

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The modification (blue bike lanes) that is the subject of this case study is not compliant with the *Manual on Uniform Traffic Control Devices*, nor is it currently being considered for inclusion. Accordingly, it is imperative that any jurisdiction wishing to utilize blue bike lanes (or any other non-approved traffic control device) should seek experimental approval from the Federal Highway Administration. For information on how to do so, please visit this Web site: http://mutcd.fhwa.dot.gov/kno-amend.htm.

PORTLAND, OREGON #23

# Crossing an Arterial through an Offset Intersection: Bicycle-Only Center-Turn Lane

## BACKGROUND

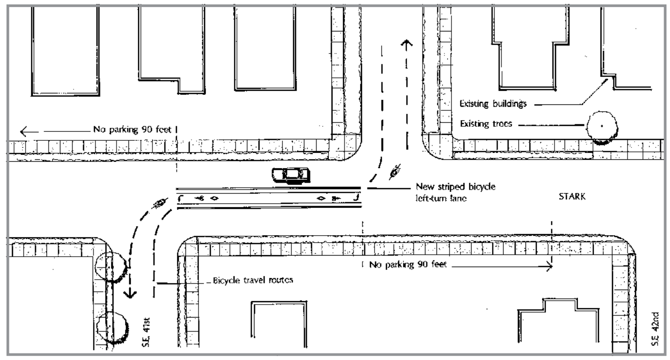
The North-South 40s Bikeway is a 12.2 km (7.6 mi) bicycle corridor about 4 km (2.5 mi) from Portland's downtown core. Developed in 1999, the bikeway runs the entire breadth of Portland from north to south, connecting residential neighborhoods to five commercial districts, six parks and 10 schools and intersecting 10 perpendicular bikeways. It comprises 9 km (5.6 mi) of bicycle boulevards, 2.9 km (1.8 mi) of bicycle lanes and 152.4 m (500 ft) of off-street path[1].

A minor arterial with an average daily traffic of about 10,000, SE Stark Street, intersects a segment of the bikeway on SE 41st Avenue. The junction is complicated by a 35 m (115 ft) offset of 41st as it crosses Stark. North and south approaches are stopped with stop signs. The standard set of crossing treatments were considered but posed significant drawbacks for this project. The only effective civil option would have been a median refuge, which would have prohibited some turning movements from Stark to 41st.

## COUNTERMEASURES

In the end it was decided to stripe a bicycle-only center-turn lane. This two-way, 3 m (10 ft) lane provides a refuge for cyclists who cross Stark by essentially executing first a right-turn onto Stark and then a left-turn back onto the bikeway[2].

Roger Geller, Bicycle Coordinator, City of Portland, Oregon




Rendering of bicycle-only center-turn lane.

Photo of bicycle-only center-turn lane as implemented.

## EVALUATION AND RESULTS

There has been no formal evaluation, but feedback from cyclists has been positive and the intersection continues to function as intended.

## CONCLUSIONS AND RECOMMENDATIONS

This treatment successfully addressed three criteria: it offered a refuge for crossing cyclists and allowed them to cross one direction of traffic at a time; it maintained all automotive turning movements, and it provided an inexpensive solution to this crossing that left more available funding for conventional civil treatments at other intersections on the bikeway.

## COSTS AND FUNDING

Costs for thermoplastic paint to make the bike markings were minimal. The project was implemented as part of a larger plan, so there is no break-out for this treatment.

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[1]Portland stripes bicycle lanes on roads with average daily traffic volumes of 3,000 or greater. Bicycle boulevards are low volume streets that generally work well for bicycling. The city typically improves arterial crossings, alters the stop sign pattern, and occasionally diverts automotive traffic to make them work better.

[2]We considered two options—crossing making first a right turn and then a left turn, or using the next street to cross making first a left turn and then a right turn. Doing the latter would require only striping receiving bicycle lanes on the cross street. We rejected that in favor of the right-turn first scenario because to make the left turn first would necessitate crossing both lanes of cross traffic at once, rather than crossing one lane at a time, as is done when making the right turn first.

# Improving Sight Distance between Cyclists and Motorists

## BACKGROUND

A shared-use pathway for bicyclists and pedestrians travels east to west along the Panhandle portion of Golden Gate Park, bordered by a couplet of one-way arterials. Fell Street, the west-bound portion of the couplet, is the closest to the path and to the north. The path travels along the park mostly free of intersections with any roadways except at Masonic Avenue where the path crosses the street in the south crosswalk. The intersection is controlled by a two-phase signal where motorists on Fell Street and people in the east-west crosswalk see a green light and WALK signal at the same time (see figure 1).

There are approximately 300 vehicles per hour turning left from Fell Street to Masonic Avenue in the evening peak hour. That same time is also peak usage for the pathway, which serves as a popular commute route for cyclists. In 2002, 100 cyclists per hour were counted on the path. Given city-wide trends and anecdotal observations, there are likely more cyclists than this today. The number of pedestrians and other wheeled path users contributes to the number of people in the crosswalk at any given time.

Given the popularity of the path, the number of left-turning vehicles traveling across the path, and the number of close calls reported, it has been widely recognized that improvements were needed to ease the potential for conflicts in the crosswalk.

Michael Sallaberry, PE, Associate Transportation Engineer, San Francisco Department of Parking and Traffic
Contributions by Dustin White, intern, San Francisco Department of Parking and Traffic


Figure 1. Aerial view of path intersection with Masonic Avenue and Fell Street.

## COUNTERMEASURES

About five years ago, some measures were implemented to improve this area. First, an approximately 3 m (10 ft) long red (no parking) zone approaching the intersection on Fell Street was painted to improve sight lines. Three meters in length was chosen as it was feared that a longer red zone would be routinely violated, as parking demand in the area was high and it may not be clear to motorists why a long red zone was needed. Later on, signs were installed stating LEFT TURN YIELD TO BIKES AND PEDS (figure 2).

Since then, the path was widened and repaved to handle increased demand. As the number of path users continued to climb, so did the number of reported collisions and near-collisions. Another round of improvements to the crossing was warranted.

Though many believed it might be time to have a separate phase for path users and for left turning vehicles, it was recognized that this change would require more time and funding for the needed signal upgrade. Some also thought that perhaps a more moderate, shorter term ap-


Figure 2. Signage at path crossing.

proach might suffice. In any case, all recognized the need for improvements in the near term. Thus, the next round of improvements included the following:

- A longer red (no parking) zone on the Fell Street approach to the intersection to improve sightlines
- Striping to encourage wider and thus slower left turn movements
- A ladder-treatment to the crosswalk with advanced stop bar on Masonic Avenue
- A leading pedestrian signal interval (see figure 3)

The proposed red zone improves sightlines between motorists and path users, and is now 18.3 m (60 ft) long, a 15.2 m (50 ft) extension of the existing 3.0 m (10 ft) zone. To improve compliance with this parking restriction, a cross-hatched area was striped in addition to the usual red curb paint and the NO PARKING signs. Speeds on Fell Street are controlled using regularly spaced signals and are 48kph (30mph) during the evening peak period. With a 15.2 m (50 ft) increase to the existing red zone, motorists are able to see people in the crosswalk 1.1 seconds sooner.

The same cross hatching used to emphasize the NO PARKING restriction also discourages motorists from moving closer to the curb as they turn right. A curved extension of the cross-hatching is intended to encourage wider and slower turn movements. Prior to the restriping, many motorists cut the turn with minimal reduction in their speed. The other striping change was to make the crosswalk a ladder-style crossing with a stop bar for northbound Masonic Avenue motorists. These markings were intended to increase the visibility of the crosswalk, and create some space between northbound motorists and the crosswalk. The additional space was intended to allow some margin of safety between path users entering the crosswalk on a stale green and motorists eager to proceed north at their green.

A leading pedestrian interval (LPI) of 3 seconds was also implemented to allow path users to establish themselves in the crosswalk before the platoon of vehicles on Fell Street arrived at the intersection. The LPI also provides a 3 second all-red for the intersection, a secondary benefit. It should be noted that the pedestrian signal is a countdown signal, which displays the amount of time left during the "flashing hand."

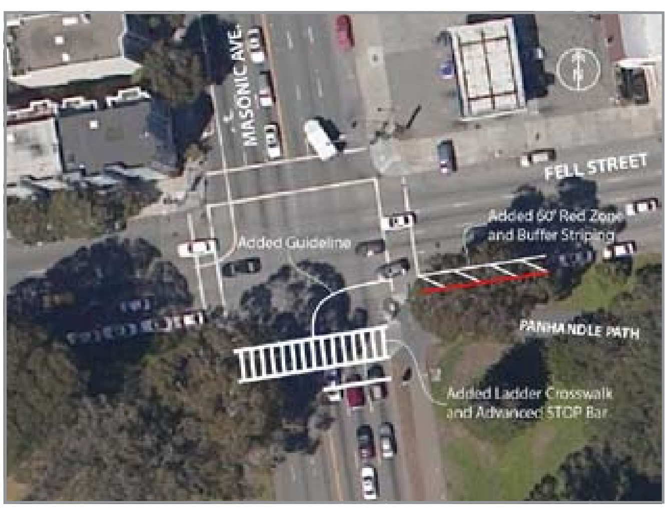


Figure 3. Aerial view of the intersection with the improvements.

Figure 4. Eastbound view of the crosswalk/path and westbound motorists on Fell Street.

## EVALUATION AND RESULTS

To determine the effectiveness of the changes, a survey was taken of path users. A more scientific approach would have been to observe the intersection and collect data. However, given limited resources and the difficulty of evaluating various levels of conflict and near-collisions between path users and left turning motorists, it was decided that a survey would have to suffice. The survey was taken at various times of the day, mostly on weekdays but also on a Saturday. An effort was made to pick 100 people randomly so that cyclists, pedestrians, and other path user groups would be represented.

Fifty-six percent of path users surveyed did not notice the changes. The 44 percent who did were asked on a 1 to 5 scale what they thought of the changes, 1 meaning "much more safe", 2 meaning "more safe", 3 meaning "no change," 4 meaning "less safe," and 5 meaning "much less safe." The average score from this response was 2.3, somewhere between "more safe" and "no change." More than half of the 42 who responded (two did not) gave a score of 2 ("more safe") while three respondents replied they felt either "less safe" or "much less safe."

Anecdotally, some observations have been made. Many motorists are still cutting the turn short, but a higher percentage than before is taking it wider and slower. Northbound motorists on Masonic Avenue obey the stop bar set back 1.5 m (5 ft) from the crosswalk approximately 80–90 percent of the time. Also, there have been very few incidents of motorists parking in the extended red zone. Based on the much higher incidence of motorists parking in the previous 3 m (10 ft)–long red zone, this indicates the crosshatching along the curb makes a difference.

## CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the survey and anecdotal observations, these changes have improved the crossing. However, as noted in the survey results, 56 percent of the respondents did not notice the improvements. The next steps are to consider additional short term improvements and concurrently consider the costs, benefits, and impacts of a separate phase for crosswalk users and left-turning vehicles. As the intersection is already near a volume/capacity ratio of 1.0, there is not much time during a signal cycle to work with. Splitting the phase would yield a significantly shorter crossing time for path users, up to half what it is today. Still, the proposal will be studied in greater detail so that a more informed decision can be made.

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## COSTS AND FUNDING

It cost approximately $5000 to design and implement the changes and take the survey. The funding was provided by the San Francisco Transportation Authority via Proposition K funds, a fund developed by a half-cent sales tax devoted to transportation improvements within the city and county of San Francisco.

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# Grandview Drive Roundabout and Corridor Improvements

## BACKGROUND

Because Grandview Drive (an arterial road) lacked adequate shoulders, children bicycling and walking to school were forced to travel along the edge of paved travel lanes, adjacent to 45 mph traffic. In 1996, the University Place Council and staff commenced a public involvement process in the community to determine the improvement options for Grandview Drive. Grandview Drive is a secondary arterial that provides access to a high school, middle school and over 200 residents. It ends at the City's undeveloped 700-acre waterfront. The one-mile stretch of road did not have any pedestrian or bicycle facilities, and although the speed limit on the road was marked as 35 mph (56 kph), the average speed was as high as 42 to 45 mph (73 kph). Therefore, the children were forced to negotiate this commute—adjacent to high speeding vehicles—by walking on the edge of travel lanes, as there was no other place for them to walk (see figure 1).

In addition, the intersection of Grandview Drive and Olympic Drive was controlled by a four-way stop, causing traffic to back up hundreds of feet in every direction during peak hours. Many impatient drivers, waiting to cross the intersection, did not pay attention to the pedestrians and bicyclists who were trying to cross the roadway.

## COUNTERMEASURES

After many public meetings, the City Council decided to build Washington State's very first modern roundabout at the intersection of Grandview Drive and Olympic Drive.

Ben Yazici, City Manager, City of Sammamish, WA; Former Assistant City Manager/Director of Public Works for City of University Place, WA
Contributions by Steve Sugg, Current Director of Public Works, University Place, WA

Figure 1. Grandview Drive before roundabouts bike lanes, and other improvements were added.

Initially, there was overwhelming opposition to the roundabout from the community. Many residents were concerned that it would create more safety problems for pedestrian and bicyclists. So, the Council decided to build a temporary roundabout for twelve months. At the end of the twelve-month period, an analysis was to be conducted, including an assessment of the community's acceptance along with technical data to help decide the fate of the roundabout.

The City did extensive research on the roundabout. Fewer and less severe accidents were expected with roundabout-controlled intersections than with signal or stop-controlled intersections. While there are 32 potential conflict points at a conventional (sign or signal controlled) intersection, there are only 12 potential conflict points in a roundabout (figure 2).

After the test period, community acceptance of the roundabout was measured at 75+ percent, so the Council decided to keep it as a permanent traffic control device. Ultimately, the entire roadway was reconstructed with curbs, gutters, sidewalks, bike lanes, planter strips and street lighting (see figure 3). And four additional roundabouts were

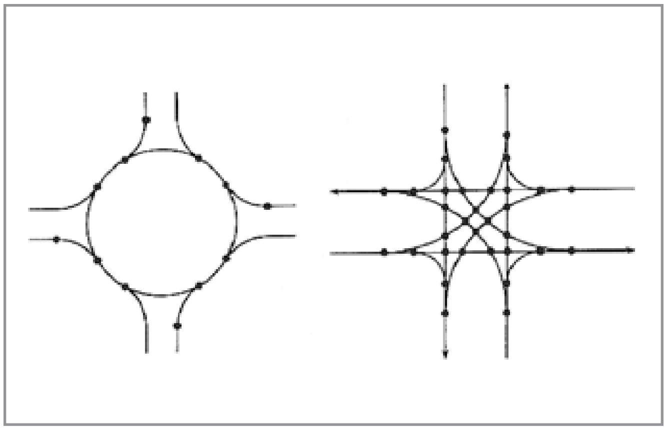

Figure 2. Diagram of conflict points at roundabout and conventional four-way intersections.

Figure 3. Redesigned Grandview drive with roundabout, bike lanes, crosswalks, curb and sidewalk with buffer strips and enhanced lighting.

constructed, along with four mid-block school crosswalks with yellow flashers.

## EVALUATION AND RESULTS

Delay and crashes have both decreased for motor vehicle traffic. Residents perceived the roadway's gravel shoulders as unsafe for pedestrians before the project, so pedestrians have a much greater level of comfort with the new design. And bicyclists are more comfortable because of the new bicycle lanes.

Average speed at a mid-block location on Grandview Drive was lowered from over 40 mph (64 kph) to 32 mph (52 kph). Another study of midday speeds found that the design with the roundabout and pedestrian and bicycle enhancements reduced average speeds by 4.1 mph (6.6 kph) without the support of increased enforcement. Average midday speeds on a parallel roadway that was targeted with heavy enforcement, but did not have any design changes, experienced a reduction of only 0.8 mph (1.3 kph).

ADT on Grandview Drive at Olympic Drive was 6932 in 1994, before the improvements, and 6503 in 2001, after the improvements were completed.

## CONCLUSIONS AND RECOMMENDATIONS

Because the roadway design is much more aesthetically-pleasing, residents now consider Grandview Drive to be the City's "linear park" as it connects to the undeveloped waterfront.

No official data have been collected, but pedestrian activity has increased along Grandview Drive. According to Steve Sugg of the University Place Public Works Department, "sidewalks brought the people out."

The project was a complete success as the citizens of University Place have overwhelmingly supported the street improvements and the roundabouts. Further, the Washington State Department of Transportation developed roundabout guidelines and many communities in Washington State built roundabouts after the Grandview Drive project was completed.

## COSTS AND FUNDING

The first roundabout, at Grandview and Olympic Drives, cost only $20,000 more than the projected cost of the traditional intersection improvement that was initially planned and designed for the intersection.

The entire project cost $6.15 million and was funded and built in three phases. It includes five roundabouts and over three miles (4.8 km) of reconstructed roadway. Funding came from a variety of sources, including City general funds (~$3 million), a low interest loan from a state public works revolving loan fund ($1.8 million), local bonds ($1 million), County funds and donated right-of-way ($320,000), and a contribution from a local gravel business ($50,000).

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# Innovative Application of the Bike Box

## BACKGROUND

Bike box is a term that has gained popularity in the United States for a European treatment usually known as the advanced stop bar (figure 1). The box is a right angle extension to a bike lane at the head of the intersection. The box allows bicyclists to get to the head of the traffic queue on a red traffic signal indication and then proceed first when the traffic signal changes to green. Such a movement is beneficial to bicyclists and eliminates conflicts when, for example, there are many right-turning motor vehicles next to a right side bike lane. Being in the box, and thus at the front of the traffic queue, also tends to make bicyclists more visible to motorists.

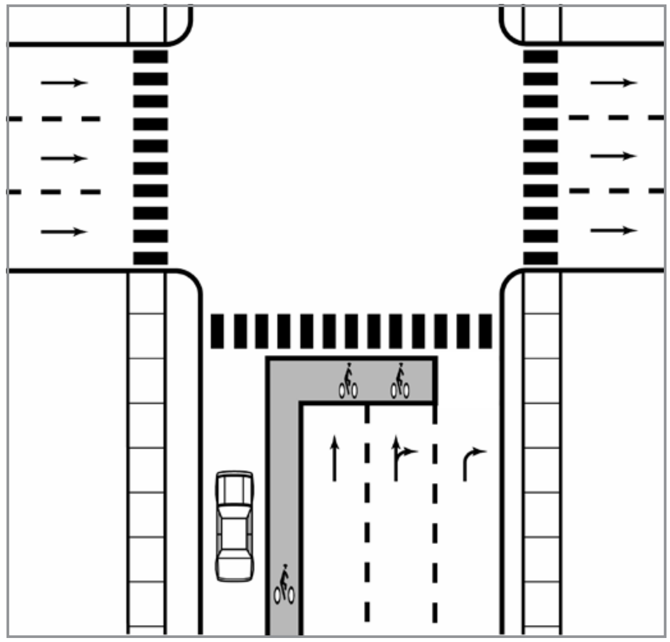

Figure 1. Diagram of a bike box used with left side bike lane.

## COUNTERMEASURES

A bike box and accompanying traffic signs, but with no special traffic signals to hold motorists or direct bicyclists to the box, were installed on High Street at 7th Avenue in Eugene, OR, in the summer of 1998. The application of the bike box was innovative in the sense that the intent was to give bicyclists a safer way to change from one side of the street to the other at a busy downtown intersection featuring two one-way streets. Prior to the box, the vast majority of cyclists approached on High Street in the left-side bike lane adjacent to parked motor vehicles. The bike lane was left-side to match with another one-way couplet and to avoid having a right-side bike lane next to intersections with double right-turn lanes. Many of the cyclists approaching in the left-side bike lane preferred to switch to the right-side (through) bike lane on the far side of the intersection because at the next block cyclists in the left-side bike lane must turn left. Moving from left to right side after the intersection entails crossing three lanes of traffic. The average annual daily traffic on High Street is about 8,500 vehicles per day, and the peak hour total is about 1,000 motor vehicles. When traffic was busy, bicyclists could have difficulty finding a gap large enough to allow an easy move from left to right. Some bicyclists were aggressive and used hand signals to indicate their movement from left to right. Many, however, simply stopped in the bike lane and waited for a suitable gap.

William W. Hunter, Senior Research Scientist,
UNC Highway Safety Research Center

Besides the crossover from left to right after the intersection identified above, there were a variety of other ways used by bicyclists to negotiate this intersection. Some would shift from the bike lane to the motor vehicle traffic lanes prior to the intersection. Others rode or walked their bicycle through the crosswalks on both High Street and 7th Avenue as pedestrians would, a movement that delays right-turning motorists. Some bicyclists would intentionally disobey the traffic signal at the intersection proper while motorists waited for the signal to change, move into the intersection, and then shift from left to right.

With the bike box in place, bicyclists desiring to change from the left to the right side of High Street can proceed to the head of the traffic queue on a red traffic signal indication and then cross over to the front of the second lane of traffic (figure 2). The second lane is a combination through/right-turn lane. The right-most lane is right turn only. Right turn on red is not permitted; however, some motorists do not comply. The box is not meant to be used on a green traffic signal indication.

Bicyclists have the right of way when in the box. They generally are able to accelerate quickly through the intersection ahead of motor vehicles when the signal changes to green, then safely switch to the through bike lane on the right-hand side of High Street such that motorists are not inconvenienced.

Several other steps were taken to help bicyclists and motorists understand the use of this innovative treatment at this intersection. A press release was prepared and stories run in the local newspaper and the University of Oregon student newspaper. A special sign board with information about how to use the bike box was placed on a construction barricade near the intersection pedestrian crosswalk. The barricade with educational sign also had a flashing light attached. Traffic signs with orange diamond attachments added for conspicuity were placed at the intersection to indicate that traffic, except bikes, should stop prior to the box on a red signal indication (STOP HERE ON RED, with EXCEPT BICYCLES mounted below). A yellow diagrammatic sign with a BICYCLES MERGING message was already in place.

## EVALUATION AND RESULTS

Cyclists traveling through the intersection were videotaped before and after placement of the box. The videotapes were coded to evaluate operational behaviors and conflicts with motorists, other bicyclists, and pedestrians. Other data concerning bicyclists' characteristics and experience, as well as their opinion of how the bike box functioned, were obtained through short oral surveys. These surveys were performed on days when videotaping was not occuring.

The use of a bike box to facilitate the movement of bicyclists from a left-side bike lane, through an intersection, and across several lanes of a one-way street to a right-side bike lane was an innovative approach. The data indicated that the use of the box was reasonably good. Usage can be examined several ways.


Figure 2. Three bicyclists using the box correctly.

- For all bicyclists coming through this intersection, 11 percent used the box as intended (i.e., approaching from the left-side bike lane and then moving into the box on a red traffic signal indication).

- Including bicyclists who used the box through other maneuvers, such as crossing from left to right before the intersection and then moving into the box, 16 percent of all bicyclists used the box.

- Narrowing further, of the bicyclists who approached in the left-side bike lane and then crossed to the right side of the street (the bicyclists for whom the box was most intended), 22 percent used the box.

- Many more bicyclists in this target group could have used the box (i.e., they had a red signal indication and enough time to move into the box). Had these bicyclists done so, then some 52 percent would have used the box. This last percentage thus approximates the upper limit of bike box use for this pilot location and left-to-right maneuver during this time period.

A problem with motor vehicle encroachments into the box likely diminished the amount of use. Overall, encroachments occurred in 52 percent of the red traffic signal indications after the box had been in place for five months. While this is not uncommon, even in Europe where the design has been in place for some time, it is troubling, and remedies should be sought. Bicyclists surveyed about the pilot location tended to frequently complain about the encroachment problem.

The bike box had no effect on signal violations. Some 6 to 7 percent of bicyclists violated a red signal indication both before and after placement of the box.

The rate of conflicts between bicycles and motor vehicles changed little in the before and after periods. The rate was 1.3 conflicts per 100 entering bicyclists before the bike box and 1.5 conflicts per 100 entering bicyclists after. However, the pattern of the conflicts did change. Eight of the 10 conflicts in the before period involved a bicyclist moving from left to right across the travel lanes after the intersection. Two of the 10 conflicts in the after period were of this type. Six of the after conflicts took place within the intersection proper, but three of these involved bicyclists coming off the right sidewalk and conflicting with right turning motor vehicles. No conflicts took place while using the bike box in the normal sense.

## CONCLUSIONS AND RECOMMENDATIONS

Use of the bike box to help bicyclists negotiate a difficult maneuver at this intersection was considered to be a rigorous test. All things considered, the innovative treatment worked reasonably well. More evaluations should be conducted in other settings and for other maneuvers to further understand how well this design works in the United States and how it might be improved. For upcoming evaluations, a number of recommendations can be made.

- Education of both bicyclists and drivers as to the proper use of the box is important. This can be accomplished through newspaper stories, radio and television public service announcements, brochures in bike shops, etc. The special education sign posted at the Eugene intersection came about after it was learned in the oral survey of bicyclists that the box was not well understood. One of the bicyclists participating in the oral survey suggested use of a banner across the roadway. This would be an excellent way of drawing attention to the presence of the box and the expected movements, especially for motorists.
- Use of bold demarcation of the box is vital. This could involve wider striping than the norm or perhaps painting the box a bright color.
- Steps should be taken to limit motor vehicle encroachment. Setting stop bars back a short distance from the box might lessen encroachment. Offset (or staggered) stop bars also would be beneficial, not only for encroachment purposes but also to help motorists see bicyclists moving into the box. Some police presence may also be necessary to instruct, warn, or ticket motorists about improper encroachment.

In summary, the bike box is a promising tool to help bicyclists and motorists avoid conflicts in certain kinds of intersection movements. More boxes need to be installed and evaluated to further understand their effectiveness in different settings. Pilot testing the Danish treatment of recessed stop bars for motor vehicles is also recommended.

## COSTS AND FUNDING

Costs included paint (regular, not thermoplastic) removal, new thermoplastic, two signs near intersection and informational sign for approximately $2,500 parts and labor. If traffic loops have to be moved: $1,000/lane extra.

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The modification (bike box) that is the subject of this case study is not compliant with the *Manual on Uniform Traffic Control Devices*, nor is it currently being considered for inclusion. Accordingly, it is imperative that any jurisdiction wishing to utilize the bike box (or any other non-approved traffic control device) should seek experimental approval from the Federal Highway Administration. For information on how to do so, please visit this Web site: http://mutcd.fhwa.dot.gov/kno-amend.htm.

# Comprehensive Maintenance Planning for Bicycle Facilities

## BACKGROUND

A comprehensive budget and maintenance plan should be developed before construction of a bicycle facility. The costs involved with maintaining a facility should be considered and budgeted for during the planning process.

The most important concept to keep in mind when considering maintenance costs is the direct relationship between what is built and what is maintained. If you build it, it will have to be maintained. If you don't build it, it won't have to be maintained. For example, if you install automatic sprinkler systems, you will have to follow a sprinkler maintenance schedule supplied by the manufacturer. If you install informational and directional signs, you will have to replace a certain percentage of them each year. Your facility design, therefore, should directly reflect the amount of money you anticipate having available for maintenance.

A second important concept to keep in mind is that it is very difficult to secure maintenance dollars. Foundation and government grants, while available for design and construction of bicycle facilities, are generally not available for maintenance. Additionally, it is difficult to get the public involved in raising funds for routine maintenance. The lesson is that maintenance costs are best addressed through prevention. For example, it is always easier to include the cost of installing a good drainage system in the initial cost of a project than it will be to secure funding for fixing a drainage problem at a later date.

The third and final important point is that developing an accurate maintenance budget is a process, not an exact science. Because of differences in bookkeeping methods, wages, facility design, topography, availability of maintenance equipment, community expectations and a host of other variables, it is impossible to determine the potential maintenance costs of any one facility, per mile per year. For example, two identical trails in different communities will frequently have radically different per-mile maintenance costs. It is, however, possible to develop an accurate estimate of maintenance costs for a particular facility system if proper procedures are followed.

Peter Lagerwey, Pedestrian & Bicycle Program Coordinator, City of Seattle

## COUNTERMEASURE

Seattle's solution for developing a maintenance program for bicycle facilities has been to develop and implement a seven-step approach:

### 1) EXISTING COSTS

When developing a maintenance plan for a new facility, the first step is to check current costs for maintaining an existing facility. The key is to get the costs for maintaining a facility that is similar to the facility you plan to construct. When reviewing cost information, go over the budget with someone who can explain exactly what items are included in the cost figures. For example, you will want to know if they include labor and overhead costs. Do they include one-time costs on major equipment such as sweepers and trucks? Do they include charges for bringing debris to the local landfill? Do volunteers do some of the maintenance?

### 2) BOOKKEEPING

A second important step is to find out costs that will be assigned for various maintenance activities. In particular, you will want to look at major equipment, labor and overhead costs. For example, if you are going to need a sweeper, the agency may have a separate capital fund to pay for the sweeper, in which case you only pay the labor costs of the operator. On the other hand, the maintenance budget may be charged a per-hour fee that covers the amortized, lifetime costs associated with the purchase and maintenance of the sweeper. Labor and overhead can also vary greatly. For example, a maintenance employee who makes $14 an hour may actually cost the maintenance budget $28 per hour if all overhead costs are included. Again, every agency keeps its books differently, with some having separate budgets for categories like benefits, office space, and management support, and others having bookkeeping systems that include these items in their per hour labor costs. The bottom line is that the bookkeeping methods used by the agency managing your bicycle facilities will have a major impact on how you develop a maintenance budget.

### 3) MAINTENANCE CHECKLIST AND COST

The next step in developing a maintenance budget and plan is to create a checklist of all possible maintenance activities. A good way to begin is to list everything included in the facilities design. Once again, the rule of thumb is that you will have to maintain whatever you build. Besides each maintenance activity, list its frequency, its cost per application, and its annual cost. Listing the annual cost, while a lot of work, is doable if you are familiar with the bookkeeping system and with how charges will be assigned.

### 4) ROUTINE AND MAJOR MAINTENANCE

Once you have completed a draft list of maintenance activities, divide them into "routine" and "major" maintenance categories. In general, maintenance activities such as mowing, that have a frequency of one or more times per year, will fall into the category of routine maintenance. Activities such as repaving a trail surface, that have a frequency of two or more years, will fall into the category of major maintenance. While major maintenance occurs infrequently, it should be budgeted for on an annual basis to avoid the periodic need for a major infusion of cash.

### 5) MAINTENANCE PRIORITIES

Once you have divided maintenance activities into routine and major maintenance categories, you will want to set maintenance priorities by identifying which activities are critical to the safe operation of the facility, and which ones are critical to other objectives, such as protecting the investment in the infrastructure, protecting the environment, and protecting aesthetics. While some priorities may vary to reflect local community expectations, safe operation of the facility should never be compromised. The American Association of State Highway and Transportation Officials (AASHTO) *Maintenance Manual* recommends that maintenance should seek to maintain conformance with the design guidelines used to build the facility. Where proper guidelines were not used, maintenance should include improvements that will improve the facilities' safety and operation.

### 6) TRACKING

The final task is to create a tracking system to insure that all maintenance activities are completed in a timely, systematic way. More than likely, the agency that will manage a facility already has a system in place. Typically, you will want a checklist for field crews that includes instructions and frequency. Once completed, checklists should be reviewed and kept on file for developing future maintenance budgets and plans. There also needs to be a system for requesting specific maintenance improvements such as sign replacement. A standardized work instruction form should be developed and sent to the field crew, then returned to the maintenance supervisor for filing once the work has been completed. Finally, there needs to be a way to track resident complaints and requests for maintenance. This is particularly critical from a liability standpoint. Once an agency has been "put on notice" concerning a particular safety-related maintenance problem, it must be corrected within a reasonable period of time. When residents call or write in, their concern should be put on a standard form that includes the resident's name and day phone number, the date, and the location and nature of the problem. This should be followed up with a field visit and a call back to the resident explaining what, if anything, will be done about the situation. Again, all complaints should be filed for future reference.

### 7) MAINTENANCE BUDGET AND PLAN

Once the above steps have been completed, the maintenance budget and plan is ready to be put in final form. It should include a checklist of all maintenance items, the frequency of each activity, the cost for each activity, the annual cost of each activity and an indication of who will perform the activity. Priorities related to safe operation of the facility should be clearly identified and a tracking procedure clearly outlined.

### SAFETY

As previously mentioned, maintenance activities related to the safe operation of a facility should always receive top priority. The AASHTO *Maintenance Manual* identifies seven maintenance activities that should be carried out on a routine basis. They include:

#### Signs and Traffic Markings

Signs warning both the motorist and bicyclist should be inspected regularly and kept in good condition; and striping should be kept prominent.

#### Sight Distance and Clearance

Sight distances on parallel roadways and trails should not be impaired leading up to crossings and curves. Trees, shrubs and tall grass should be regularly inspected and either removed or trimmed if they can interfere. Adequate clearances on both sides and overhead should be checked regularly. Tree branches should be trimmed to allow enough room for seasonal growth without encroaching onto the street or trail.

**Surface Repair**

Streets and trails should be patched or graded on a regular basis. It is important that finished patches be flush with the existing surface. Skid resistance of surface should be the same as the adjoining surface. Ruts should be removed by whatever measures are appropriate to give a satisfactory result and avoid recurrence.

**Drainage**

Seasonal washout, silt or gravel washes across a street or trail, or sinking should be watched for and appropriate measures taken. Installation of culverts or building small bridges could be considered a maintenance function to achieve an immediate result and avoid the expense of contracting. Drainage grates should not have parallel openings that could catch narrow bicycle tires. Maintenance personnel should be especially instructed to assure that grates are positioned so that openings are at angles to the bicyclist's direction.

**Sweeping and Cleaning**

The tires of a bicycle can be easily damaged by broken glass and other sharp objects. Bicycle wheels slip easily on leaves or ice. Small solid objects such as loose gravel or a stick on an asphalt surface can cause a serious fall. There also should be concern when mechanically sweeping roadways that material is not thrown onto a bike lane, shoulder or trail. Materials such as bark or gravel may ravel and necessitate frequent sweeping.

**Structural Deterioration**

Structures should be inspected annually to ensure they are in good condition. Special attention should be given to wood foundations and posts to determine whether rot or termites are present.

**Illumination**

Lighting improvements should be made at busy arterials. Once installed, the lights should be maintained not only to guarantee reliable operation, but also to ensure that they are kept clean and replaced as required to maintain the desired luminescence.

### SAMPLE MAINTENANCE ACTIVITY LIST

The following is a partial list of some of the maintenance activities to consider when developing a maintenance budget and plan. It is important to note that this list should be modified to reflect your particular needs and community expectations. This includes identifying priorities and classifying activities as routine or major maintenance. For example, while mowing may be a weekly activity in a wet, warm area, it may never be required in a dry, arid part of the country. When you develop your own plan, you will want to include the frequency, cost per application, cost per year and specific instructions for each item listed as previously described.

- Replace missing and damaged regulatory and directional signs.
- Repaint worn pavement markings.
- Trim trees, shrubs and grass to maintain sight distances.
- Patch holes, fill cracks and feather edges.
- Clean drainage systems, make modifications to eliminate the formation of ponds.
- Sweep to remove mud, gravel and other debris
- Mow bike lane, roadway and trail shoulders (0.8 to 1.5 m (2.5 to 5 ft) back from facility).
- Inspect structures for structural deterioration.
- Spot pruning to maintain view, enhance aesthetics.
- Maintain furniture and other furnishings.
- Mow selectively where groomed look is desired.
- Install and remove snow fences.
- Maintain irrigation lines.
- Pick up trash, empty trash cans.
- Clean rest rooms and drinking fountains, repair as needed.
- Remove graffiti from retaining walls, rocks, etc..
- Prune dense understory growth to improve user safety.
- Spray for weed control.
- Remove snow and ice.
- Maintain emergency telephones.

## EVALUATION AND RESULTS

Seattle's Maintenance Program is evaluated by the feedback of residents, the number of claims resulting from poor maintenance and the number of people bicycling.

The program is a success by all measures. The city has been recognized five times as one of the best bicycling cities in North America. Public involvement has been and continues to be high with the Bicycle Program Web site, the location visited most frequently by those accessing the Seattle Department of Transportation site.

## CONCLUSIONS AND RECOMMENDATIONS

After more than 30 years of building and maintaining bicycle facilities, Seattle has been very successful in encouraging people to bicycle more often while reducing the number of crashes. Additionally, Seattle residents enthusiastically support the program and have twice voted for million dollar bonds and levies to construct more bicycle facilities.

## COSTS AND FUNDING

Multiple funding sources include gas tax funds, general revenue funds, B & O Tax funds, car tab revenues, federal and state grants, etc.

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# Road Hazard Identification Pilot Project

## BACKGROUND

Road conditions such as potholes, debris, drain grates, cracked or uneven pavement, railroad tracks, and overhanging vegetation can cause bicyclist crashes by disturbing the delicate balance between rider and machine. These hazards may contribute to falls which account for 50 percent or more of bicyclist crashes. Road hazards also may result in crashes with fixed objects, other bicyclists, or motor vehicles if a bicyclist swerves to avoid a hazard. Collisions between bicyclists and motorists are usually the most serious. More than 90 percent of bicyclist fatalities occur in crashes with motor vehicles (Baker, et al, 1993). In 2003, 622 bicyclists were killed and 46,000 injured in reported crashes with motor vehicles in the United States (National Center for Statistics and Analysis, 2003 data). Road hazards increase the chances that a bicyclist will be involved in a crash.

In addition, bicyclists tend to avoid roads and trails that they feel have unsafe or otherwise uncomfortable riding surfaces. Decreased bicycling may result if more acceptable routes are not available.

Bicyclists are often reluctant to report road hazards because they do not know how and they often believe that the necessary repairs will not be made even if reported. It is often difficult for cyclists to identify which jurisdiction has maintenance responsibility for a given section of road such as the city vs. the county.

Road crews seldom are trained to identify and repair bicycle road hazards. They are typically better at dealing with hazards for motorists. However, by the time something is hazardous for motorists, it has long been a danger to bicyclists. For example, a 1.3 cm (0.5 in)–wide crack in the road that runs parallel to the direction of travel is sufficient to cause a bicyclist to fall, but will not present a problem to motorists (California. Dept. of Transportation, 1995).

Peter Flucke, President – WE BIKE

Bicycle tire in a drain grate.

The Road Hazard Identification Pilot Project was developed and tested for the Wisconsin Department of Transportation. Local sponsors were the Village of Howard and the Bay Shore Bicycle Club. The project was based on similar "spot improvement" programs in Seattle, WA, Chicago, IL, and Madison, WI. The goal was to develop a system which could be used by public or private entities to easily and inexpensively facilitate the identification and repair of bicycle road hazards. Such a system improves bicyclist safety and enjoyment as well as cooperation between bicyclists, road crews and decision-makers. The greater Green Bay, WI, area consisting of six municipalities within Brown County was chosen to pilot test the project. Before the pilot program there were no organized efforts, either public or private, to identify and repair bicycle-specific road hazards. Municipalities in the pilot project area ranged in population size from 1,400 to 96,000.

## COUNTERMEASURES

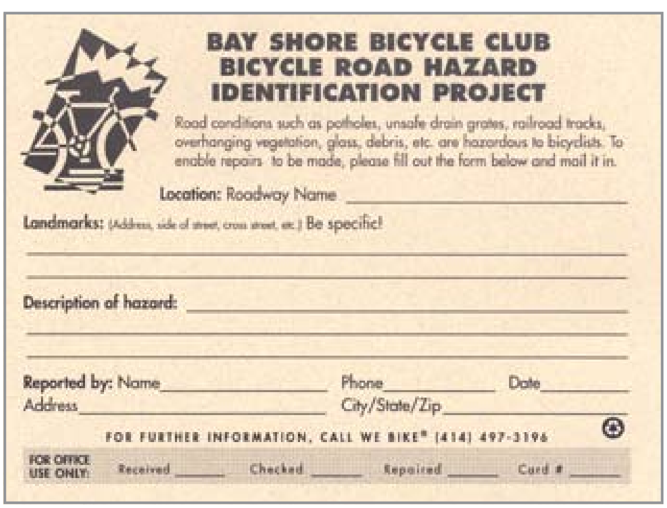
The pilot project ran from June through September 1995 in the greater Green Bay, WI, area. Road Hazard Identification postcards were distributed to the public through bicycle shops, bicycle clubs, recreation departments, county, city, and village offices. These cards were used by bicyclists to report hazards. After a card was completed it was mailed (at the sender's expense) to a central location where the hazard identification information was entered into a specially designed computer database. The database allowed the hazard to be tracked by the project coordinator from the time it was reported until it was repaired. The database also assisted in identifying which jurisdiction was responsible for repairs, and in creating hazard reports which were sent to affected jurisdictions. Following data entry, the card was given to a trained volunteer who checked the card and hazard for accuracy and validity via a site visit. Two weeks after hazard reports were forwarded to jurisdictions, repair status updates were requested. The project coordinator contacted jurisdictions personally for subsequent status reports.

Prior to the implementation of the pilot project, a computer program was developed for tracking hazards, volunteer inspectors were identified and trained, public works directors and the County Highway Commissioner were consulted, and specialized bicycle road hazard training was offered to each jurisdiction involved.

## EVALUATION AND RESULTS

Road Hazard Cards were tabulated to determine the number of hazards reported and the repair status of these hazards. Hazard inspector activity was analyzed, and bicyclists, inspectors and public works supervisors were surveyed about the project.

During the four-month pilot project, 120 hazards were reported. Of these, 23 were repaired or deemed unrepairable. The "unrepairable" designation usually referred to minor streets that were in overall rough shape but that were not scheduled for resurfacing for several years. The other common situation was where a sheet of concrete road surface had risen up or subsided and because of the excessive cost of repair, the repair would not be made until the situation became much worse or, more likely still, when the entire road was replaced. (Without major road work, 67 were scheduled for repairs and the remaining 30 were working their way through the system at the time the pilot evaluation ended.)



BAY SHORE BICYCLE CLUB
BICYCLE ROAD HAZARD
IDENTIFICATION PROJECT

Road conditions such as potholes, unsafe drain grates, railroad tracks, overhanging vegetation, glass, debris, etc. are hazardous to bicyclists. To enable repairs to be made, please fill out the form below and mail it in.

Location: Roadway Name ____________________

Landmarks: (Address, side of street, cross street, etc.) Be specific!

Description of hazard: ____________________

Reported by: Name ______________ Phone ____________ Date ____________
Address ______________ City/State/Zip ______________

FOR FURTHER INFORMATION, CALL WE BIKE® (414) 497-3196

FOR OFFICE USE ONLY: Received ______ Checked ______ Repaired ______ Card # ______

Twenty-four different bicyclists reported hazards during the pilot project. Reporters tended to be experienced bicyclists, often commuters, who reported hazards primarily on busy, narrow collector and arterial streets.

Positive outcomes of the project as reported by the project coordinator, public works supervisors, hazard inspectors and bicyclists were:

For bicyclists:

- Increased awareness of road hazards;
- Increased opportunities to report hazards;
- Increased bicyclist safety;
- A core group of "hazard" educated bicyclists formed;
- Professional contacts by bicyclists developed with street departments;
- Ease of implementation;
- Change in street departments attitudes;
- Hazards often were repaired before they could be reported because of increased awareness among road crews.

For municipalities:

- Safer streets;
- Decreased exposure to liability;
- Decreased maintenance costs;
- Ease of implementation;
- Cost-effective to identify hazards and coordinate repairs;
- Improved traffic flow;
- Good public relations;
- Less critical attitudes of bicyclists toward public works departments.

There still are several areas of concern which need to be further addressed:

For bicyclists:

- Relatively small number of bicyclists reported hazards;
- Project information may not be reaching all bicyclists;

- Some reporting bicyclists were discouraged because of slow hazard repairs (perceived or actual);
- Some hazards were difficult for inspectors to locate because of inadequate site descriptions ;
- Continuation of project following pilot test.

For municipalities:

- Slow to make repairs;
- Hazards were sometimes difficult to locate;
- Some hazards are expensive to repair (including sections of entire streets);
- Some jurisdictions communicated poorly with project director;
- No maintenance department accepted the offer of bicycle hazard identification training for their staff;
- Project/effort discontinued following pilot.

## CONCLUSIONS AND RECOMMENDATIONS

A formal system for identifying road conditions that are hazardous to bicyclists is important for improving bicyclist safety and enjoyment. Once established, the Road Hazard Identification Project proved to be an inexpensive and effective means of identifying and facilitating the repair of bicycle road hazards. This program, or a similar one that incorporates bicyclist and professional training and input, would be valuable in any community.

## COSTS AND FUNDING

The main costs of developing the program are project coordinator training and research (about eight hours), computer database setup (about eight hours), inspector and public works trainings (about three hours) and advertising (about three hours). The project coordinator spent about two hours per week on the project, and public works supervisors spent about the same amount of time.

Funding for the project was provided by the Wisconsin Department of Transportation's Bureau of Transportation Safety using Federal Highway Safety (402) Funds. The total cost of the project, including development and the pilot test, was $9,615.

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# Bikeway Speed Humps

## BACKGROUND

Portland's Bike Program enlisted the help of the Traffic Calming section for a speed hump project in spring 1998. Speed humps were identified by local citizens as the most appropriate tool to address traffic problems on Southeast Clinton Street. Though three traffic circles were constructed toward the east end of Clinton in 1990, speeding vehicles continued to be a problem. Clinton had been designated a City Bikeway but did not have adequate curb-to-curb width to mark bike lanes without removal of parking. Reduction of traffic volume on the street was obtained in conjunction with the 1990 project that installed traffic circles, so speed reduction was the primary objective for this project.

The specific goal of the project was to enhance street safety for bicycle riders by reducing the 85th percentile speed of vehicles using Southeast Clinton closer to the legal maximum speed limit of 25 mph. Portland has determined speed humps to be an effective tool to reduce traffic speeding.

Southeast Clinton was divided into three segments for the undertaking of this project. A middle portion of the street, 21st Avenue to 26th Avenue, is part of a transit route that jogs through the neighborhood. This segment of Clinton necessitated a speed table design by City policy.

Southeast Clinton is a local service street and serves a mixed single-family residence and commercial neighborhood. Southeast Clinton is fairly level and straight. The entire length of Southeast Clinton has parking, sidewalks and curbs on both sides of the street.

Scott Batson, PE, Senior Engineering Associate, Traffic Investigations Section, Bureau of Transportation Management, Portland Office of Transportation

### OPEN HOUSE

Residents along Southeast Clinton were invited to an open house on June 3, 1998, to review and comment on the proposed speed hump installation. Forty-five people attended the open house. Most of those who attended expressed approval for the proposed project. Some considered the humps to be excessive or inadequate, while others expressed concern over noise and hump location. A petition was available at the open house for residents along Southeast Clinton to sign, and was circulated after the open house by local residents. Petition results in aggregate for the three segments were as follows:

| In favor of speed humps | Number | Percent of Total |
|---|---|---|
| Yes | 179 | 77 |
| No | 52 | 23 |
| Total | 231 | 100 |

## COUNTERMEASURES

Five 4.3 m (14 ft) speed humps, at 121.9 to 161.5 m (400 to 530 ft) spacing, were constructed along the 0.7 km

(0.44 mi) length of Southeast Clinton, from 12th to 21st avenues. Two 6.7 m (22 ft) speed tables were constructed along the 0.4 km (0.24 mi) length of Southeast Clinton, from 21st to 26th in the segment used by transit. Nine 4.3 m (14 ft) speed humps, at 97.5 to 182.9 m (320 to 600 ft) spacing, were constructed along the 1.3 km (0.83 mi) length of Southeast Clinton from 26th to 39th avenues. The projects were completed between September 26 and October 18, 1998, by Portland's Bureau of Maintenance.

## EVALUATION AND RESULTS

Standard velocity and volume counts, before and after speed hump construction, were used to measure the change in vehicle speed. Measurements taken after speed hump construction were averaged over the length of the street for comparison to speed before construction. The after velocities were weighted based on distance from the center of the nearest speed hump. Manual peak-hour turning movement counts were also conducted to assess the change in usage by cyclists. Counts were taken six months after construction was completed.

### TRAFFIC SPEEDS

Table 1 describes the change in speed in the three sections of Southeast Clinton.

The changes in traffic speed associated with this project were typical of speed hump projects elsewhere in Portland.

### TRAFFIC VOLUME

Table 2 summarizes the change in traffic volume in the three sections of Southeast Clinton.

Typical daily fluctuations of traffic volume are expected to be 10 percent. The 25 to 30 percent reduction on Southeast Clinton is greater than normal (see table 2). The 1990 traffic circle project was constructed as part of an effort to deter use of Clinton as an alternative to parallel streets of higher classification.

Table 2. Vehicle Volume Changes

| Segment | Speed Hump | Average Volume, vpd[1] Before | After | Change |
|---|---|---|---|---|
| 12th to 21st | 14 ft | 3400 | 2300 | -30% |
| 21st to 26th | 22 ft | 3300 | 2450 | -25% |
| 26th to 39th | 14 ft | 2600 | 1800 | -30% |
| [1]Vehicles Per Day | | | | |

Table 3. Cyclist Usage

| East-West 7-9 AM | | | |
|---|---|---|---|
| Intersection | Before | After | Change |
| Clinton at 26th | 40 | 66 | 40% |
| Clinton at 39th | 20 | 35 | 75% |
| East-West 4-6 PM | | | |
| Intersection | Before | After | Change |
| Clinton at 26th | 37 | 83 | 128% |
| Clinton at 39th | 24 | 36 | 50% |

Traffic volume measurements at over 40 locations adjacent to Southeast Clinton identified four that had volume increases that warranted additional monitoring. Subsequent reevaluation determined the volume increases to be anomalous.

The increase in usage by cyclists is another indication of the success of this project (see table 3). Feedback from local residents has been very positive.

## CONCLUSIONS AND RECOMMENDATIONS

Traffic calming on Southeast Clinton from 12th to 39th Avenues successfully reduced the average 85th percentile speed

Table 1. Vehicle Velocity Changes

| Segment | Speed Hump | Average Speed[1], mph | | Highest Speed[1], mph | Speeders, Over Posted 25 mph | | Speeders, Over 35 mph | |
|---|---|---|---|---|---|---|---|---|
| | | Before | After | After | Before | After | Before | After |
| 12th to 21st | 14 ft | 33 | 25 | 27 | 80% | 12% | 10% | 0% |
| 21st to 26th | 22 ft | 26 | 24 | 26 | 15% | 8% | 0% | 0% |
| 26th to 39th | 14 ft | 31 | 25 | 28 | 58% | 8% | 15% | 0% |
| [1]85th Percentile Speed | | | | | | | | |

closer to the posted speed and produced an unexpected benefit of decreasing the number of cars using the street. The speed reduction associated with the use of speed humps will provide increased safety to cyclists using this bikeway.

Feedback from cyclists regarding a preference for speed humps versus speed tables has been mixed. It is unclear from this project if speed tables would have had as significant an effect on speeding if they were implemented along the entire project length. It is likely that speed tables will produce less discomfort to cyclists than do speed humps. A common theme with traffic calming projects is the tradeoffs such projects involve. The potential discomfort of the cyclist traversing a speed hump or table should be compared to the discomfort associated with the speed of adjacent vehicles.

Southeast Clinton is part of a dense grid of streets (typical 61-m (200-ft) block faces). Monitoring of adjacent streets for unintended diversion is critical. If diversion is identified as a significant issue and possibility, modification of the hump layout or use of the longer table design is recommended.

## COSTS AND FUNDING

| Item | Cost | Quantity | Subtotal |
|---|---|---|---|
| 4.3-m (14-ft) speed hump, including markings | $1,500 | 14 | $21,000 |
| 6.7-m (22-ft) speed table, including markings | $1,800 | 2 | $3,600 |
| Warning Signs and posts | $160/ group | 7 | $1,120 |
| Total Construction Costs | | | $25,720 |

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# Speed Cushions for the Evergreen Corridor Bike Lane Project

## BACKGROUND

Evergreen Boulevard serves as a popular bike route with great potential as a bike commuter route. It was rated by the *Cycle Clark County Map* as having a low level-of-service for bikes. Its roadway classification is collector with an average daily traffic of 3200 vehicles per day. It connects between downtown and a large residential neighborhood. The width is 9.8 m (32 ft), with parking allowed on one side before the project (figure 1). It has commercial bus service that serves both blind and deaf students in the area.

Figure 1. Evergreen Boulevard before the project in area of speed cushions.

The street was an old state highway before the construction of Washington SR 14 and still provides access to the City's Historic Reserve.

Community goals for the project were to improve bicycle safety and compatibility, pedestrian access for persons with disabilities, to slow traffic, and to enhance the roadway aesthetics with the hope of spurring redevelopment.

John Manix PE PTOE Neighborhood Traffic Engineer, City of Vancouver, WA

The work on the corridor was broken down into phases. This report focuses on Phase 1 from E. Reserve to Grand Boulevard.

Speeding on Evergreen Boulevard was a common neighborhood complaint with the speed posted at 25 mph. The 85th percentile speed was 34 mph, with about 90 percent of the vehicles traveling over the speed limit.

The phase 1 section of Evergreen Boulevard is 0.65 miles long and had relatively few collisions. In the three years before construction, 20 collisions were reported with the majority (12) at Grand Boulevard. The majority of the collisions at Grand Boulevard were "approach turn" collisions related to Grand Boulevard traffic, not Evergreen Boulevard. Most of the other collisions were at minor intersections and were of the "right angle" type. No bike or pedestrian collisions were reported along Evergreen Boulevard in the phase 1 section.

The surrounding and adjacent neighborhood associations had identified a goal of creating a bicycle path along Evergreen Boulevard in their Neighborhood Action Plan. Installation of a path was infeasible, so the alternatives were to install bike lanes, place signs along a bike route, or improve an alternative route.

The project scope proposed installation of bike lanes on Evergreen Boulevard, but this required removal of all on-street parking. Removal of parking is never popular, particularly on this section with commercial land use. Knowing parking restriction would not be popular, staff proposed installation of bike lanes and "streetscape" improvements to minimize the protests associated with the loss of parking. The streetscaping was supported by the local neighborhood association because it reinforced the goal to beautify the street.

After extensive public involvement, the consensus was to install bike lanes on most of Evergreen Boulevard but to leave 26 on-street parking spaces for three blocks in the commercial district. To enhance bicycle compatibility in this section with shared travel lanes and on-street parking, traffic calming was proposed. Traffic calming also addressed resident concerns with speeding on Evergreen Boulevard.

The traffic-calming tool of choice was then an important consideration. Typical speed humps were ruled out based on the impacts to commercial transit service and fire department response time. The use of certain traffic calming measures was controversial with bicyclists because of safety concerns. A previous traffic-calming project on a popular bike route used curb extensions that generated many bicycle safety complaints associated with bike riders being pinched between moving traffic and the curb extensions.

## COUNTERMEASURES

Staff had, for some time, considered the use of "speed cushions" as an alternative to speed humps to provide an effective traffic-calming tool on arterial, collector, or local streets that serve as emergency response routes.

Speed cushions are modified speed humps. The shape resembles a cushion or pillow placed in the roadway, but a speed cushion does not span the entire roadway or traffic lane. The intent is to slow most motor vehicles, similarly to a speed hump, but to allow wide wheel-based vehicles such as buses and fire trucks to drive over them with minimal impact, as cushions are narrower than the wheel base of these vehicles.

In researching the topic, staff found speed cushions in use in the United Kingdom as early as 1993 and learned of American experience in the cities of Sacramento, CA, and Austin, TX. Sacramento's experience with what they refer to as a "speed lump" was particularly important because these devices are designed for the same size of fire engine and commercial bus as used in Vancouver. Figure 2 illustrates the trial speed lump from Sacramento.

Vancouver tested speed cushions using rubber speed hump components that could be assembled to match the Sacramento speed lump width dimension of 1.8 m (6 ft) (see figure 3).

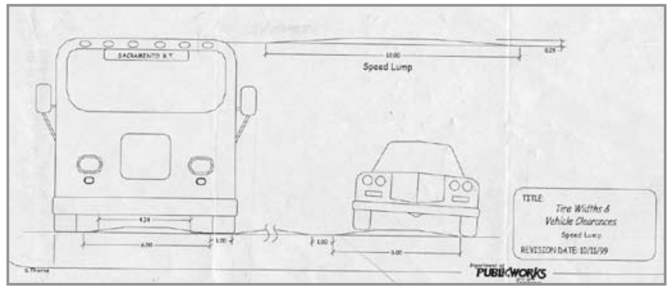

Figure 2. Sacramento speed lump.

Figure 3. Trial rubber speed cushion.

These trials allowed the City to test several configurations related to the position of speed cushion in the street. For example, should one cushion be placed in the center of the roadway like Sacramento's speed lump, or should they be placed in the center of the travel lane? If in the lane, how far apart should adjacent cushions be?

With the fire department's endorsement of the rubber speed cushion, the City implemented two other traffic calming projects concurrently with the Evergreen Corridor bike lane project that used speed cushions. These projects were West 33rd Street from Main Street to Columbia Street, and Southeast 155th Avenue from Southeast Mill Plain Road to Southeast 1st Street. They were only intended to slow traffic and were not intended as bike improvements. The before and after speed survey data from the three projects as well as one other is provided in the evaluation.

## EVALUATION AND RESULTS

Before and after bike counts were collected, compared and found inconclusive. The pre-project Evergreen Boulevard bike volumes were about 1 percent of the total traffic as measured in the midweek afternoon peak hour. The after volume was about the same but at this small a sample size, the staff does not feel confident that the results can be attributed to the project.

*The Bicycle Compatibility Index: A Level of Service Concept* (Bicycle LOS) by FHWA was used to evaluate the projects' effects on bicycling on Evergreen Boulevard. This method is straightforward and matches local experience. In previous work, staff found that this evaluation tool approximately matched the evaluation used by the Clark County Bicycle Advisory Committee's Bike Map (*Cycle Clark County*) that independently rated roadways for bicycle compatibility. The Bicycle LOS evaluation included comparing the shared lane with parking on one side of Evergreen Boulevard section before and after the speed cushions were installed, and also that of the section with bike lanes and no parking allowed.

The secondary performance measures were related to community goals not exclusively linked to bicycling. The neighborhood hoped for a reduction in speeding. This objective was evaluated with a before and after speed survey, a traffic count, and a collision history review. The speed survey and traffic count data were collected via hose counters in the vicinity of the proposed traffic calming before and midway between speed cushions following installation. The traffic data were collected for one midweek day. This report includes the results of three other speed cushion projects to evaluate the effectiveness of this relatively new traffic calming tool.

Staff anticipated a collision reduction associated with the traffic calming. The city's collision database was queried for three years before and one year after the project was implemented.

City staff hoped the speed cushions would demonstrate a bicycle, fire truck, and transit-friendly speed hump design. To evaluate these objectives, staff solicited comments from local bike club members, the local transit agency and the fire department.

The results of installing speed cushions in the section of Evergreen Boulevard with parking improved the Bicycle Level of Service or Compatibility, but not nearly as much as the section with bike lanes and no parking. Table 1 shows the results of the Bicycle LOS evaluation.

Table 1. Bicycle Compatibility Index Results for Evergreen Boulevard.

| Midblock Identifier | BCI | Level of Service | Bicycle Compatibility Level |
|---|---|---|---|
| Evergreen Boulevard—Before Project EB without Parking | 3.47 | D | Moderately Low |
| Evergreen Boulevard—Before Project WB with Parking | 3.47 | D | Moderately Low |
| Evergreen—After Project with bike lanes & no parking | 1.97 | B | Very High |
| Evergreen—After Project WB with Parking | 3.24 | C | Moderately High |
| Evergreen—After Project EB without Parking | 3.24 | C | Moderately High |

The LOS changed from a high D to a mid-level C with the addition of speed cushions. This minor change is significant because LOS of C is noted in *The Compatibility Index: A Level of Service Concept, Implementation Manual* as a bench mark for roadways where casual bicyclists are expected. As a popular recreational bikeway, this is a reasonable expectation for Evergreen Boulevard.

The Bicycle LOS of B for the bike lane section confirms staff efforts to keep the shared lane section as short as possible.

The Bicycle LOS evaluation looked at the before and after traffic data, noting changes in traffic volume, speed and parking occupancy of the on-street parking. The Bicycle LOS was calculated for each direction because parking was allowed on one side only. But parking had little impact on the Bicycle LOS because the occupancy rate is low (less than 25 percent) both before and after the project.

In all cases, the speed cushions significantly reduced the speed of vehicles and have likely reduced the number of collisions. Table 2 shows the results of the speed survey and collision history of the four streets with speed cushions. All locations had very consistent results.

Table 2. Traffic Survey Results of Streets with Speed Cushions.

| Roadway with Termini | Traffic Collisions per yr | Daily-Traffic Volume | 85% Speed | Percent-age of Vehicles Over 30 MPH |
|---|---|---|---|---|
| Evergreen Boulevard; X St to Winchell—Before | 1.25 | 3,900 | 34 mph | 42% |
| Evergreen Boulevard; X St to Winchell—After | 0 | 3,400 | 29 mph | 8% |
| W 33rd St; Washington to Columbia—Before | NA* | 3,300 | 33 mph | 19% |
| W 33rd St; Washington to Columbia—After | 0 | 3,000 | 29 mph | 7% |
| SE 155th Ave; Mill Plain to SE 1st St—Before | 0 | 3,400 | 34 mph | 37% |
| SE 155th Ave; Mill Plain to SE 1st St—After | 0 | 3,100 | 28 mph | 9% |
| NE 49th St: NE 26th St to Work St—Before | .33 | 1,500 | 35 mph | 44% |
| NE 49th St: NE 26th St to Work St—After | 0 | 1,300 | 31 mph | 17% |

* This location had speed humps changed to speed cushions to address fire department concerns with response delays associated with humps.

The 85 percent speed is at or slightly lower than 30 mph on all streets that have a 25 mph speed limit. More importantly, the percentage of vehicles over 30 mph dropped dramatically (see table 2).

The traffic volume on each of the streets with speed cushions dropped about 10 percent. This traffic diversion could cause complaints on parallel routes, but no complaints have been received.

None of the four sites had a significant number of collisions in the three years before the project. One year after the installation of speed cushions, there are encouraging, but inconclusive results with no collisions since installation (see table 2).

The following information was gained from the trial with rubber humps and permanent installation of four projects:

- The proposed shape of a speed cushion matching the profile of our current speed hump (7.6 cm (3 in) high and a 4.3 m (14 ft) parabolic curve profile), 1.8 m (6 ft) wide with side ramps of 3.7 m (12 ft) (1:4 grade) could be traversed by a fire engine without significant impacts.

- Using a speed cushion less than 1.8 m (6 ft) wide (one trial at 1.7 m (5.5 ft) significantly compromised effectiveness).

- Speed cushions should be spaced approximately 91.4 to 121.9 m (300 to 400 ft) apart along a roadway to keep the 85 percent speed of traffic at or below 30 mph.

- The configuration shown in figure 4 should be used with parking restrictions in the vicinity of the speed cushion if the street is narrower than 11.6 m (38 ft). With our West 33rd Street project, we review conflicts between parked cars and fire trucks. The West 33rd Street is 11.5 m (36 ft) wide. Based on our work, the fire department staff concluded that the distance between the parked car and the fire truck (about 0.6 m (2 ft)) was too close for them to feel comfortable responding to an emergency at normal speed and safely traversing the speed cushion. See figure 5 for a photograph of a fire engine traversing a speed cushion near a parked car. In the case of West 33rd Street, we are modifying the design by restricting parking on one side of the street and adjusting the position on the other side to allow for greater clearance between parked cars and the fire trucks.

- The speed cushion should be positioned in the center of the travel lane so buses and fire engines can align over the center of the cushion and remain within the travel lane.

- The speed cushion should be used on straight sections of roadway for fire trucks to position over the hump. From our trial it appears that speed cushions installed on a horizontal curve will be of little benefit because the rear wheels do not track the same as the front.

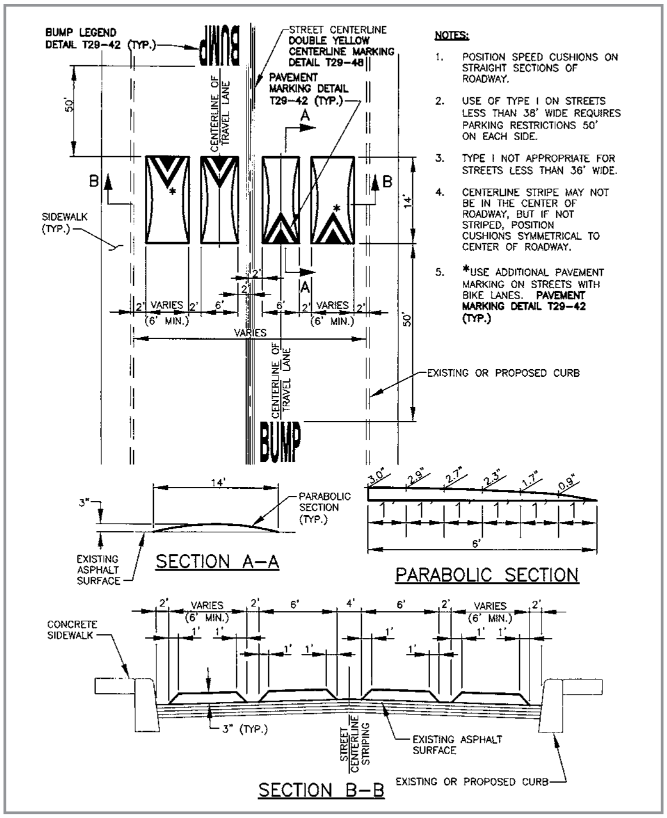


Figure 4. Speed cushion design configuration for 36–38 ft streets—use with parking restrictions.


Figure 5. Fire engine over speed cushion—too close to parked vehicle.

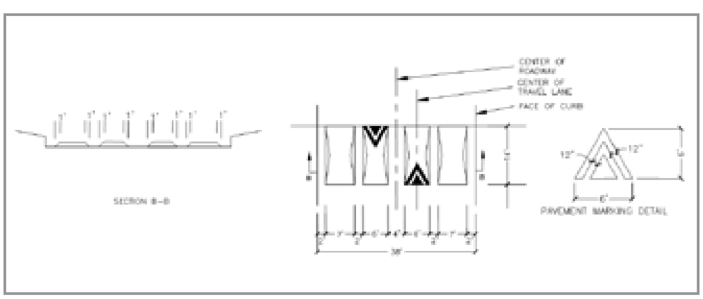


Figure 6. Speed cushion design with pavement marking.

- The gap between the speed cushions should be 0.6 m (2 ft). Our 0.3 m (1 ft) spacing appeared too narrow.

- With the speed cushion centered in the travel lane and the marking centered over the cushion, the marking helps fire engine and bus drivers line up wheels to straddle the cushion. This design also facilitates the use of a marking that is in compliance with the *Manual on Uniform Traffic Control Devices, Millennium Edition*, (U.S. Department of Transportation Federal Highway Administration, 2001).

Figure 6 shows the speed cushion with pavement marking detail that is in compliance with the MUTCD ME.

Our striping crew has added the same pavement marking on the additional hump which spans the shoulder-parking area to the right of the speed cushion. This marking is technically incorrect but conforms with past practice used by many agencies that use an arrowhead-type marking on humps.

The first comments regarding the speed cushions on Evergreen Boulevard from Vancouver Bicycle Club (VBC) members were negative because the speed cushions were initially installed incorrectly, making them uncomfortable to ride over. This was true for both cars and bikes. They also objected to them because of concerns with loss of control and apparent lack of need. After the modifications, the City received the following comment from a member of VBC:

> "Bicyclist" stopped in to tell you that you that Evergreen Boulevard is "wonderful." He was very pleased with the speed bumps being "redone." We also have received positive comments regarding the bicycle improvements on the corridor.

Comments related to transit have been very positive. The C-Tran representative commented:

> Thanks for the information that you provide; it was very helpful. I checked with the current operators driving through Evergreen Boulevard and have not had any negative feedback. In fact, the cushions seem to be allowing them the ability to travel through with limited interference. They appear to be "transit-friendly" with the most recent adjustments.

Another comment from a City Council member to the City Manager:

> While on the same bus trip with the Japanese kids I referenced earlier, we took Evergreen eastbound. (It looks absolutely GORGEOUS.) The bumps were no

problem for the driver. In fact, he said that they were so much better than Portland's. That was Evergreen Coach that took us. Big bus, not uncomfortable at all.

Fire department staff gave positive comments on the speed cushions several times. The quality of the ride on Evergreen is relatively poor because of dips at cross streets, so it is not an important response route. The West 33rd Street traffic calming project demonstrated that the fire engine drivers need ample clearance (0.9 m (3 ft) or more) with parked cars to traverse the speed cushion at full speed.

The staff has taken several comments from the public regarding the lack of effectiveness of the speed cushions. The comments are generally related to comparison with speed humps and can be paraphrased as: "I can drive over those humps at a high rate of speed." But the speed data do not support that opinion.

## CONCLUSIONS AND RECOMMENDATIONS

Adding speed cushions to Evergreen Boulevard increased the Bike LOS to a level (C) that will accommodate recreational riders expected on this facility, and allowed the city to address the desire of the commercial community to maintain on-street parking. But if parking had significantly increased, the lower speeds and volumes would not have adequately compensated to keep the Bicycle LOS to C. The Bike LOS evaluation methodology is more sensitive to changes in parking than the speed of traffic.

Thus the use of speed cushions is not recommended as a replacement for bike lanes for long sections of roadway, but they are a valuable tool in assuring that the total project was a success in accommodating multiple interests – in this case the businesses that valued parking, bicyclists that needed safe bicycle facilities, and transit and emergency response. Speed cushions are relatively new traffic calming tools that appear to be successful at calming collectors or arterials that serve both as fire response and transit routes and carry moderate levels of bicycle traffic.

Traffic calming remains controversial with some bicycle riders. The main concern with speed cushions relates to loss of control by hitting the tapered side of the speed cushion near the gutter. If the speed cushion design can provide a clear wheel path through the speed cushion, this safety concern would be addressed. On future projects with bike lanes the city plans to modify the design to minimize the risk that bicyclists will traverse the speed cushion on the tapered side.
The use of traffic calming on streets classified as "collector" will always be controversial. If time proves speed cushions to be a successful traffic calming tool, we must be wary of overuse. A likely negative outcome of overuse is diversion of traffic onto parallel residential streets. In the past, increases in emergency response time and the high cost of alternative traffic calming tools have limited deployment. Because speed cushions address these issues, adoption of policies to prevent a slippery slide of overuse is recommended. The policy should limit the use on collectors to bracketing important crosswalks, parks, schools or short sections of parking on bike routes.

## COSTS AND FUNDING

Speed cushions (material and labor): $2,000 each

Funded within a larger project included a Federal Transportation Enhancement grant and local matching funds.

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# Neighborhood Mini Traffic Circles

## BACKGROUND

Seattle's Neighborhood Traffic Control Program (NTCP) started in 1968 when the city began to respond to resident requests to slow motor vehicle traffic and reduce the number of crashes at intersections of residential streets. Of all the treatments used in Seattle, the traffic circle has proven to be the most effective at solving this problem. Since 1973, over 800 circles have been constructed in Seattle and NTCP staff members receive about 700 resident requests for new circles each year.

## COUNTERMEASURES

Potential traffic circle locations are identified through community requests or investigation of high accident intersections. Each request is investigated and an initial assessment is performed to determine if a traffic circle is feasible. Residents' requests are responded to with a letter explaining the process for installing a circle and the likelihood of the location competing successfully for full city funding. In order to ensure that the city's traffic safety funding is allocated to intersections demonstrating the greatest need, a priority point system is used to rank the intersections where traffic circles are requested. Ranking criteria include the number of crashes that have occurred at the intersection in the last three years; traffic speed (85th percentile); and traffic volume. To compete for funding, residents are required to submit a petition with signatures representing 60 percent of the households within a one-block radius of the proposed traffic circle. Funding is allocated starting with the intersection with the worst combination of problems and proceeds as far down the list as funding allows. The cost to construct each circle ranges from $4,000 to $7,000.

Each traffic circle is individually designed to fit the intersection without having to modify the street width or corner radii. Most of Seattle's local streets are 7.6 m (25 ft) wide and traffic circles are usually 3.7 to 4.9 m (12 to16 ft) in diameter. A single unit truck having a 13.7 m (45 ft) turning radius is used as a design vehicle to ensure that fire trucks can pass by the circle without running over the curbs. The fire department reviews all intersections where circles are to be constructed and field tests are conducted where they have a specific concern. While traffic circles are designed to allow fire trucks to pass by them, they are constructed with a 0.6 m (2 ft)–wide mountable curb that allows fire trucks or larger vehicles, such as moving vans, to run over the curb without damaging either the vehicle or the circle.

Landscaping is included in all the traffic circles as long as a neighborhood volunteer is identified who will maintain the circle (almost always). The pavement inside the traffic circle is removed during construction to allow for drainage and to accommodate tree roots. The landscaping plays two important roles—it makes the circle more at-

John Marek, Neighborhood Traffic Control Program Engineer, City of Seattle
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tractive to the neighborhood residents, and changes the character of the street to make it less appealing for high speed driving. The local residents are required to maintain the plantings, which consist of ground cover and one to three trees. Residents are allowed to add their own low-growing plants that will not block pedestrian or driver visibility.

## EVALUATION AND RESULTS

Traffic circles are evaluated by comparing the number of crashes occurring in the 12 months before and the 12 months after a traffic circle is installed. Additionally, surveys are mailed to residents following the construction of a traffic circle.

In 1997, a study of 119 traffic circles constructed between 1991 and 1994 showed a 94 percent reduction in all types of crashes. Since the study, subsequent spot checks of other locations have produced similar results. While most of the non-arterial intersections in Seattle have no right-of-way control, 32 of the 119 locations studied had existing two-way stop or yield signs, which were removed when the traffic circles were installed. These locations, which previously had right-of-way control, experienced accident and injury reduction rates similar to those found at uncontrolled intersections.

In addition to reducing accidents, traffic circles have been effective at reducing vehicle speeds but have not significantly reduced traffic volumes. The effect on speed generally carries over to the middle of the block, but to a lesser extent than near the intersection. As might be expected, multiple circles at every intersection are more effective than an isolated circle. The minimal impact on traffic volumes allows circles to be used as a spot or street-long safety device without needing to address the impacts of traffic diverting to other residential streets.

Traffic circles generally have been well-accepted by bicyclists. The circles slow down motor vehicle speed, which reduces the speed differential between bicyclists and motor vehicles. Bicyclists have not complained of being "squeezed" by motor vehicles as they go around the circle since the speeds of the motor vehicles are comparable to the bicyclists. A few bicyclists have complained that the circles cause them to slow down (in the same way they slow the motorists).

The success of traffic circles is also measured by its acceptance among residents living near them. By far, the majority of residents are enthusiastic about the traffic circles. For example, nearly 700 requests for new circles are received each year and about 3,000 signatures are received on petitions for new circles each year. Only two circles have been removed out of more than 800 constructed (residents are guaranteed that the city will remove a traffic circle if, after construction, 60 percent of the households within a one block radius have signed a removal petition), and surveys mailed to residents following construction of a traffic circle indicate that 80 percent to 90 percent of residents feel the circles have been effective and want to keep them permanently.

## CONCLUSIONS AND RECOMMENDATIONS

After nearly 30 years of experience installing mini traffic circles, Seattle has found them an effective device for controlling neighborhood traffic and improving the safety of residential streets. Additionally, residents feel traffic circles have successfully addressed their safety concerns and make their neighborhoods better places to live. By slowing down motor vehicle speeds, they benefit neighborhood bicyclists. If a residential street has high volumes of bicyclists or is a bicycle boulevard, other treatments, such as diverters for motor vehicles, should be considered before installing a traffic circle.

## COSTS AND FUNDING

$5,000 to $8,000 including staff time.

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# Bicycle Boulevards — Bryant Street Example

## BACKGROUND

A three-mile residential street was transformed into a mostly stop-free bicycle arterial that serves cyclists of all levels. This "bicycle boulevard" treatment is straightforward and would be replicable in many cities.

### THE BICYCLE BOULEVARD CONCEPT

Bicycle travelways are generally classified as shared roadways, shared roadways with signs, bike lanes and shared-use paths (*Guide for the Development of Bicycle Facilities*, AASHTO 1999). Each type attracts cyclists according to their desire for directness, avoidance of motor traffic and other factors. In the absence of vehicle calming and diversion measures, direct through routes for cyclists often also attract through motor traffic, decreasing their attractiveness for less traffic-tolerant cyclists of all ages.

A bicycle boulevard is a treatment of a low-volume, local street shared roadway that creates a mostly stop-free "arterial" for bicycles while diverting most through motor traffic. Motor vehicle parking and access to all properties is unchanged. Through motor traffic is diverted by bicycle-permeable street closures and mandatory-turn devices spaced every half-mile to a mile. Most stop signs face most cross-streets, creating two-way stops favoring the boulevard. The city of Palo Alto, CA, implemented what is believed to be the nation's first bicycle boulevard by transforming Bryant Street.

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Contributions by Gayle Likens, Carl Stoffel, and Ashok Aggarwal (City of Palo Alto Transportation Division), Paul Goldstein (Bicycle Advisory Committee chairperson), and Ellen Fletcher (BAC vice-chair and former City Councilmember).

Bryant at Matadero Creek: Separate bicycle and pedestrian bridges.

## COUNTERMEASURES

### BICYCLE BOULEVARD HISTORY IN PALO ALTO

Discussion of bicycle-priority streets arose in Palo Alto during the environmental movement of the 1970s, reflecting the community's desire for bicycle routes with low vehicle traffic to complement busier bike-laned streets. Safety was a secondary goal to be achieved mainly by lowering motor vehicle volume and reducing car-bike conflicts. The city's first bikeway network plan was adopted in 1972, and its 1976 Comprehensive Plan called for a network of bicycle boulevards and identified several possible streets. The 2000 Draft Bicycle Transportation Plan further develops the proposed bicycle boulevard network.

For its first bicycle boulevard, the city evaluated three parallel streets serving the same north-south travel corridor (Bryant, Waverley, and Cowper). All are residential except for three blocks through downtown, and all have parallel parking for their entire length except for some diagonal parking downtown. All three serve the same destinations, including several schools, and function as nearby multilane through streets favored by motorists. At the northern city limit all three streets end near a bicycle and pedestrian bridge across a major creek, enabling extension of the route into the adjacent city (Menlo Park). Each had a signal at one of the two east-west arterial streets they crossed. One (Waverley) was a bus route.

Bryant was selected because it was not a bus route, it had an existing pedestrian bridge across a creek that diverted through motor traffic—a key bike boulevard feature, and it already had a signal at the southern arterial street that would be crossed. The bicycle boulevard conversion was implemented in two segments each 11 years apart, in part because of the anticipated expense of placing a signal at the crossing of the northern arterial street.

The southern segment, extending 3 km (1.9 mi) from East Meadow Drive to Churchill Avenue, was implemented in 1981 and involved four major elements. The first was a bicycle- and pedestrian-only crossing of a creek that had a wooden pedestrian bridge that was scheduled for replacement. Because of the anticipated increase in bicycle travel due to the boulevard transformation, the old bridge, just one block from an elementary school, was replaced with a bicycle-only bridge aligned with the street centerline and a separate pedestrian-only bridge aligned with one of the sidewalks. These were actually constructed after the boulevard segment opened. The other elements were two bicycle-permeable street closures, and the changing of all stop-controlled intersections to two-way stops on the cross streets except at two intersections that remained four-way stops. The latter change enables uninterrupted pedaling for a mile or more between four-way stops and signals.

The northern segment, extending 1.9 km (1.2 mi) from Churchill Avenue to the northern city limit, was implemented in 1992 and involved three major elements. The first, constituting most of the cost, was a new signal at Embarcadero Road, a four-lane residential arterial street carrying 25,000 vehicles daily, combined with islands that force right-turn-only movements for motor vehicles on Bryant. The cost of the proposed signal attracted a great deal of non-cyclist opposition because of an existing signal one block away. Cyclists responded that a two-block detour added turning movements and compromised navigability, and that interaction with buses on the parallel street was undesirable. The city added the signal and coordinated it with the adjacent signal to minimize delays on the arterial street. The second element was a bicycle-permeable street closure just south of Channing Avenue, which also attracted opposition due to resident concerns over traffic diversion and impacts on an urgent-care medical facility. After a six-month trial, the closure was replaced with a neighborhood traffic circle one block south at Addison. The third element was stop sign changes similar to those implemented on the first segment.

Bryant at Lowell: Typical street closure.


Bryant approaching Embarcadero: Turn restriction sign.

## EVALUATION AND RESULTS

### FIRST (SOUTHERN) SEGMENT

Bryant's first bicycle boulevard segment was evaluated during a demonstration period from May through October 1982, just after its implementation. Results are reported in the staff's *Bicycle Boulevard Demonstration Study – Evaluation* report of December 9, 1982, which states:

> Comparative bicycle counts were taken at three locations on Bryant and at three other locations prior to and during the bike boulevard study. Counts were taken during a twelve hour period (7:00 a.m. – 7:00 p.m.) on mid week days. Base counts were taken in May 1981 and April 1982; counts at these locations were taken again in October 1982.
>
> Twenty-four vehicular traffic counts were taken at eighteen locations along the bike boulevard corridor. These counts included locations along Bryant as well as parallel and cross streets where changes in traffic patterns were anticipated. Base counts were taken in May 1981 and 1982; counts were taken again in October 1982.

The results showed that bicycle traffic on Bryant increased dramatically – 85 percent and 97 percent for two key locations – and that Bryant's rate of increase in bicycle traffic exceeded that of other streets. Bryant was found to carry 475 to 725 bicycles per day depending on location. Bike traffic decreased substantially on two nearby parallel multilane streets favored by motorists (-35 percent and –54 percent for two key locations).

Motor vehicle volumes within the overall corridor, encompassing Bryant and several parallel streets, remained fairly constant. All but three of the streets in the corridor carried considerably less than 1,000 vehicles per day, quite acceptable for local residential streets. Motor traffic on Bryant near the two street closures declined by 52 percent (953 to 457 vehicles) and 65 percent (481 to 170), respectively. Motor traffic diverted by the closures split about evenly to the two closest parallel streets.

The Palo Alto Police Department reported that collisions remained at a low level on the southern segment. No collisions occurred near the street closures.

Staff sent a letter to all residents within one block of Bryant along the corridor, and 18 individuals responded. Before implementation, neighborhood residents raised several kinds of concerns — increased speeding, motorcycle and moped violations of the street closures, and residence access issues. Speeding complaints were received soon after implementation but dropped off. Twelve-hour motorcycle and moped counts at the two street closures noted 79 moped violations and 4 motorcycle violations. (Mopeds fell out of fashion after the 1970s, and few if any motorcyclists currently use Bryant for through travel because nearby parallel multi-lane streets serve their needs.) One complaint related to driving schools using the streets and


Bryant at Addison: Neighborhood traffic circle.

their new cul de sacs as practice areas, but after being contacted the schools agreed to use other routes. The police and the fire department reported no serious impairment of emergency response (Palo Alto has a fully connected street grid that offers many route options).

There was some concern about changes to cyclist behavior at intersections on a route with most stop signs removed in the bicycle travel direction. On a weekday in October 1982, a member of the city's Bicycle Advisory Committee observed cyclist behavior at one of the remaining four-way stops on Bryant's first segment. Three hundred to 400 cyclists were observed during each of the morning and afternoon commute periods. Most scanned for cross traffic, some scanned and slowed, and a few made a complete stop. This is typical of cyclist behavior at other stop-controlled intersections in the city.

### SECOND (NORTHERN) SEGMENT

Bryant's second bike boulevard segment was implemented in 1992. Unlike the first segment, whose full length underwent a six-month demonstration, the only trial element was the street closure four blocks north of the new signal. One reason for testing this element was its location next to an emergency medical care building, though that facility subsequently relocated out of the corridor. The trial's results appeared in the staff report of July 15, 1993 titled *Evaluation of Six-Month Trial of Bryant Street Temporary Street Closure for the Bicycle Boulevard Extension*. Only one parallel street block experienced traffic increases predicted to be "noticeable" by the "Traffic Infusion on Residential Streets" methodology used by neighborhood traffic management researchers. Staff recommended that the closure be made permanent, but residents persuaded the city council to replace it with a neighborhood traffic circle at the nearest intersection to the south. That circle went through its own trial period and is now permanent.

Because of the lack of a street closure on the segment from the northern arterial to downtown, this segment still attracts considerable short-distance through motor traffic. Motor vehicle volumes there are higher and car-bike interactions more frequent than on the boulevard's purely residential southern segment.

### OTHER FEEDBACK

Some cyclists on Bryant have remarked that motorists approaching on stop-controlled cross streets sometimes fail to yield to non-stop through cyclists on Bryant. When each boulevard segment was first installed, the city temporarily added yellow "Cross Traffic Does Not Stop" warning plates below cross-street stop signs to educate drivers about the traffic control change. In both phases these were removed after several months because they are nonstandard traffic control devices and because their size impacts sightlines.

As was the existing practice for bicycle-permeable street closures in Palo Alto, the two closures on the boulevard's southern segment were both placed just behind the corner curb returns at intersections, forming an apparent three-way junction that was actually four-way for bicycles. It was found that motorists approaching such intersections do not always scan for and yield to bicyclists traversing the street closures. Palo Alto now installs new street closures several car lengths back so intersections appear as four-way for all parties.

### SUBSEQUENT EVALUATION

The city has conducted occasional counts of bicyclists at various locations since the completion of the Bryant bicycle boulevard in 1992. Eight-hour intersection counts conducted in May 1997 tallied 385 bicycles at one location on Bryant. Staff attributes the substantial reduction from 1982 levels to cultural changes — the bicycle's share of commute and utility trips has dropped since the first energy crisis, and a greater fraction of students are driven to school as compared to 20 years ago. The city recently hired a full-time transportation systems management coordinator devoted to facilitating adult and student commute alternatives including bicycling.

## CONCLUSIONS AND RECOMMENDATIONS

The bicycle boulevard treatment successfully transformed a local street into a bicycle throughway while retaining motor vehicle access to all properties. Bicycle volumes increased substantially, and bicycle trip times compare favorably with parallel route options. Bryant Street has become a widely known and well-used through route on the San Francisco Peninsula, both for inter-city commutes and intra-city trips, including student commutes to elementary, middle, and high schools. In honor of her multi-decade role in the street's transformation, the city recently designated the street to be the Ellen Fletcher Bryant Street Bicycle Boulevard.

The process of identifying potential bicycle boulevards is straightforward, and implementation is relatively simple compared to full-on traffic calming. Other cities throughout the country have implemented bicycle boulevards or are considering them. One Bay Area example is Berkeley. There is a future example in nearby Sunnyvale, where Borregas Avenue, a local street currently severed by two freeways, will become a bicycle boulevard when those gaps are closed by new bicycle-pedestrian bridges.

## COSTS AND FUNDING

California's Transportation Development Act, Article 3 (TDA-3) program dedicates a small fraction of the state sales tax on gasoline for bicycle and pedestrian transportation projects throughout the state. TDA-3 is allocated by city population so it is a fairly predictable — albeit variable — funding source.

For the first (southern) segment of the Bryant bicycle boulevard, Palo Alto obtained $35,000 of FY 1983-84 TDA-3 funds for a new bicycle bridge across a creek. The remainder of the funding for this segment came from city Street Improvement funds.

The second (northern) segment cost $243,000 in 1992, including the traffic signal. The signal — including interconnection to the city's control system and the adjacent signal — was paid for with $75,000 of FY 1992–93 TDA-3 funds and $99,000 of city Traffic Signal Capital Improvement Project funds. The balance of $69,000 came from the city's Street Improvement Program.

Cost estimates for bicycle boulevards in other locations will largely depend on the capital improvements needed to divert through motor traffic (such as bike and pedestrian-only waterway bridges and bicycle-permeable street closures), calm remaining motor traffic (such as traffic circles), and create bike route continuity across major streets (new signals, bridges or underpasses).

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# Planning, Designing and Implementing a Shared-Use Path

## BACKGROUND

There are millions of bicyclists that enjoy and prefer riding on off-road trails rather than sharing the road with trucks and cars. Off-road trails present a different set of design challenges for planners, designers and bicycle advocates. This paper offers a summary of elements that constitute good trail design and defines how such trails can be created within a given community.

Successful, functional, and shared-use (those that accommodate a variety of trail users) trails are, for the most part, the result of good planning and design. Properly planned and designed trails take into account how an individual trail fits into a comprehensive trail network, offering transportation as well as health and recreational benefits to a community. Most importantly, well-designed trails serve the needs of trail users, limit conflicts among user groups, link popular destinations, are successfully integrated into the existing built environment of a community, and are sensitive to the surrounding native landscapes and environment.

## COUNTERMEASURES

### ELEMENTS OF GOOD TRAIL DESIGN

There are many factors that go into the development of a functional and successful shared-use trail. This paper does not make an attempt to address all factors. The most important factors have been selected and described herein.

**Accommodating the User**

The most important consideration for the design of a trail is the accommodation of the trail user. Most shared-use trails will need to serve the interests of a wide range of

users, including people who want to walk, jog, bike, and in-line skate. Most shared-use trails will be developed at a minimum width of 3 m (10 ft). This is done to accommodate two-way traffic on the prepared trail tread surface. It may be necessary to increase the width to 3.7 or 4.3 m (12 or 14 ft) in order to accommodate heavy traffic on a given trail. It would also be advisable to divide the trail into "wheeled" and "non-wheeled" treads if the right-of-way and landscape can support two trail treads. The wheeled tread should be 3 m (10 ft) wide. The non-wheeled tread can be 1.8 or 2.4 m (6 or 8 ft) in width.

All trails must be designed and constructed to be accessible to all persons regardless of their abilities. There are very few reasons why a given trail cannot be built to be fully accessible. The best guidebook on this subject is *Designing Sidewalks and Trails for Access: Part 2, Best Practices Design Guide*. Every trail designer and manager should have this reference book on hand to ensure that trail projects are accessible.

**Connectivity**

The best trails are those that link people to popular destinations. Each trail segment should have logical and functional endpoints. Trails that serve as links throughout a community are the most popular for trail users. While this seems obvious, sometimes off-road trails will end abruptly,

Charles A. Flink, FASLA, President, Greenways Incorporated

especially in urban areas. It is very important that trails be linked to other trails, to parks, and to an on-road network of bicycle facilities and sidewalks.

**Reduce Multi-User Conflict**

Multi-user conflict is regarded as the most serious safety concern for off-road trails. Conflicts between cyclists and pedestrians are the most prevalent and are usually caused by reckless and unsafe behavior, incompatible use values or by overcrowding. The most effective remedies for this conflict begin with design and management. Trails can and should be designed to reduce conflict by widening the trail tread or by separating the trail tread for different users. Single tread, multi-use trails can also be managed to reduce conflicts, sometimes by separating users under a time of use policy. Involving user groups in the design of a trail is the best way to both understand local needs and resolve the potential for shared-use conflict. Posting trails with a trail use ordinance and providing educational materials on how to use the trail is also important.

**Fitting Trails to the Environment**

The most enjoyable trails to use are those that celebrate the natural landscapes and native environments traversed by the off-road trail. This is one of the most popular reasons outdoor advocates choose to use off-road, shared-use trails. Trails should have rhythm and syncopation, and flow within their surroundings so that they captivate users. Trails should follow the natural contours of the land and take advantage of native landscape features such as water, groupings of vegetation, scenic views, and interestingly built features.

**Integrating Trails into the Built Environment**

Trails should also celebrate the built landscapes they traverse. Often we try to hide viewsheds deemed unpleasant. This may not always be a good idea. Since trails are designed to be used by people, it is much better to keep viewsheds open. Trails through urban landscapes provide an opportunity to interpret the surrounding environment. Great care must also be taken to successfully fit a new trail into the urban fabric. For example, the conversion of abandoned railroad corridors has been the greatest resource for new urban trails in the past 20 years. It presents challenges for trail designers because these corridors supported a different type of transportation activity. Creating new intersections between roads and converted rail-trails is the greatest challenge for these urban trails. It is important that intersections be designed to clearly determine who has the right-of-way. Intersections should also be very clearly marked for all groups to delineate crossing zones for trail users. Pavement markings, signs, lighting, and textured pavement can all be used to make intersections safer.

## THE IMPORTANCE OF PUBLIC INPUT

Incorporating public input into the design of a trail is one of the most important steps in the process. Landowners who are adjacent to trail corridors should always be included in the design process. Finding the most appropriate method for involving the public in the design of a trail is important. A list of involvement techniques is provided below:

**Meet with individuals**

One-on-one meetings are the best way to approach people who might have opposition to a proposed trail. These meetings offer opportunity to calmly discuss alternatives, as well as specific needs.

**Citizen advisory committees**
It may be advantageous to convene a group of citizens to help decide elements of the trail design. This can create community buy-in and advocacy for the project. Be certain to have balance on this committee among user groups, as well as advocates and possible opponents.

**Public workshops**
Perhaps the best method for soliciting input is to invite the public to attend an open house or trail workshop. These meetings can be held during the week or on a Saturday. Provide opportunities for attendees to write on trail design maps and participate in other elements of the design process.

**Public hearings**
Some local governments may require a formal public hearing or presentation to an elected council or board. These official meetings are important to providing legal foundation for future trail development.

**Public survey**
It is also advisable to conduct a public survey, either an opinion poll or a statistically valid survey, to better understand interest and level of support for the trail project.

All public input should be recorded and made part of a permanent record with respect to the final design for the trail.

## CONCLUSION AND RECOMMENDATIONS

Good trail design is influenced by many factors. This paper has defined the most important components of good design. Within the context of our modern world, trail development is actually a fairly complex undertaking. It requires that we understand the opportunities and constraints of the natural and human-made environments and that we account for the diverse interests of trail users. Defining a logical process for planning and designing every trail is one way to ensure that all factors influencing trail development, function, and safe shared use, have been appropriately addressed and resolved.

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# Path and Roadway Intersections

## BACKGROUND

The Springwater Corridor is a 25.7 km (16 mi) paved shared-use path from Portland's inner eastside heading east to the adjacent suburbs of Gresham and Boring. A rail-to-trail conversion, it follows power lines and is part of a larger trail system known as the 40-Mile Loop extending throughout the Portland metropolitan area.

Currently experiencing over half a million annual users, the trail crosses 28 roadways along the way, offering an interesting case study of trail-roadway crossings. Almost all are at locations away from existing roadway intersections, thus few before and after safety or functionality comparisons can be made. However, we offer qualitative observations where appropriate.

## COUNTERMEASURES

### TYPES OF INTERSECTIONS

Evaluation of trail-roadway crossings involves analysis of traffic patterns of vehicles as well as trail users. This includes traffic speeds, street width, traffic volumes (average daily traffic and peak hour), line of sight, and trail user profile (age distribution, destinations). Although many trails or paths use grade-separated crossings of major roadways whenever possible, these are expensive and must be well-designed, or they are not used. On the Springwater Corridor Trail, there are five grade-separated crossings of roadways, three of which existed before development of the trail, and the last two were installed as a new roadway improvements project after the trail was completed. Essentially, the creation of the five grade-separated crossings were therefore funded by sources other than trail construction dollars.

By Mia L. Birk & George Hudson[1]
Principals, Alta Planning + Design

The existing crossings fall into the following categories:

1. Unprotected, marked crossings — Unprotected crossings include midblock crossings of residential, collector, and sometimes major arterial streets.

2. Routed to existing intersection — In certain locations, the trail emerged quite close (within a few hundred feet) to existing intersections and was routed to use the existing signal.

3. New signalized crossings — In four locations, new signalized crossings were installed at major roadways due to the traffic volumes, speeds, and projected trail usage.

4. Grade-separated crossings — Three grade-separated crossings were in place at the time of acquisition of the corridor. Two additional grade-separated crossings were constructed after the trail was installed. The trail takes advantage of the presence of these grade-separated crossings.

### TYPE 1: UNPROTECTED/MARKED CROSSING

Most of the minor public roadway crossings along the Springwater Corridor are serviced by unprotected crossings consisting of crosswalk markings and signs. Where the crossing is of a public roadway, trail users are required to stop for roadway traffic. In addition, there are several private driveway crossings of the trail. At these private driveway crossings, motorists are required to stop for trail users. These crossings have a low volume of traffic and are not public street right-of-ways. As a general policy on the Springwater Corridor Trail, private driveway users are required to stop for trail users as indicated by stop signs and marked crosswalks.

In each case, the crossing design took into consideration vehicular traffic, line of sight, trail traffic, use patterns, road type and width, and other safety issues such as nearby schools.


Unprotected, marked crossing of local street.

These crossings have the following characteristics:

- Crosswalks
- Maximum traffic volumes of approximately 5,000 average daily traffic (ADT) (1,000–1,500 peak hour)
- Maximum 85th percentile speeds—35–45 mph
- Maximum street width—18.3 m (60 ft) (no median)
- Minimum line of sight—25 mph zone: 31.5 m (100 ft), 35 mph zone: 61 m (200 ft), 45 mph zone: 91.4 m (300 ft)
- Warning signs provided for motorists, and stop signs and slowing techniques (bollards/geometry) used on the trail approach. Bollards also serve to minimize motorized vehicle access onto the trail.
- Vegetation and other obstacles cleared from motorists and trail-user sight lines
- Three of the unprotected intersections (Johnson Creek Boulevard, Southeast Flavel, and Southeast 92nd Avenue) have median islands that provide a pedestrian refuge area and were added in anticipation of increases in traffic volumes on these streets

**Evaluation and Results**

No trail user and motorized vehicle conflicts have been reported. The private driveway crossings typically serve large industrial complexes, and their access across the trail is permitted by the trail managing agency (the city of Portland). There have been no issues at these private driveway crossings, and motorists do stop when crossing the trail.

Two of the three median refuge islands have landscaping. The landscaping has been subject to damage from automobiles.

## TYPE 2: ROUTE USERS TO EXISTING SIGNALIZED INTERSECTION

The trail leads users very close to a major intersection at Southeast Linnwood and Johnson Creek Boulevard. This intersection went through a major redesign shortly after the Springwater Trail was built. New improvements included signalization of this intersection. Trail designers recognized the potential of increased safety by diverting trail users to the new signalized crossing.

In addition, the former rail line crossed an existing intersection at Southeast Bell and Johnson Creek Boulevard at a diagonal through this intersection. The intersection was signalized prior to the construction of the trail. Trail users now utilize the existing signal, crossing each street one at a time.

The crossings have the following characteristics:

- Crosswalks
- Traffic signals and pedestrian activated signal button
- Traffic volumes greater than 15,000 average daily traffic (ADT)
- 85th percentile speeds greater than 45 mph
- Street widths greater than 18.3 m (60 ft)
- Minimum line of sight—25 mph zone: 31.5 m (100 ft), 35 mph zone: 61 m (200 ft), 45 mph zone: 91.4 m (300 ft)
- Warning signs provided for motorists, STOP signs and slowing techniques (bollards/geometry) used on the trail approach, and bollards that serve to minimize motorized vehicle access onto the trail
- Vegetation and other obstacles cleared from motorists and trail user sight lines
- ADA compliant curb ramps
- Distance of trail to signalized intersection less than 106.7 m (350 ft)

**Evaluation and Results**

No collisions have been reported. Trail users complain of having to cross two crosswalks at Bell and Johnson Creek, thus requiring them to wait for two signal cycles.

Trail routed to Johnson Creek/Linwood signalized intersection. Trail users cross using crosswalks.

## TYPE 3: NEW SIGNALIZED CROSSINGS

There are four locations—Southeast 82nd Ave, Southeast Foster Road, Southeast 122nd Ave and Eastman Parkway—along the Springwater Corridor where the trail crosses a major roadway of above 15,000 ADT. In all four cases, the crossing width was greater than 18.3 m (60 ft), the nearest intersection more than 106.7 m (350 ft) away, and all had anticipated trail user volumes of greater than 100 per hour. Trail designers felt that new signalized crossings would be necessary to facilitate safe travel, and thus developed a signal warrant analysis that projected use through trail user numbers from the Burke Gilman Trail in Seattle, and user counts on a 1.6-km (1-mi) built portion of the Springwater Corridor in Gresham. Each location was also analyzed for sight lines, impacts on traffic progression, timing with adjacent signals, capacity, and safety.

Trail users activate the signal as follows:

- Pedestrians: push button
- Cyclists: loop detector in pavement
- Equestrians: push button mounted on pole at 2.4 m (8 ft) height

At Southeast 82nd, Southeast Foster Road and Southeast 122nd Avenue, the crossing includes a median island to reduce the crossing distance, signal activation in the median for those unable to cross the entire roadway in one movement, and advance warning signs for motorists. Other crossing features follow the guidelines provided for diverting users to an existing signal as described earlier.

### Evaluation and Results

The signalized crossings have been effective, safe, and functional. Since their installation in 1995, there have been no reported collisions, with an estimated 500,000 annual us-

Signalized crossing at 82nd Ave and 122nd Ave includes: flat grade with two marked crosswalks (one for each movement) and landscaped median; pedestrian and equestrian push button activation; bicyclist loop detector signal activation; flat grade on approaches with good sight lines; advance warning signs for motorists.

ers. Trail users note that although they must activate the signal and wait for a green light, motorists have gotten used to the signal and frequently stop before they get the red light. Traffic engineers report minimal interference with nearby signals, given the relatively distant spacing from the nearest signalized intersections. They also report no problems.

### TYPE 4: GRADE-SEPARATED CROSSINGS

There are five grade-separated crossings on the Springwater Corridor. These crossings consist of both over and undercrossings of roadways. Interstate 205, Highland Road/181st, and Telford Road were existing grade-separated crossings developed in response to the presence of the railroad. As such, these crossings are well integrated into the trail layout and easily used by trail users.

Hogan Road and the 7th Street Bridge, both in the City of Gresham, are roadway improvement projects built after the trail was constructed. At both these roadway crossings, the roadway goes over the trail, and Johnson Creek is immediately adjacent to the trail. The Hogan Road crossing was implemented in 1995, while the 7th Street Bridge project followed a few years later. Both grade-separated crossings were built in anticipation of high projected vehicle volumes and speed.

Key characteristics of these undercrossings include:

- A minimum vertical clearance of 2.4 m (8 ft)
- Placement of the trail at an elevation higher than the one year flood plain elevation of the creek
- Maximum trail grade approaching the undercrossing of 5 percent
- Alternative trail route leading up and over the bridge in the event the creek is in flooding stages
- Lighting under the bridge
- Rip-rap reinforced edge to the creek
- Limited vertical clearance warning signs for trail users

**Evaluation and Results**

Hogan Road, having been the first of the two undercrossings to be implemented, had several shortcomings. Placement of the trail at the two-year flood plain elevation resulted in regular flooding and closure of the trail. With each flooding event, sediments from the creek were deposited on the trail, requiring regular clean-up. The approach to the undercrossing did not facilitate complete visibility through the undercrossing area, resulting in unsafe feelings among users along the approach. Lighting installed in the underpass area was vandalized, requiring retrofitting of the lights with metal cages. In order to meet ADA grades on the trail approach, a switch back ramp was incorporated on the eastern side of the undercrossing approach. Turning radii used on this approach tend to be a bit tight for bicyclists' comfort. Today, about half the trail users opt to use the alternative, at grade crossing route in lieu of the Hogan Road undercrossing, regardless of creek conditions.

These lessons learned were taken to heart when the 7th Street Bridge project was proposed. Key characteristics of this undercrossing include:

- Placement of the trail at the 25 year flood plain elevation
- Alignment of the trail approach to facilitate complete visibility of the undercrossing area
- Installation of hose bib water connections to facilitate trail clean up in the event of a flood
- 2.7 m (8 ft, 9 in) of vertical clearance instead of the minimum of 2.4 m (8 ft)
- Use of vandal-resistant light fixtures
- Setback of the bridge foundation abutment from the trail, resulting in a greater sense of openness under the bridge

These improvements resulted in an undercrossing that has been well-received and equally well-used by the public. Flooding and maintenance problems are few. Most trail users are surprised to learn the bridge came in after the trail.

## CONCLUSIONS AND RECOMMENDATIONS

Trail crossing designs tailored to the site characteristics (type of cross-street, traffic volumes, street width, traffic speeds, proximity to existing intersections, etc.) have resulted in well-functioning trail-roadway intersections with no reported safety problems to date. Experience with some under-crossings highlighted the importance of good design, including open approaches with good visibility and consideration of site environmental conditions.

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# Grade-Separated Crossing Treatments

## BACKGROUND

For over a century, Boulderites have been getting around by bicycle. The city did not, however, emphasize bicyclists and pedestrians in the design of transportation facilities until the 1980s. The 1989 Transportation Master Plan (TMP) brought with it some major changes in how the city viewed transportation. Transportation's emphasis was moved away from primarily focusing on the automobile, and shifted toward a balanced view of transportation that fully included options like walking, biking, and taking the bus.

Since 1989, the city has seen many changes in transportation facilities, particularly for bicyclists. The planned network of primary and secondary bicycle corridors is largely complete, minus a few key connections that remain to be built. A network of continuous paths along Boulder Creek and its tributaries is 70 percent built. Today, Boulder's bike and pedestrian facilities are among the best in the country.

The city recognizes the importance of providing a variety of transportation options that allow citizens to travel safely and efficiently. All of Boulder's transportation facilities include several elements that have been embraced by the community. Bike and pedestrian underpasses have been such a success that they are now used throughout the city. In explaining how the city has come to provide over 55 underpasses, it is important to consider the history leading to their construction.

Cris Jones, Transportation Planner, Boulder, CO
Contributions by Bill Cowern (Traffic Operations Engineer), Annie Noble (Greenways Coordinator) Marni Ratzel (Bike and Pedestrian Planner) and Randall Rutsch (Senior Transportation Planner).

In 1910, Frederick Law Olmsted, Jr. warned the city of Boulder of the dangers of allowing development to encroach upon the floodplain of Boulder Creek. He recommended against the construction of a deep, artificial flood channel to facilitate development in the floodplain. Instead he suggested that Boulder Creek be allowed to remain in a small shallow channel for the ordinary stages of the stream, while including a much broader floodplain as a channel during larger storms. Recognizing the need to dedicate this floodplain land to a useful purpose, he suggested creating a space for public use.

In 1969, a moderate flood affected the city of Boulder. The following decade marked the city's first serious flood control efforts. Initial investigations focused on traditional flood mitigation techniques, such as hard-lining stream channels and using concrete structural facilities to channelize stream flow. These plans, however, conflicted with the city's commitment to improve both quality of life and the urban environment, and evoked considerable public opposition.

With the goal of maintaining and enhancing the aesthetic and environmental integrity of Boulder Creek and its tributaries, the city decided to pursue alternative solutions to flood control. In 1978, the city adopted a "non-containment" policy for Boulder Creek as part of the Boulder Valley Comprehensive Plan. This policy promoted ongoing city efforts to protect public safety by restricting development within the floodplain of Boulder Creek and its tributaries.

In 1984, the city adopted the Boulder Creek Corridor Plan that recommended development of a continuous path along the entire length of Boulder Creek. This corridor would serve both as a flood hazard mitigation measure and as a continuous urban park for recreational and transportation use. It would also serve to restore and enhance wetlands along with fish and wildlife habitats.

The construction of a continuous shared-use facility required separated grade crossings at each intersection throughout the corridor. Existing creek underpasses were converted to include shared-use path underpasses through fairly simple modifications. Upon its completion, the Boulder Creek Path was instantly popular and quickly became a much loved community amenity (figures 1 and 2).

Figure 1. Construction of the Boulder Creek Path underpass at Broadway.

Figure 2. The completed Boulder Creek Path underpass at Broadway.

The public acclaim of the Boulder Creek project led to an increase in public discussion about the desirability of extending and continuing the concept of the Boulder Creek project along Boulder Creek's tributaries within the city. As a result, the city designated over 32.2 km (20 mi) of stream corridors along six tributaries of Boulder Creek for inclusion in the Greenways Program.

## COUNTERMEASURES

Today, the city of Boulder is home to more than 55 underpasses built to serve bicyclists and pedestrians. While most new underpass projects are driven by the transportation department, underpasses often have benefits beyond transportation. New underpasses along Boulder's greenways have increased flood carrying capacity and improved the natural environmental systems along Boulder Creek and its tributaries.

Although most underpasses have been built as a part of Boulder's greenway system, a number of underpasses have been constructed at locations not along a waterway. These underpasses serve to eliminate pedestrian barriers and increase safety at dangerous intersections. The College and Broadway underpass, for instance, was designed with the sole purpose of increasing pedestrian safety.

Before construction of the College and Broadway underpass, thousands of students a day were forced to cross Broadway (U.S. Highway 92) at grade, in order to get between campus and the University Hill commercial district. Students often crossed (midblock) and would stand in the median before crossing entirely. Unlike most of the underpasses within the city, the Broadway and College underpass required a lengthy public process before construction. This was largely because of concerns from the merchants in the Hill commercial district. Merchants worried that an unattractive or poorly designed underpass would be perceived as unsafe and discourage pedestrian traffic to their businesses. The city went through an extensive design process, including obtaining public input, and creating photo simulations of the proposed design to gain community acceptance (see figure 3).

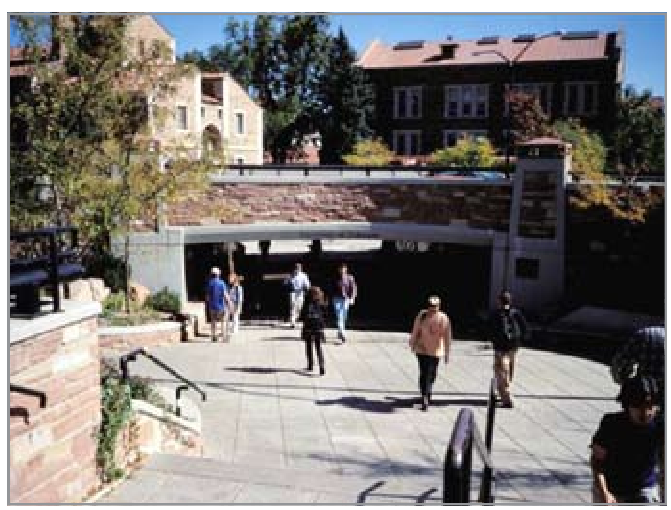

Figure 3. Pedestrian underpass at College and Broadway.

## EVALUATION AND RESULTS

The success and support of Boulder's underpasses is measured by several elements benefiting the community. These include increasing the safety and convenience of bicycle and pedestrian travel, promoting their use, and in the case of the Greenways system, providing a continuous grade-separated system appropriate for users who are not comfortable using the on-street system. The city currently employs several methods to assess the value of its underpasses relative to its transportation goals. These methods include automated pedestrian and bike counts and periodic surveys used to calculate bicycle and pedestrian mode share.

In addition to routine evaluation methods, the city updates its Transportation Master Plan (TMP) approximately every six to seven years in order to ensure the city is working toward the current needs of the community. The 1989 TMP created a vision of a grade-separated system along Boulder's greenways. This vision was refined in the 1996 TMP update with its recognition of different types of users from the novice to the experienced commuter and goal of providing facilities for all types of users. Underpass construction continues to be strongly supported by Boulder citizens and evaluation of TMP policies will determine the extent of future construction.

The planning and design efforts resulted in an award-winning project widely hailed as a complete success. Today, the College and Broadway underpass allows thousands of bicyclists, pedestrians, and motor vehicles to travel freely and safely through the intersection every day.

As mentioned above, several methods are employed to evaluate underpass use and benefit. User counts are performed at several locations throughout the city including the Broadway and College underpass. Although counts are not available for dates prior to construction, current counts indicate a high number of users. If the underpass did not exist, current users would be forced to cross Broadway at grade (figure 4). Counts at Broadway and College are taken once a month from 4:45pm to 5:30pm.

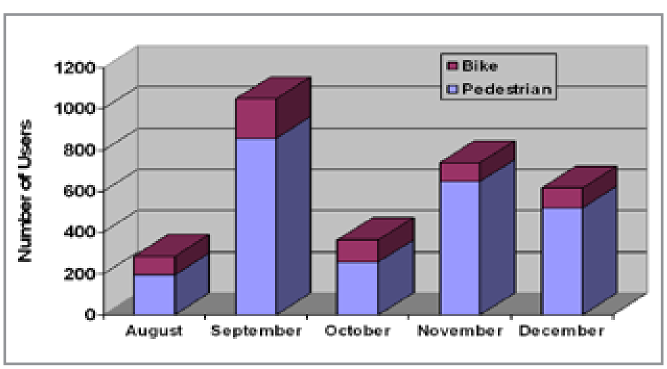


Figure 4. College and Broadway fall 2002 users.

In addition to performing manual counts, the city operates several automated bike counters along several shared-use pathways. These counters monitor use 24 hours a day, 365 days a year. Counts have revealed fairly stable use of about 600 to 800 cyclists per day year-round, excluding days of extreme cold, precipitation, and high winds.

## CONCLUSIONS AND RECOMMENDATIONS

As the city of Boulder continues to move toward completing its greenway corridors, it is important to consider the factors that have lead to the city's success (for other communities interested in building a similar system). As mentioned above, much of the success of the greenways system and its underpasses can be attributed to a community that views such a system as beneficial. It also is important to remember that the system has not been built entirely on city dollars. About 50 percent of funding has come from federal resources.

## COSTS AND FUNDING

The cost of constructing a grade-separated transportation system is a discouraging factor for many communities. It often is purported that high sales tax revenues have afforded the city's desire to construct such an extensive multi-modal transportation system. In actuality, Boulder's sales tax revenues are average among cities of similar size. It is the community's vision of responsible growth and commitment to a multi-modal network that has driven transportation efforts in the city. In addition to commitment, the rapid and extensive construction of underpasses throughout the city has depended on funding leverage. Many underpass projects have received federal funding based on flood mitigation elements. Please see the table listing of some recent underpass projects and their funding sources.

Underpass Projects and Funding Sources

| GREENWAY | PROJECT | DESCRIPTION/GOALS | FUNDING |
|---|---|---|---|
| South Boulder Creek | Central to Stazio | Trail construction including low water crossing and railroad underpass. | $ 67,000 (Lottery)<br>$ 70,000 (Flood Control) |
| Bear Creek | Baseline to US 36 though CU property | One underpass and trail connections to CU Main campus, Apache Trail and Williams Village. | $ 8,700 (Transportation)<br>$ 58,000 (Flood Control) (FAUS) |
| 1992 | | | |
| Wonderland Creek | Broadway Underpass | Flood capacity increase, channel restoration, riparian vegetation restoration, wetland and pond creation. | $ 45,000 (Transportation) |
| Wonderland Creek | Valmont Underpass | Flood capacity increase, trail underpass. | $ 30,000 (Transportation)<br>$ 45,000 (Flood Control) (FAUS) |
| South Boulder Creek | Stazio to Arapahoe | Paved trail construction, railroad underpass, wetland creation. | $ 57,000 (Lottery)<br>$ 6,000 (Transportation)<br>$ 55,000 (Flood Control) |
| 1993 | | | |
| Bear Canyon Creek | Mohawk to Gilpin | Riparian habitat widening and restoration, wetland creation, landscaping and two underpasses, trail construction. | $ 28,000 (Lottery)<br>$ 55,000 (Transportation)<br>$ 84,000 (Flood Control) |
| South Boulder Creek | Arapahoe Underpass | Trail underpass. | $ 93,000 (Lottery)<br>$ 55,000 (Transportation)<br>$ 45,000 (Flood Control) |
| South Boulder Creek | EBCC Pedestrian Bridge | New trail bridge and soft-surface trail approaches. | $ 18,000 (Lottery)<br>$ 2,000 (Flood Control) |
| 1994 | | | |
| Bear Canyon Creek | Martin to Moorhead | Food improvements, two underpasses, trail connections. | $148,000 (Lottery)<br>$335,000 (Transportation)<br>$599,000 (Flood Control) |
| 1995 | | | |
| Fourmile | Broadway Underpass | Trail underpass and flood capacity improvements. | $ 4,000 (Lottery)<br>$ 75,500 (Transportation)<br>$ 10,000 (Flood Control) |
| Goose Creek | Trail Connection at 30th Street | Trail through new 30th Street underpass to Mapleton. | $ 9,000 (Transportation)<br>$ 1,000 (Flood Control) |
| Bear Creek | Mohawk Underpass | Trail underpass and flood capacity improvements. | $ 93,000 (Transportation)<br>$ 75,000 (Flood Control)<br>$200,000 (Urban Drainage) |
| 1997 | | | |
| South Boulder Creek | Baseline to EBCC | Underpass, habitat restoration and trail connection. | $ 61,000 (Transportation)<br>$ 82,000 (Lottery)<br>$ 52,000 (Flood Control) |
| Bear Creek | Gilpin Underpass | Flood control, pedestrian and bicycle underpass. | $ 6,500 (Lottery)<br>$ 63,000 (Flood Control)<br>$211,000 (Transportation)<br>$ 97,000 (Urban Drainage) |

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# Share the Trail: Minimizing User Conflicts on Non-Motorized Facilities

## BACKGROUND

A major portion of bicycle crashes involves falls or collisions with pedestrians and other cyclists. Non-motorized facilities (sidewalks, paths, bike lanes and trails) tend to be particularly hazardous. There are a number of reasons for this:

- These facilities are sometimes crowded, particularly during busy periods.
- These facilities often have a diverse range of users, including cyclists, joggers, skaters, scooter users, pedestrians, pedestrians with pets on leashes, pedestrians with carts or packages, people using wheelchairs and other mobility aids, and even equestrians. There are a wide range of user behaviors, including fast and slow cyclists, users alone and in groups, pedestrians who stop to view, talk or play, and sometimes vendors.
- Users often include young children and pets who cannot be expected to understand traffic rules or take safety precautions.
- Facilities are often built and maintained with limited resources. Designers sometimes accept inadequate standards with the argument that, "It's better than nothing." For example, paths and sidewalks often are too narrow for their intended uses. Path intersections are often confusing to use as well.
- There is sometimes little education or enforcement of appropriate user behavior.

These conflicts are likely to increase in the future as user diversity grows. For example, in recent years public paths and sidewalks have experienced increased use by motorized wheelchairs, inline skates, push scooters and electric-powered bicycles. New devices such as Segway may become more common. Effective management of non-motorized facilities is increasingly important to avoid problems, to accommodate diverse users, and to manage resources efficiently.

Todd Litman, Director, Victoria Transport Policy Institute

This case study reports on best practices for managing non-motorized facilities. The goals and objectives of such management are to:

- Increase the safety and comfort of non-motorized facility users;
- Accommodate a diverse range of non-motorized facility users and avoid conflicts; and
- Encourage non-motorized modes for transportation and recreation.

Relying only on separation to solve user conflicts may effectively prohibit some forms of transport. For example, many communities have laws that prohibit cycling on sidewalks, yet many cyclists do not feel safe riding on busy streets. As a result, cycling becomes infeasible for many users (particularly for children and inexperienced adults along busy arterials), or the regulations are ignored by users and seldom enforced by police. Similar patterns occur with other modes, including skates, skateboards, push scooters, and Segway.

An alternative approach to constructing separate facilities is to address potential user conflicts by establishing clear rules that define how each user of a non-motorized facility should behave, supported by adequate education and enforcement efforts. Regulations concerning when and where specific activities are allowed or prohibited, maximum travel speed, and who must yield to whom can help reduce user conflicts. For example, rather than prohibiting all sidewalk cycling (including along suburban arterials where there may be few practical alternatives), it may be better to establish rules that prohibit cycling on sidewalks in commercial areas and other crowded areas, limit maximum travel speed to 10 mph on sidewalks, and require cyclists to yield to pedestrians and other sidewalk users.

In other words, good management focuses on user *behavior* more than user *type*, since it is the behavior that tends to create conflicts. For example, there may be less conflict between a walker and a slow, courteous cyclist than between a pedestrian and an inconsiderate jogger, although both of the latter would be classified as pedestrians. Focusing on user behavior can accommodate a broader range of users and address a broader range of conflicts.

## COUNTERMEASURES

### DEVELOPMENT OF PLANNING PRINCIPLES AND GUIDELINES

Many communities have adopted programs to manage non-motorized facilities, including sidewalks, paths, bike lanes and trails. Such programs are particularly important on heavily-used urban trails, but virtually any non-motorized facility requires some degree of management involving a combination of education and enforcement regarding the safe and considerate sharing between different types of users.

Good management requires the establishment of the basic principles and priorities to guide individual policies and practices. Decision-makers (which may include agency staff, policy makers, citizen advisory groups, etc.) should identify the factors they want to consider when setting priorities for different non-motorized facility users, such as the relative importance and impacts of different types of activities, and the needs and abilities of different types of users. For example, transportation activities may be given priority over other uses of sidewalks and paths, such as paths (signs, vendors, games), and more vulnerable users (wheelchair users and children) and modes that impose fewer impacts on others (pedestrians) can generally be given priority over less vulnerable and higher impact activities (cyclists, skaters and users of motorized mobility devices).

The table below provides an example comparison of non-motorized modes that has been applied to the management of the Galloping Goose Regional Trail in British Columbia. While some of the listed modes, such as motorized wheelchairs, are not strictly "non-motorized" modes, they frequently use non-motorized facilities such as sidewalks, paths and trails. Of course, these factors, such as speed, maneuverability, and priority are somewhat subjective and may need to be modified to address the needs of a particular situation.

This type of information can help decision-makers develop appropriate guidelines and regulations to manage the use of non-motorized facilities based on the performance and value of each mode. For example:

- Higher-priority modes should have priority to lower-priority modes. For example, recreational modes (such as skateboards) should yield to modes that provide basic mobility (such as walking and wheelchair users) if conflicts exist.

- Lower-speed, smaller modes should have priority over higher-speed, larger modes. For example, bicycles should yield to scooters, and scooters should yield to walkers.

Example Comparison of Non-Motorized Facility Users on British Columbia's Galloping Goose Trail (VTPI, 2002)

| Mode | Speed | Size (Width) | Maneuverability | Priority |
|---|---|---|---|---|
| Walkers | Low | Narrow | High | High |
| Walkers with children | Low | Medium to large | Medium to low | High |
| Walkers with pets | Low | Medium to large | Medium to low | Medium |
| Human powered wheelchairs | Low | Medium | Low to Medium | High |
| Motor powered wheelchairs | Medium | Medium | Medium | High |
| Joggers and runners | Medium to high | Narrow | Medium | Medium |
| Skates, skateboards and push-scooters | Medium | Narrow to medium | Medium | Low |
| Powered scooters and electric human transporters (Segway) | Medium | Narrow to medium | Medium | Medium |
| Handcarts, wagons and pushcarts | Low | Medium to large | Medium | Medium |
| Human powered bicycle | Medium to high | Medium to large | Low to medium | Medium |
| Motorized bicycle | High | Medium to large | Low to medium | Low |
| Equestrians | Medium to high | Large | Low | Low |

- Special efforts should be made to accommodate a wide range of users (including cyclists, skaters and runners) where there are no suitable alternative routes (for example, adjacent roadways are unsuitable for such modes).

- Cyclists, skaters and motorized modes should reduce their speed when using mixed use paths (6 to 12 mph maximum, depending on conditions) and yield to non-motorized modes. People who want to go faster should use roadways.

- Posted regulations should clearly indicate when and where pets are forbidden, when and where they are allowed if leashed, and when and where they may run free.

The report, *Conflicts on Multiple-Use Trails: Synthesis of the Literature and State of the Practice* (Moore, 1994), provides further guidelines for developing programs to manage trails. Although this report is primarily concerned with recreational, off-road trails, the guidelines are generally appropriate for managing any non-motorized facilities, including sidewalks and bicycle paths. The report is available at no cost from FHWA. The report identified the following 12 principles for minimizing conflicts on multiple-use trails:

- Recognize Conflict as Goal Interference
- Provide Adequate Trail Opportunities
- Minimize Number of Contacts in Problem Areas
- Involve Users as Early as Possible
- Understand User Needs
- Identify the Actual Sources of Conflict
- Work with Affected Users
- Promote Trail Etiquette
- Encourage Positive Interaction Among Different Users
- Favor "Light-Handed" Management
- Plan and Act Locally
- Monitor Progress

## TRAIL USER EDUCATION AND ENFORCEMENT

User guidelines and regulations for sharing non-motorized facilities are only as effective as their education and enforcement. Such programs require special efforts, since there are no testing and licensing requirements for using non-motorized modes as there are for motor vehicles.

Once guidelines and regulations are established, it is important to promote them using signs and brochures, by enlisting the help of public organizations (such as walking and cycling clubs) and schools and by promoting responsible behavior at events such as fairs. Some communities use staff or volunteers to talk with users and distribute brochures and other information materials on public trails during particularly busy times. Special outreach efforts may be warranted for particular groups, such as wheelchair users, pet owners, skaters and mountain bikers.

Educational information should be presented frequently. For example, in dense urban areas, signs with trail use guidelines can be located at every intersection or every few hundred meters. In less dense areas they may be located every kilometer or so. In general, the more frequent the better to ensure broad distribution of this information.

Messages should be simple, easy to understand, and presented in a friendly way. They should clearly state what behavior is expected from trail users. It generally is better to communicate the intent of the law than to present the actual wording of a law (laws are often difficult to understand). The boxes below illustrate examples of such guidelines.

An example of an education program designed to minimize conflicts among user groups is the Galloping Goose Regional Trail in British Columbia (see figure). *The Official Guide: The Galloping Goose Regional Trail* brochure (Mulchinock, 1996) promotes the following about shared-use trail etiquette:

The key word is multi-use. Share the trail. Keep right except to pass. Motorized vehicles are prohibited (except for motorized wheelchairs). Respect private property adjacent to the trail.

- If you're on foot or on wheels, pass horseback riders with caution — horses can be spooked by startling noises or motions.


Figure 1. An example of "Share the Trail" signs along the Galloping Goose Trail in Victoria, British Columbia.

- If you're on horseback, let other trail users know when your horse is safe to pass.

- If you're cycling, yield to pedestrians, control your speed and warn — call out or use a bell — other trail users before passing.

- If you're walking your dog, keep it under control or on a leash, and please pick up its droppings.

Additional guidelines directed at cyclists on how to share public trails are available in the League of American Bicyclists' Fact Sheet titled "Sharing the Path" (see http://www.bikeleague.org/educenter/factsheets/sharingthepath.htm). They include showing courtesy and respect for other users, announcing yourself when passing, yielding to other users when entering or crossing, keeping to the right, passing on the left, being predictable, using lights at night, not blocking the trail, cleaning up litter and using roadways rather than paths for higher speed travel. A similar set of guidelines for shared-use trails is also available from the International Bicycle Fund (http://www.ibike.org/education/trail-sharing.htm).

It may also be important to develop special enforcement procedures for non-motorized traffic violations. Existing traffic enforcement practices often are ineffective for non-motorized modes, because such modes do not generally require a license or vehicle registration, and many non-motorized trail users are children. It is unrealistic to impose a standard traffic citation on non-motorized violations, in part because the fines will seem too large to many residents and in part because there often is no effective mechanism to process a citation if the violator is a minor or does not have a driver's license.

An alternative approach, recommended by the International Bicycle Fund, relies as much on education as on enforcement and creates a friendlier, positive relationship between non-motorized facility users (and their parents) and public officials. The text of a model ordinance is available on the IBF Website (http://www.ibike.org/education/trail-ordinance.htm). Non-motorized facility enforcement is also an ideal application for bicycle police (see IPBMA Website, http://www.ipmba.org) and for bicyclist diversion programs.

## EVALUATION

Most non-motorized facility management programs appear to be successful. However, we have not found any evaluation studies that measure before-and-after or with-and-without effects, so it is not possible to say with any confidence to what degree such programs reduce crashes, reduce user conflicts, improve user experiences or increase non-motorized travel.

Different communities have had different experiences with programs designed to encourage responsible sharing of non-motorized facilities, virtually all of which are positive. If trails are functioning well with a minimum of conflicts among users, this could be taken as evidence of good trail design and/or management programs.

## CONCLUSIONS AND RECOMMENDATIONS

Management programs that address potential conflicts are important for the safety and comfort of non-motorized facility users. This applies to sidewalks, paths, bike lanes and trails.

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## COSTS AND FUNDING

Costs vary depending on the type of program and its activities. Most non-motorized facility management programs require staff time for planning, plus resources to produce signs, brochures and other outreach materials, which are usually funded from local transportation or parks budgets. Most other activities, such as traffic law enforcement on non-motorized facilities, are included within existing agency budgets.

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# Shared Lane Markings

## BACKGROUND

Shared roadways make up the majority of most bike route networks. These shared roadways are often composed of curb lanes too narrow for motorists and bicyclists to safely share side by side (defined here as "substandard width"). On these roadways, the following problems often occur:

- Cyclists are pressured into hazards on the edge of the road or lane, such as the "door zone" where motorists leaving parked cars may suddenly open their door in a cyclist's path.
- Motorists attempt to pass cyclists too closely or intimidate cyclists legally in the lane.
- Cyclists decide to ride on the sidewalk illegally.
- Cyclists ride the wrong way on the road.

Though these problems are faced regularly by municipalities, there is no accepted pavement marking standard for shared roadways. Denver attempted to address this issue by developing an arrow with cyclist symbol inside to be placed in shared lanes. San Francisco used this marking on some streets but determined that the marking could be more visible.

## COUNTERMEASURES

After obtaining permission from the California Traffic Control Device Committee (CTCDC) to experiment, San Francisco hired a consultant to review a number of marking designs and study the best two in the field. The two marking designs (see figures 1 and 2) were placed on six city streets with substandard curb lane widths (5.1 m (16 ft, 10 in) to 6.7 m (22 ft) wide, with parking).

Michael Sallaberry, PE, Associate Transportation Engineer, San Francisco Department of Parking and Traffic

Figure 1. "Bike and Chevron"

Figure 2. "Bike-in-House"

Based on previously recorded observations which showed that car doors open to about 2.9 m (9 ft, 6 in) from the curb face, the markings were placed 11 feet from the curb, giving cyclists with 0.6 m (2 ft) wide handlebars approximately 15.2 cm (6 in) of clearance from opened doors.

## EVALUATION AND RESULTS

"Before" and "after" video was taken at each marking location, and a limited number of surveys were distributed to cyclists and motorists to determine their understanding of the marking designs. Recorded behaviors taken with video included:

- Cyclists' positions on roadway (e.g. distance from parked cars).
- Motorists' positions (e.g. distance from cyclists when passing).
- Cyclist direction (with or against traffic).
- Cyclist location (street or sidewalk).
- Conflicts between cyclists and motorists.

After reviewing videotape of 2400 cyclists and 2400 motorists, the most effective pavement marking design, the "bike and chevron" (figure 1), was shown to:

- Encourage cyclists to ride 20.3 cm (8 in) further away from the door zone.
- Encourage motorists to give 68.6 cm (2 ft, 3 in) more space when passing cyclists.
- Reduce the incidence of wrong way riding by 80 percent.
- Reduce the incidence of sidewalk riding by 35 percent.

There was no statistically significant change in hostile or aggressive behavior by motorists, but this may be attributed to the very small number of observed conflicts in both the "before" and "after" videotapes.

Through the motorist and cyclist surveys, it was determined that the meaning of the markings was not always clearly understood.

## CONCLUSIONS AND RECOMMENDATIONS

As a result of this study, the bike and chevron design (figure 1) was recommended by the California Traffic Control Device Committee as a pavement marking to be included in the MUTCD 2003 California Supplement. As of October 2004, the CTCDC and Caltrans had developed draft language for inclusion of the marking in the manual. The language discusses the optional use of this marking on roadways used by bicyclists, and gives placement guidance.

San Francisco is developing a set of local warrants to help determine on what streets the markings will be placed. Thus far, the following list of factors to consider has been developed:

- Curb lane width
- Parking turnover
- ADTs
- Dooring, overtaking, midblock bicycle collision history
- Gap in otherwise continuous Class I/II bikeway

- Current demand by cyclists
- Prevailing speeds by motor vehicles and cyclists
- Prevalence of cyclists riding on sidewalk or in wrong direction
- Anticipated addition of Class II bikeway to street

Based on the results of the surveys taken as part of the study, outreach campaigns explaining this new marking are recommended. San Francisco plans to launch a campaign, using bus tail cards for example, and other advertising, to explain the shared lane marking. This will likely be an ongoing effort for the first year or so of implementation as people grow accustomed to the new marking.

## COSTS AND FUNDING

The $73,000 study was funded by grants generated by local and state initiatives (San Francisco and California) which earmark portions of sales taxes for transportation projects.

A rough cost estimate of labor and materials for markings applied using methyl methacrylate is $100 each.

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*San Francisco's Shared Lane Pavement Markings: Improving Bicycle Safety*, written by Alta Planning + Design for the San Francisco Department of Parking and Traffic, February 2004, http://www.sfgov.org

## CONTACTS

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The modification (shared lane markings) that is the subject of this case study is not currently compliant with the *Manual on Uniform Traffic Control Devices*, but it is being considered for inclusion (the "Bike-in-House" marking in Figure 2 is not being endorsed by the Bicycle Technical Committee of the National Committee on Uniform Traffic Control Devices, however). Accordingly, it is imperative that any jurisdiction wishing to utilize the shared lane markings (or any other non-approved traffic control device) should seek experimental approval from the Federal Highway Administration. For information on how to do so, please visit this Web site: http://mutcd.fhwa.dot.gov/kno-amend.htm.

# Bicycle Detection Program

## BACKGROUND

Bicyclists' inability to "get a green light" has been the cause of many a call to the Traffic Engineering office. The callers typically display frustration, confusion, and a sense of modal discrimination. The Bicycle Detection Program was developed as a two-phase strategy to address these complaints. Phase 1 involved correcting actual detection problems at each traffic signal. Phase 2 involved educating the public about how and where to be detected at traffic signals.

The City of Santa Cruz has 40 signalized intersections. Thirty intersections use inductive loop detection and 10 intersections use video detection. Typical loop layout is three "A" loops and a stop bar "Q" or "D" loop for each motor lane. Bicycle lanes typically have a bike "Q" loop at the stop bar for the minor legs. Bicycle detection is not always provided for the major legs if the signal rests in green on the major legs. Video detection intersections use Peek Video cameras. Four arterial corridors are interconnected using Traconet with Traconex controllers.

## COUNTERMEASURES

### PHASE 1: ENGINEERING

1. Citizen requests and work orders regarding bicycle detection were compiled to determine signals with a history of complaints.

2. A work list was created prioritizing locations and the stated complaints, with proposed short-term and/or long-term solutions and cost estimates.

3. The locations were tested by the Bicycle/Pedestrian Coordinator and the Traffic Signal Technician in the field. The Coordinator rode an aluminum frame bicycle over each lane and the Technician recorded the level of detection at the signal cabinet. Detection levels were adjusted and re-tested as necessary to detect the bicycle (short term solution).

4. Long-term solutions include cutting new loops, adjusting cameras, and installing bike push buttons where necessary. These repairs are funded from an annual Minor Traffic Signal Maintenance budget.

Cheryl Schmitt, Bicycle/Pedestrian Coordinator,
Santa Cruz, CA

### PHASE 2: EDUCATION

1. The lead loop in left-turn lanes, curbside lanes without bike lanes, and bike lanes were marked with the *Manual of Uniform Traffic Control Devices* bike detector marking if sawcut lines were not visible.

2. A brochure was developed to describe how traffic signals work and to explain where bicyclists should position themselves on sawcut lines in order to be detected. This brochure is available on-line on the City's Web site at http://www.ci.santa-cruz.ca.us/pw/trafeng/bikedet.pdf

3. Signal detection is discussed at the 2-hour bicycle safety class required of all applicants to the regional bike loan and e-bike rebate programs. Over 500 participants have received the Bicycle Detection brochure through this program.

4. Bicyclists on the local e-mail bike list were kept abreast of the program and encouraged to contact the Bike/Pedestrian Coordinator with comments.

## EVALUATION AND RESULTS.

Complaint calls to the Traffic Engineering office have decreased dramatically. Bicyclists on the local e-mail bike list and bicyclists' newsletter describe a greater level of confidence in being detected and willingness to wait through the red.

## CONCLUSIONS AND RECOMMENDATIONS

Some of the technical problems are difficult to solve. Turning up the sensitivity on the detector amplifier to detect bikes will sometimes work for a period of time, but it usually ends up "locking on," causing a maximum recall condition. Rapidly decaying street infrastructure is resulting in more loop failures, with no funding in sight for repairs.

Video detection is much more reliable overall, but there was a learning curve for the field crew to become proficient with it. Nevertheless, the Bicycle Detection Program has been and continues to be a success.

## COSTS

Loops are approximately $500 each; for bike detection, there are typically two loops per direction of travel. Video detection is approximately $35,000 for a complete intersection installation. Pedestrian/bicyclist push buttons with the conduit and conductor to the controller cabinet is approximately $1500; each pole with push button is about $300.

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The modification (bicycle detector markings) that is the subject of this case study is allowed by the *Manual on Uniform Traffic Control Devices* (MUTCD), but if used, one specific design is required. The specific markings used by Santa Cruz and shown in the article are not in conformance with the technical provisions of the marking shown in Figure 9C-7 of the MUTCD.

# Bicycle Signal Heads

## BACKGROUND

The city of Davis, CA, has been a mecca for cycling since the mid 1960's. Bicycling accounts for about 17 percent of the mode share in Davis, whereas nationally, two to three percent is considered high. Whenever possible, grade separations have been built to minimize conflicts between cyclists and motorists. These include undercrossings and overcrossings of mostly collector and arterial streets. Where grade separations have not been possible, specially designed traffic control devices have been added at selected intersections.

To help manage the large number of bicyclists utilizing the city's transportation network, there has been a continually increasing need to explore new engineering techniques that would benefit cyclists and enhance safety for all road users. The use of bicycle signal heads was chosen as one such approach. The goal was to enhance safety for cyclists while maintaining adequate levels of service for motor vehicles at each of the intersections where these signals have been installed.

However, bicycle signal heads never had been approved for use by the California Department of Transportation (Caltrans), so the city was required to go through an approval process that included an experimental, conditional-use phase of the bicycle signal heads. Final approval would ultimately be subject to review and acceptance by the California Traffic Control Devices Committee (CTCDC) under the purview of Caltrans.

Timothy Bustos, Bicycle and Pedestrian Coordinator, City of Davis, California
Contributions by Dave Pelz, former Public Works Director, City of Davis, California (retired), Jonathon Flecker, former Traffic Engineer, City of Davis (now in private practice)

Although the use of bicycle signals had not previously been formally used in California, they have been widely used for many years in countries such as China, England, and the Netherlands. A former Public Works Director for the city of Davis had at one point visited the Netherlands, and brought the concept of the bike signal heads back with him.

Potential intersections that were evaluated for retrofitting with bicycle signal heads were selected based on three primary criteria:

1. Volumes of bicyclists at peak hour(s)
2. Bicycle and motor vehicle crash data
3. Proximity to schools (primary, secondary, and university levels)

Other locations considered for placement were those where separated bike paths connected with intersections in such a way that conventional traffic light configurations could not be seen by cyclists. These were typically locations where there was a three-way intersection for motorist's (i.e. "T" intersections) that became four-way intersections for bicyclists.

## COUNTERMEASURES

Bicycle signal heads actually are similar to conventional traffic signals. However, rather than red, yellow and green "balls," the new signal heads use red, yellow, and green bike icons. Initially, the city had to have these custom-made by blacking out conventional colored lens covers to hide everything but the bike shape. The newer signals now use red, yellow, and green LED's in the shape of a bike that are much brighter, yet more energy-efficient. These lights are also actuated in the same way as traditional traffic lights: through the use of bicycle sensitive loop detectors and, where appropriate, bike push buttons. As technology has advanced, newer intersections utilizing conventional or bicycle signal heads now use camera detection.

Although several locations throughout the city met the criteria listed previously, the location that would ultimately prove the viability of bicycle signal heads was the intersection of Sycamore Lane and Russell Boulevard. This location is a "T" intersection for motor vehicles, yet it is a "five-way" intersection for bicyclists due to the presence of bike lanes and bike paths that converge at this location. It is also a primary access point to the University of California for many of the students in the northwest quadrant of the city. Manual traffic counts at this location indicated that approximately 1,100 cyclists and 2,300 motor vehicles passed through this intersection during peak hours. Additionally, this would be the first location where both motorists and cyclists could see the conventional traffic lights and the bicycle signal heads.

Previously, all bicyclists, pedestrians, and motor vehicles would proceed through this intersection concurrently, with many bicyclists and pedestrians choosing the routes they perceived to be the most direct, not necessarily the safest. Bicycle signal heads were chosen for this location to help make the respective movements more predictable, and thereby safer. To this end, movements were split, with bicyclists and pedestrians moving through the intersection first and motor vehicles proceeding only after all the bicyclists and pedestrians had cleared the intersection. Additionally, a changeable message sign was added for the motorists, indicating "NO RIGHT TURN ON RED" to prevent through cyclists from being hit by right-turning motorists.


## EVALUATION AND RESULTS

In order to objectively assess just how effective the bicycle signal heads were in reducing conflicts, surveys were conducted with both motorists and cyclists before and after the addition of bicycle signal heads. Additionally, video footage was taken of bicycle, pedestrian, and motor vehicle movements before and after intersection modification (both horizontally and vertically). Bicycle and motor vehicle crash reports were also evaluated before and after the installation of the bicycle signal heads.

Both motorists and bicyclists found the new signal heads to be effective in reducing conflicts between the various modes passing through the intersection. Evaluation of crash data seemed to reflect this as well. For the two-year period before the installation of bicycle signal heads at the intersection of Sycamore and Russell, there were about 16 bicycle and motor vehicle collisions. For the two-year period following the installation, there were only two collisions, neither of which involved bicycles.

## CONCLUSIONS AND RECOMMENDATIONS

This study demonstrated that:

- Bicycle signals enhance safety by separating large volumes of bicycle and auto traffic.
- There is minimal additional delay to motor vehicles
- Bike signals are easy to comprehend by cyclists and motorists
- Bicycle traffic signals should be considered on a case-by-case basis taking into account intersection geometry and bicycle and motor vehicle volumes

As a result of what the city of Davis was able to demonstrate regarding the effectiveness of bicycle signal heads, CTCDC voted to approve use of this traffic control device in 1998. Subsequently, the California legislature amended the California Vehicle Code to allow its use statewide, and it was signed into law by the governor in 1999.

## COSTS AND FUNDING

Cost will depend on the complexity and size of the intersection, but in general, costs are comparable to the installation of conventional traffic signals (e.g. controller boxes, detection devices, mast arms, etc.)

## CONTACT

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The modification (biycle signal heads) that is the subject of this case study is not currently compliant with the *Manual on Uniform Traffic Control Devices*, but it may be considered for inclusion once research is completed. Accordingly, it is imperative that any jurisdiction wishing to utilize the bicycle signal heads (or any other non-approved traffic control device) should seek experimental approval from the Federal Highway Administration. For information on how to do so, please visit this Web site: http://mutcd.fhwa.dot.gov/kno-amend.htm.

SEATTLE, WASHINGTON #40

# Pedestrian/Bicycle Crosswalk Signals (Half-Signals)

## BACKGROUND

Bicyclists using residential streets often have trouble crossing arterial streets at unsignalized intersections. This is especially true for bicyclists trying to cross high-volume, multi-lane arterial streets.

Where streets are laid out in a traditional grid pattern, residential streets become particularly attractive to inexperienced bicyclists. However, if crossing major arterials results in too much delay or makes the crossing too difficult, inexperienced bicyclists who are not comfortable using arterial streets will be discouraged from bicycling.

## COUNTERMEASURES

Seattle's solution has been to install pedestrian or bicycle crosswalk signals (formally called half-signals). A crosswalk signal is a pedestrian- or bicyclist-actuated light that stops arterial traffic only, leaving the lower-volume cross-street unsignalized. It allows bicyclists and pedestrians to cross safely upon demand without unnecessarily creating delays for arterial street traffic that a fully signalized intersection might impose. It also can prevent cut-through motor vehicle traffic on the residential street that can happen with the installation of a full signal.

Crosswalk signals also have been successfully installed to facilitate "bicycle boulevards" in various communities around the country. These are bike routes that are designed to encourage fast, through bicycle traffic on residential streets while discouraging through motor vehicle traffic. The crosswalk signals are combined with other treatments such as diverters (for motorists) to create the bicycle boulevard. More often, these signals also have been installed to facilitate pedestrian crossing near schools, hospitals and in neighborhood shopping districts. To date, more than 80 crosswalk signals have been installed in Seattle.


Peter Lagerwey, Pedestrian & Bicycle Program Coordinator, City of Seattle

## EVALUATION AND RESULTS

It is relatively easy to evaluate the success of a pedestrian half-signal. If the number of crashes and bicycle and pedestrian complaints goes down, then it's a success. In Seattle, half-signals have consistently had crash rates equal to or lower than full signals. If the arterial has high volumes, traffic impacts such as the frequency of motorist delays should be studied. If frequent red phases cause delays, consider lengthening the green phase a bit. To strike the right balance, observe the intersection throughout the day and, if necessary, vary the timing.

Seattle's crosswalk signals have been well received. In most ways, they operate like the midblock signals that are used in many communities. If installed with the same care that midblock signals are installed, they can be effective and safe. When Seattle's crosswalk signals are reviewed by other communities, their traffic engineers often express concerns about possible driver confusion which in turn could lead to increased crashes. This has not been Seattle's experience—they don't increase crash rates, people like them, and there is constant demand to have them installed at new locations.

## CONCLUSIONS AND RECOMMENDATIONS

Most jurisdictions use the *Manual on Uniform Traffic Control Devices* (MUTCD) to determine signal warrants, whether the signals are to be installed for vehicular traffic or pedestrians. Crosswalk signals, however, have not yet been incorporated into the MUTCD. Consequently, it is necessary to create more flexible guidelines for installing a crosswalk signal instead of a full signal when there are insufficient gaps for bicyclists and pedestrians. We have two suggestions for installing a crosswalk signal: 1) when traffic volumes on the intersecting street are less than 50 percent of MUTCD recommended benchmarks for a full traffic signal; and 2) when a substantial amount of motor vehicle traffic might be induced to opt for and use a lower volume, residential street if a full signal were installed.

## COSTS AND FUNDING:

Cost depends on a lot of factors, including the location of the nearest power source, the type of poles installed and the availability of space for signal equipment. However, in general a crosswalk signal is about half the cost of a full signal. In many cases, they can be installed for less than $30,000.

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> The modification (half signals) that is the subject of this case study is not compliant with the *Manual on Uniform Traffic Control Devices*, nor is it currently being considered for inclusion. Accordingly, it is imperative that any jurisdiction wishing to utilize the half signals (or any other non-approved traffic control device) should seek experimental approval from the Federal Highway Administration. For information on how to do so, please visit this Web site: http://mutcd.fhwa.dot.gov/kno-amend.htm.

# Share the Road Sign Initiative

## BACKGROUND

The North Carolina Department of Transportation Division of Bicycle and Pedestrian Transportation (DBPT) first installed "Share the Road" signs along designated bicycle routes in 1987. Funding was provided as part of the first annual allocation of Bicycle Transportation Improvement Program (TIP) funds received by the Bicycle Program, as DBPT was known at the time.

The *Manual on Uniform Traffic Control Devices* (MUTCD) specifies what types of signs can be installed along Federal Aid Highways. In 1987, no authorized sign with the "Share the Road" message had been approved. DBPT recognized the need for such a sign and worked within the MUTCD guidelines to develop a state "supplementary" sign. The design chosen utilized an approved black on yellow diamond-shaped bicycle warning sign (designated as W11-1 by the MUTCD) with a supplementary "Share the Road" plaque. In 2000, the Secretary of Transportation decided to use a reflectorized fluorescent yellow-green version of the sign to increase visibility. This design was adopted as a national standard in the most recent MUTCD update.


The sign serves to make motorists aware that bicyclists might be on the road and that they have a legal right to use the roadway. It typically is placed along roadways with high levels of bicycle usage but relatively hazardous conditions for bicyclists. The "Share the Road" sign is especially useful in cities and towns where a significant number of bicyclists use a roadway that by its nature is not suitable to be designated as a bicycle route, but which is an important connection for bicycle transportation. The sign should not be used to designate a preferred bicycle route, but may be used along short sections of designated routes where traffic volumes are higher than desirable.

Mary Paul Meletiou, Program Manager for Planning and Safety, North Carolina Department of Transportation, Division of Bicycle and Pedestrian Transportation

## COUNTERMEASURES

The North Carolina "Share the Road" sign has been installed along many miles of roadways since it was created in 1987. It is used along cross-state, regional and local designated bicycle routes on sections of roadway where traffic volumes are higher than desirable. These sections of roadway typically are less than a mile in length and serve to connect the more lightly-traveled roads that comprise the majority of a given route. The signs are placed on the roadway in each direction, just before the bicycle route joins that particular road, so that motorists will be made aware that cyclists may be on the roadway. If a particular high-volume road must be used for a distance greater than two miles, additional signs are installed. These signs are placed where the greatest number of motorists will see them, based on turning movements off intersecting roads. To elaborate, if there is a choice between placing a sign just before a secondary road with traffic volumes of 1,500 cars versus placing it a short distance farther along the route before a more major road with a traffic count of 5,000, choose the latter. Fieldwork and engineering judgement are necessary to fine-tune the placement of signs.

"Share the Road" signs also have been placed along roads that are not part of a designated bicycle route, both in towns and cities, as well as on rural roadways. Roads and bridges heavily used by cyclists, particularly where on-road improvements cannot be made, are prime locations for such signs. Some examples include a major road near a college or university where many students commute by bike; coastal or mountain roads in tourist areas where no alternate routes exist; or on a bridge approach where no other convenient crossings provide an efficient transportation link.

Installation of "Share the Road" signs is an ongoing process. Each new route system that is developed is assessed for "Share the Road" sign needs. Periodic field inspections of existing routes are conducted not only to check the condition of existing signs, but also to identify areas where changing traffic conditions may warrant additional "Share the Road" signs.

As one example of the extent of sign posting, on a 241-km (150-mi) segment of roadway in Randolph County, NC, a total of 45 "Share the Road" signs were posted (in both directions of travel).

"Share the Road" sign next to a busy roadway.

## EVALUATION AND RESULTS

No formal evaluation on the sign's effectiveness has been conducted, but public feedback has been favorable. Cyclists have noted that motorists seem more courteous in areas where "Share the Road" signs are prominent. One interesting note is that DBPT staff members have received calls from several motorists indicating their willingness to share the road but commenting that cyclists they have encountered do not seem willing to do the same.

## CONCLUSIONS AND RECOMMENDATIONS

"Share the Road" sign projects may be a low-cost way to increase the awareness of motorists and enhance the safety of cyclists. The fluorescent yellow-green W11-1 signs are visible from a great distance.

## COSTS AND FUNDING

Fabrication and installation of "Share the Road" signs range from $75 to $100 each. The fluorescent yellow-green sign costs about twice as much to fabricate as the yellow and black version.

## REFERENCES

*North Carolina Bicycle Facility Planning and Design Guidelines*, North Carolina Department of Transportation Division of Bicycle and Pedestrian Transportation, 1994.

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# Placement of 20-mph School Zone Signs

## BACKGROUND

Different jurisdictions across the nation do not use the same policies in determining where school speed zones are established. Not all jurisdictions even use the same speed limit in the school zone. Seattle had experienced pressure from parents and schools to place 20-mph school zone signs as a matter of course in the vicinity of any school. No written policies were previously in place, and most decisions were made on a case-by-case basis. However, certain factors remained constant, including the placement of these signs only at elementary schools, and only in direct relation to a marked crosswalk (in contrast to a set area around the school regardless of crossing facilities).

This project looked at defining and updating current placement of the 20-mph school zone signs (as well as all school crosswalk signs) in Seattle. The goal of studying where to place 20-mph school zone signs was to provide consistency of use for better motorist understanding, and better motorist compliance with the speed limit. A secondary goal was to have better internal guidelines on sign placement to improve consistency of responding to public and school requests for 20-mph school zone signs. The underlying project goal was to reduce driver speeds at the locations where elementary school children were most likely to be walking or bicycling to or from school.

One decision about the placement of the 20 mph speed zone signs was already made by the state of Washington. Locations with a School Patrol present, where there is no form of traffic control, are required to have 20-mph speed zone signs. In Seattle, School Patrol is an optional student program run by the individual elementary school. Participating students are typically in 5th grade and have an adult supervisor. School Patrol members help other students cross safely, but must remain in sight of the school. By contrast, adult crossing guards are adults employed by the Seattle Police Department.

Megan Hoyt, Pedestrian Safety Engineer, Seattle Department of Transportation


Figure 1. Standard reduced speed school sign.

Combined with this project was an effort to make the 20-mph school zone signs more readily understood as to when the reduced speed limit is in effect and increase motorist compliance. Almost all 20-mph school speed zone signs in Seattle have a qualifying sign attached that reads "WHEN CHILDREN ARE PRESENT" (see fig. 1). This sign is defined through the Washington Administrative Code (WAC) as when:

1) School children are occupying or walking within the marked crosswalk.

(2) School children are waiting at the curb or on the shoulder of the roadway and are about to cross the roadway by way of the marked crosswalk.

(3) Schoolchildren are present or walking along the roadway, either on the adjacent sidewalk or, in the absence of sidewalks, on the shoulder within the posted school speed limit zone which extends 300 feet in either direction from the marked crosswalk.

The general perception in Seattle was that 20 mph school zones are often not obeyed. The Seattle Department of Transportation (SDOT) Pedestrian Program receives a number of complaints from motorists each year asking for clarification of the sign used to qualify 20-mph speed zones. Quite often, the motorist has just received a speeding ticket and is not clear on precisely when the reduced speed limit is in effect. In general, speed zones in Seattle do not receive the respect that parents and school administrators would like to see. The speed at which a motorist travels has a direct effect on the injury sustained by the pedestrian in a collision, and can also increase driver compliance in stopping for pedestrians at crosswalks. A new school zone sign that reads "When Lights are Flashing or When Children are Present" and flashing beacon (figure 2) will replace the sign reading "When Children are Present" and will be set to flash during the times of the day that children are most likely to be traveling to and from school.

The city of Seattle has historically reduced speeds to 20-mph in school zones. The decision of what speed limit to use depends largely on what the normal roadway speed limit is. Almost all arterial streets in Seattle have a speed limit of 30-mph. As the goal of these signs is to reduce motorist speed, the reduced speed should be an achievable change in speed that does not require heavy enforcement. For instance, a reduced speed zone of 15-mph in a section of roadway where the normal speed limit is 40-mph may get very little compliance if it is not enforced. Interestingly enough, however, the city of Tuscon, AZ, has achieved very high compliance in their 15-mph school zones, showing that in the right circumstances this is achievable.

The opportunity for this project occurred as the SDOT upgraded all school crosswalk signs from yellow to fluorescent yellow-green, and changed the school sign at the crosswalk to include an arrow pointing to the crosswalk itself. The field checks necessary to perform the sign replacements presented an opportunity to bring consistency to all school speed zone signs. The pre-existing conditions of each location varied. Fluorescent yellow-green signs were already replaced on principal arterials throughout the city. All other school crosswalks had yellow signs.

## COUNTERMEASURES

The project itself was three-fold. First, the existing conditions had to be documented.

- Where were our 20-mph school zone signs presently located?
- What was the traffic control at the crosswalk?
- Was there a School Patrol or an adult crossing guard present?

Second, new School Sign Placement Guidelines were established. Lastly, we implemented the new 20 mph sign policy. During this implementation, a particular location would either:

- keep the signs it originally had (they would just be upgraded).
- gain 20-mph speed zone signs (where currently only advance warning signs were in place).
- lose 20-mph speed zone signs.

Additionally, criteria were developed to prioritize where to use the new signs and flashing beacons. In the program's first year, new speed zone signs with flashing beacons were installed at 12 locations. An additional 14 locations received beacons in 2004. No funding has been identified for further implementation.


Figure 2. Modified reduced speed zone sign used in conjunction with a flashing beacon.

## SURVEY

To find out what the existing conditions were, a sample survey was taken around several schools. First, we defined the different types of locations possible. The following elements were considered:

- type of traffic control (uncontrolled, stop sign, traffic signal, crosswalk signal)
- type of street (arterial street or residential street)
- whether the crosswalk was attended (School Patrol, adult crossing guard, or unattended)

While the number of lanes of traffic a pedestrian must cross is an important factor for SDOT when evaluating uncontrolled marked crosswalks, this factor did not play a big role in this analysis. The main reason for this is that few marked crosswalks across more than two lanes of traffic are established as elementary school crosswalks. The speed limit on the roadway also did not play a major role in the survey as only several arterial streets in the city have a speed limit greater than 30. This was a factor in the final decision of where to install the beacons, however.

It was not feasible to survey the entire city (the city of Seattle has over 300 uncontrolled marked school crosswalks alone), so the surveyor sought to find a minimum of five examples of each combination (there were a total of 18 combinations).

Once the survey was complete, we had a better understanding of the existing conditions (see table 1).

## SPEED ZONE GUIDELINES

When the survey was complete, we drafted guidelines that both met the department's goals of consistency and combined somewhat accurately with existing conditions.

The old 20-mph school zones were inconsistently established. The new guidelines included:

- keeping the zones at all uncontrolled locations with an active School Patrol presence. (required by state law)
- providing 20 mph signs at uncontrolled crosswalk with adult crossing guards.

(Maps showing the locations of School Patrol had been outdated; through this process we were able to update some of the locations.) The second priority guideline established was to begin placing 20 mph zones at any uncontrolled crosswalk location with an adult crossing guard present. The philosophy behind this decision was that

Table 1. School Zone Signs Field Survey Totals

| # Crosswalks Sampled | School Signing Scenario | | Signs Present At X-Walk | Advance Signs Present | 20-mph Sign Present | End Speed Zone | Midblock crossing |
|---|---|---|---|---|---|---|---|
| 29 | Arterial: Marked Cross-walk; No Traffic Control | unattended | 27 | 23 | 5 | 2 | 2 |
| 17 | | Adult Guard | 16 | 16 | 10 | 3 | |
| 8 | | School Patrol | 8 | 8 | 6 | 1 | |
| 23 | Arterial: Stop Sign | unattended | 2 | 0 | | | |
| 3 | | Adult Guard | 2 | 2 | 1 | | |
| 3 | | School Patrol | | 1 | | | |
| 20 | Arterial: Full Signal | unattended | 2 | 2 | 1 | | |
| 21 | | Adult Guard | 2 | 6 | 1 | | |
| 5 | | School Patrol | | 3 | 2 | | |
| 18 | Arterial: Crosswalk Signal | unattended | 4 | 8 | 2 | 1 | |
| 8 | | Adult Guard | 6 | 7 | 1 | 1 | |
| 3 | | School Patrol | 3 | 3 | 3 | 2 | |
| 22 | Res: Marked Crosswalk | unattended | 20 | 14 | 9 | | |
| 0 | | Adult Guard | | | | | |
| 19 | | School Patrol | 17 | 14 | 9 | | |
| 0 | Res: Stop Sign | unattended | | | | | |
| 1 | | Adult Guard | | | | | |
| 2 | | School Patrol | | 1 | 1 | | |

the adult crossing guards are typically placed at locations where traffic volumes and intersection characteristics are such that students require extra guidance in crossing safely. The locations where adult guards are typically posted also see the highest number of students crossing. Therefore, reducing driver speeds at the locations likely to see the most student traffic focuses attention on the intersections that benefit the most students.

Revised guidelines were discussed among Seattle Department of Transportation staff from the different traffic management divisions. School zone signs were not used at stop- or signal-controlled locations (including crosswalk signals). (See table 2 for placement guidelines.)

## FLASHING BEACONS

In prioritizing the flashing beacon locations, we used the above criteria and also considered average daily traffic (ADT), with higher ADT locations receiving a higher priority. For more consistency with standard engineering practice, and because of the weekday-only nature of the flashing beacon signs, the list of selected locations also includes the most current Average Week Day Traffic (AWDT).

A recent study released by the Federal Highway Administration notes the factors that influence pedestrian safety at marked crosswalks (Zegeer et al., 2002). These are the number of lanes of motor vehicle traffic, the average daily traffic (ADT) and motor vehicle speeds. To select the final 12 locations, staff at the SDOT evaluated all marked crosswalks qualifying for a 20-mph school speed zone. None of these locations had more than two lanes, and only a few had a speed limit higher than 30 mph. Therefore, the locations were ranked by ADT.

Twelve locations ranked highest on selected criteria for the first year of implementation. All locations had adult crossing guards posted. While almost every marked crosswalk considered for this treatment was an uncontrolled marked crosswalk, there were several locations that had crosswalk signals (also referred to as half-signals). One of these locations had not only very high ADT and high vehicle speeds, but also was a high complaint location. This location also was on a roadway with a speed limit of 35-mph. For that reason, it was included in this list of the top 12 locations. The subsequent year of beacon installations used the next 14 locations on this same list. Two locations on the list were not implemented due to construction and timing issues.

## IMPLEMENTATION

With guidelines in place, sign replacement, including the establishment of new 20-mph school zones, was

Table 2. School Sign Placement Guidelines

| School Signing Scenario at Marked Crosswalks | | Signs Present At Marked X-Walk | Advance Signs Present | R 2M (20mph) Sign Present | End Speed Zone |
|---|---|---|---|---|---|
| Arterial: Marked Crosswalk No traffic control | School Patrol | Yes | Yes | Yes | Yes |
| | Adult Guard | Yes | Yes | Yes | Yes |
| | unattended | Yes | Yes | No | No |
| Arterial: Marked Crosswalk Stop Sign | School Patrol | No | No | No | No |
| | Adult Guard | No | No | No | No |
| | unattended | No | No | No | No |
| Arterial: Marked Crosswalk Full Signal | School Patrol | No | No | No | No |
| | Adult Guard | No | No | No | No |
| | unattended | No | No | No | No |
| Arterial: Marked Crosswalk Crosswalk Signal | School Patrol | W-37 overhead sign only | No | No | - |
| | Adult Guard | W-37 overhead sign only | No | No | - |
| | unattended | W-37 overhead sign only | No | No | No |
| ResidentialMarked Crosswalk No Traffic Control | School Patrol | Yes | Yes | Yes | Yes |
| | Adult Guard | Yes | Yes | Yes | Yes |
| | unattended | Yes | Yes | No | No |
| Residential Marked Crosswalk Stop Sign | School Patrol | No | No | No | No |
| | Adult Guard | No | No | No | No |
| | unattended | No | No | No | No |

begun. Signs on minor and collector arterials were replaced in 2002. Signs on non-arterial streets were replaced in 2003.

The installation of the flashing beacons required utility poles on which to mount them. All beacons were installed on the side of the road approximately 200 feet in advance of the marked crosswalk. In several cases, it was possible to use an existing pole. However, the majority of locations required the installation of a new pole. Due to restrictions in where a utility pole could be installed, or existed already, some of the school speed zone boundaries were altered. All efforts were made to place the zone limits as close to the MUTCD guidelines as possible.

## EVALUATION AND RESULTS

Defining specific evaluation criteria was difficult for this project because we did not know until halfway through which locations would change and which would stay the same. There is also the fact that all locations were being upgraded to the fluorescent yellow-green school signs, which complicated the effect the 20-mph speed zone alone would have.

Therefore, the evaluation could best be examined in terms of public feedback and internal opinion. Positive feedback came from the adult crossing guards themselves because quite a number of them did not have the reduced speed zone signs at their locations. This project also created consistent guidelines for 20 mph zone establishment, and has resulted in clearer communication to the public about where the signs are placed and the reasons for the particular sign placement. There have been some negative comments from citizens, however, who wonder why the school speed zones are being established at the locations *with* an adult crossing guard rather than the ones that lack a guard. This particular complaint requires ongoing explanation of the advantage SDOT sees in focusing attention on the places where the most children cross, and where (through placement of an adult crossing guard) it has been determined that children need more guidance in crossing safely.

Before/after speed assessments were performed for several of the flashing beacon locations to determine if motorist compliance increased. The before measures were taken in spring 2002 for most locations, as project completion was originally scheduled for August 2002 (actual construction occurred in August 2003). The before results showed a clear disregard for the 20-mph school speed zones. 'Before speeds' when children were present ranged from 32 mph to 40 mph.


Speed data were also collected several months after the signs and beacons were installed. In all but one case, vehicle speeds when an adult crossing guard was present were lower following installation of the new signs and beacons. The largest decrease in speed noted was a 22 percent decrease (the 85th percentile speed dropped from 37 mph to 29 mph). Despite the reduction in vehicle speed, the range of speeds measured (29 mph to 34 mph) were still well above the 20 mph speed limit.

## CONCLUSIONS AND RECOMMENDATIONS

The SDOT relied directly upon the placement of crossing guards in sign placement. Other jurisdictions may want to consider other criteria in the placement of 20-mph speed zone signs. Criteria that could be considered include the distance from the crosswalk to the school and the number of students using the crosswalk. An important detail to keep in mind is the amount of annual survey work that must be conducted to keep signs current. While the number of students using the crosswalk is important, collecting this information for hundreds of crosswalks could be a large task.

It was very useful to do the survey work and create guidelines for sign placement throughout the city. It is an excellent way to gain internal concurrence on guidelines and to take time to verify that current practices are still useful.

It is not clear whether the consistency of the signs has been noticed or appreciated by the public. In most cases, residents are happy if the change in guidelines allows a school speed zone to be established at a crossing they often use.

While the speed study analysis did not show as large a drop in vehicle speed as we would have liked, it did result in reduced vehicle speeds within the reduced speed school zones. A notable result of the new beacons has also been more effective enforcement by the SDOT. Officers are given a list of the beacon locations and the times they will be in effect. Targeted enforcement is therefore possible, and the SDOT keeps a log of the times the beacons flash which reduces the number of motorists who can contest a ticket.

## COSTS AND FUNDING

The upgrade of the school crosswalk signs was funded through state grant funding. The survey work and background gathering necessary for this project were made possible by help from a graduate school intern and a transportation crew worker on light duty. The first year of flashing beacon installation was funded by a state grant, and the second year was funded by the Seattle Department of Transportation.

## REFERENCES

Zegeer, C.V., J.R. Stewart, H.H. Huang, P.A. Lagerwey, J. Feaganes, and B.J. Campbell. *Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations: Final Report and Recommended Guidelines*. Federal Highway Administration, Office of Safety Research and Development: McLean, Virginia, February 2005, 110 pp. [FHWA –HRT-04-100] available at: http://www.walkinginfo.org/pdf/r&d/safetyeffects.pdf

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# Shared-Use Arrow

## BACKGROUND

A bicycle lane stripe provides a lateral positioning reference for both motorists and bicyclists, and the presence of the stripe, as well as signs, informs motorists that bicyclists are typically present upstream. In contrast, the absence of bicycle-specific pavement markings in wide outside lanes (also known as wide curb lanes), another widely acknowledged way to accommodate bicyclists, obviously means that there is no reference for lateral positioning, or a visual cue to the existence of upstream bicyclists.

Another argument put forth is that bicycle lanes are clearly marked spaces for bicyclists that have been shown to draw riders off of adjacent sidewalks and onto the roadway, a desirable outcome given the inherent dangers of sidewalk riding. On the other hand, because there are no bicycle-specific markings in wide outside lanes, they are not recognized as an on-road bicycle "facility" by many bicyclists, resulting in a higher incidence of adjacent sidewalk riding than could otherwise be the case.

## COUNTERMEASURES

The shared-use ARROW is a symbol placed on the roadway with a stencil and is used to indicate proper positioning for a bicyclist in a shared travel lane. The shared-use ARROW (figure 1) was developed with the intention of addressing the deficiencies of wide outside lanes mentioned above. Furthermore, for situations at which sufficient pavement width exists to choose between striping a bicycle lane or leaving a wide outside lane, the shared-use ARROW may offer a third option, "bridging the gap" between the two existing treatments. Unlike a bicycle lane stripe, the shared-use ARROW does not restrict bicyclists and motorists to separate areas of the roadway, thus addressing several potential problems of bicycle lanes. The shared-use ARROW also requires less pavement marking materials than a bicycle lane stripe, and the ARROW reinforces the correct direction of travel, an issue of great importance for bicycling safety.

William W. Hunter, Senior Research Scientist,
UNC Highway Safety Research Center

Figure 1. Shared-use ARROW.

The original shared-use stencil was developed by James Mackay, the Bicycle and Pedestrian Planner for the city and county of Denver, CO. The city of San Francisco, through Manito Velasco, assistant transportation engineer, has also used the stencil. They elongated it from 1.3 m (4.25 ft) to 1.8 m (6 ft) and also altered the placement specifications. The current ARROW builds upon these efforts by establishing a widened opening along its centerline in an effort to channelize and make it more obvious to bicyclists to track down the centerline of the symbol.

Lateral placement was proposed at 0.8 m (2.5 ft) from the curb face, which was based on the local conditions of a 4.6-m (15-ft)-wide lane with no gutter pan and preliminary BEFORE measurements which showed bicyclists riding 0.5 m (1.6 ft) on average from the curb. Furthermore, with this specified spacing, it was expected that motor vehicle tires would be less likely to track over and wear out the marking. However, earlier paving over the old gutter pan had left a seam about 0.6 m (2 ft) from the curb. Thus, instead of at 0.8 m (2.5 ft) from the curb face, the ARROW was placed at 1.1 m (3.5 ft) by Gainesville Public Works (Figure 2).

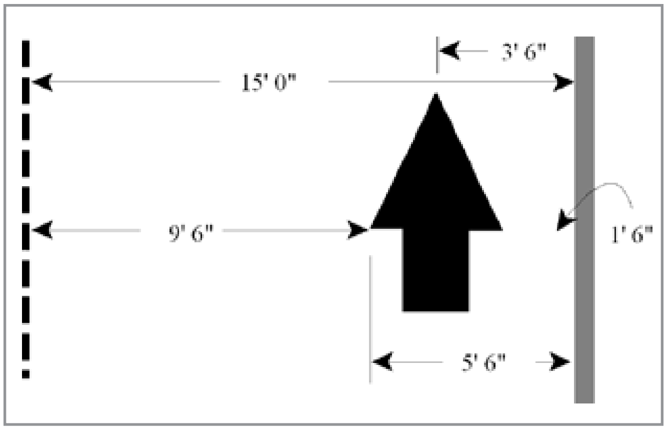


Figure 2. Actual lateral placement.

## EVALUATION AND RESULTS

A before and after evaluation was conducted. Four locations along 13th Street (US 441) in Gainesville, FL, were examined using videotaping equipment to record bicycles and motor vehicles. In this study area 13th Street has four lanes with wide outside lanes in both directions. The street has a 30 mph speed limit and carries about 35,000 vehicles per day. Sites 1-3 were acceptable for all data that was to be collected, while one site (Site 4) was not acceptable for spacing measurements.

Seventeen videotaping sessions about two hours long were used to gather data both before and also after the ARROW was installed for a total of 34 sessions. Concurrent with installation of the device, about one week of public awareness was conducted. A press release was prepared, and television crews filmed bicyclists riding along the stenciled street. Information about the stencil was widely disseminated to University of Florida students, faculty, and staff through normal channels. The videotapes were examined by HSRC personnel. Three lateral spacing measurements were made using Jandel Scientific SigmaScan Pro Image Measurement Software on still images of the videotape captured by Snappy Version 3.0. The measurements were bicycle to curb, bicycle to motor vehicle, and motor vehicle to curb.

Before the ARROW was placed, 39.3 percent of bicyclists rode in street, with traffic. After the ARROW was placed, the proportion of bicyclists riding in street, with traffic increased to 45.3 percent. Comparing in street, with traffic with all other positions and directions combined (a 2x2 table, chi-square test) yields a statistically significant increase ($p<.05$) toward riding in the street with traffic after the placement of the ARROW.

Bicycle-to-curb measurements were made to determine if the ARROW was associated with a change in the lateral positioning of bicyclists. The difference between the before measurement of 0.5 m (1.6 ft) and the after of 0.6 m (1.8 ft) (about 76.2 mm (3 in.)) was statistically significant ($p<.01$). However, this small difference was not considered to be practically significant.

Bicycle-to-motor vehicle measurements were made when a motor vehicle with a driver with unobstructed view was directly next to the bicyclist, the front wheels of the motor vehicle and bicycle in line. The mean bicycle-to- motor vehicle measurement in the before period was 1.8 m (6 ft) ($n=92$). The mean bicycle-to-motor vehicle measurement in the after period was 1.9 m (6.1 ft) ($n=83$). The difference was not statistically significant.

The motor vehicle-to-curb distance was measured from the outside edge of the front tire (or in some cases the rear tire) to the curb face when there were no bicyclists nearby to influence the drivers' positioning. The difference between the before mean of 1.9 m (6.3 ft) and the after of 2 m (6.4 ft) was not statistically significant.

There was an interesting difference in the distributions of the measurements that were made, and the difference was associated with the Bicycle-to-Curb distance. There was increased spread in the lower end of the distributions in the after period, such that the proportion of bicyclists riding 0.5 to 0.8 m (1.8 to 2.5 ft) from the curb increased substantially, in effect increasing their safety margin.

## CONCLUSIONS AND RECOMMENDATIONS

There were no practical differences in the average lateral spacing measurements of bicycle-to-curb, bicycle-to-motor vehicle, and motor vehicle-to-curb. However, the proportion of bicyclists riding 0.5 to 0.8 m (1.8 to 2.5 ft) from the curb showed a substantial increase, giving them a larger safety margin. There was a statistically significant increase in the proportion of bicyclists riding in the street after placement of the ARROW. This shift from the sidewalk to the street should increase safety by putting cyclists where they are more visible to motorists and out of conflict with vehicles entering or exiting driveways that cross sidewalks, as well as reduce the conflicts with pedestrians.

The 13th Street corridor was chosen because there were enough bicyclists riding on a daily basis to make data collection efficient. In retrospect, however, the number of cyclists may be a factor that mitigates against possible shifts in the distance measures of effectiveness. It is certainly possible that motor vehicle drivers on this route are well attuned to the presence of bicyclists, and thus may already have shifted their traffic lane location away from the curb to account for the space needs of bicyclists before the ARROW was installed. However, the shift in the lower end of the Bicycle-to-Curb measurement which yielded more riding space for bicyclists is compelling enough to "keep the jury out" on this shared lane treatment a bit longer. More trials in other locations are recommended and should result in more conclusive findings.

The modification (shared use arrow) that is the subject of this case study is not compliant with the *Manual on Uniform Traffic Control Devices*, but a version of this marking (bike symbol followed by chevrons, shown on page 279, Figure 2) is being considered for inclusion. Accordingly, it is imperative that any jurisdiction wishing to utilize the shared use arrow (or any other non-approved traffic control device) should seek experimental approval from the Federal Highway Administration. For information on how to do so, please visit this Web site: http://mutcd.fhwa.dot.gov/kno-amend.htm.

## COSTS AND FUNDING

Approximate costs were the following:

| | |
|---|---|
| Labor | $500 |
| Trucks and arrow board | $216 |
| Paint and stencil | $118 |
| Total | $834 |

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# Enforcement for Bicycle Safety

## BACKGROUND

The enforcement of laws, both for bicyclists and motorists, is critical to improving bicycle safety and enjoyment. Very little effective enforcement typically occurs, however, in U.S. cities and towns. Wisconsin's Enforcement for Bicycle Safety (EBS) course was designed to help law enforcement agencies and officers correct this situation.

Police officers are the only ones who can enforce laws, yet most officers never receive any bicycle-specific training. Bicycle issues generally are not a police priority. The public and many officers assume that since officers are trained in traffic enforcement, this training includes bicycle safety. Police officers tend not to enforce laws that they do not know or cannot justify enforcing.

In Wisconsin, police recruits receive 400 hours (and soon 520) of basic standards training, of which 10 hours cover traffic law. Laws related to bicycling could be covered during this basic training, but they normally aer not discussed. Following recruit school, newly hired officers go through 10+ weeks of field training. This is another bicycle training opportunity, but it is seldom used. All police officers are required to take 24 hours of continuing education each year. This presents a third opportunity for bicycle safety training, but until the creation of EBS in 1995, there was no such training available (this absence of training tends to be true nationwide). Therefore, most police officers have never been taught the leading causes of bicycle crashes, the laws specific to bicycle safety, and how selective enforcement can improve bicycle safety. Without this information, police officers are unlikely to contribute significantly to bicycle safety and enjoyment in their communities.

Enforcement for bicycle safety is part of police culture in only a few communities. EBS is changing the belief of both officers and the public that "Bicycle violations are trivial." Bicycle safety should be a recognized part of every officer's job. In 2001, 728 bicyclists were killed and 45,000 were injured in reported crashes with motor vehicles in the United States (U.S. DOT, 2002).

Peter Flucke, President, WE BIKE

Law enforcement has a role, along with engineering, education and encouragement, in improving bicycle safety. Well-targeted enforcement (with or without citations) has great potential to positively affect bicycle safety and enjoyment. Officers can also help engineers, educators and others to identify possible problems and solutions.

### THE GOALS OF EBS:

**Short Range**

1) Provide police officers with basic training about bicycling and bicycle safety issues.
2) Develop awareness among police officers about the significance of bicycling and its related issues.
3) Convince officers that they can improve traffic safety by enforcing laws, both for bicyclists and motorists.
4) Encourage police departments to adopt a bicycle law enforcement policy.
5) Demonstrate the need to develop additional bicycle education curricula and materials for police agencies.

**Long Range**

1) Promote a safer and more enjoyable bicycling environment.
2) Reduce deaths and injuries to bicyclists.

## COUNTERMEASURES

The Enforcement for Bicycle Safety Course (EBS) was developed in 1995 for the Wisconsin Department of Transportation Bureau of Transportation Safety, in conjunction with the Law Enforcement Training Center at

Lakeshore Technical College (LTC) in Cleveland, WI. LTC was chosen because courses developed with a state-certified law enforcement training center are automatically approved by the Department of Justice for continuing education hours and training dollars.

EBS is a two-day course designed to give police officers the basic bicycle safety information they need to manage traffic and provide a safe bicycling environment in their communities. The course is designed for all police officers who are assigned patrol duties and will encounter bicyclists. Officers patrolling by bicycle and those involved in bicycle education find EBS particularly helpful. Topics covered include bicycle history, bicycle types, why and where people bicycle, engineering, bicycle crashes, enforcement, laws, crash investigation and reporting, education, bicycle theft, bicycle registration, police bicycle patrols, and on-bike training.

Courses initially were offered through the state's law enforcement training centers at vocational-technical colleges, but this approach was quickly abandoned in favor of offering the course through individual police departments.

## EVALUATION AND RESULTS

For the first few years of the course, officers were given pre-tests and post-tests designed to measure both their basic bicycle safety knowledge and their attitudes about enforcement for bicycle safety. The bicycle enforcement activities of 10 officers from one department were evaluated for a five-year period before the course and then one year after the course. Feedback is solicited from course participants following every course via a course evaluation form. The number of officers trained is tracked, and the future bicycle safety activities of some of these officers are monitored. Requests for courses and presentations about the course are tracked both within and outside of the state.

Initially, it was difficult to schedule courses and to fill them once scheduled. It seemed logical to offer the course through the vocational-technical colleges because this is where police officers receive their recruit school and continuing education training. But because of a lack of familiarity with the topic and insufficient advertising, few of these courses were successful. Once the courses were transferred to individual departments they became highly successful. The success of department-run courses is primarily because of incentives and marketing. Hosting departments are offered free spots in the course once a minimum number of students is reached. Hosting departments advertise the course heavily to reach this minimum and receive the free spots.

There now are three instructors running regular EBS courses in the state, but reliable course data is available from only one instructor. That instructor, the course developer, has conducted 15 courses over the last eight years. Class sizes average approximately 11 students, and 167 officers have been trained.

During the eight years that the course has been offered, the types of officers participating has changed. For the first few years, most of the attendees were new to the law enforcement field, had little, if any, bicycle experience and were sent by their training officers. Over the years this has changed. More recently the course has attracted officers who have experience in law enforcement (three to five years plus), are already trained as bicycle patrol officers (either by the Law Enforcement Bicycle Association (LEBA) or IPMBA) and have requested the training. Because of their on-bike training and experience, these latter trainees have tended to do better in the course and enjoyed it more.

Based on pre- and post-test results, officers attending EBS significantly improve both their bicycle safety knowledge and their attitudes about enforcement for bicycle safety. Typical comments from officers include, "I wish that I had taken this course years ago," and "It would be a good idea to send every officer through your class." One supervisor commented, "This is the first time that an officer came back from a (class) and shared the information.... Thank you for the presentation."

The bicycle enforcement activities of 10 officers from one department were evaluated for a five-year period before the course and then one year after the course. Before the course, these officers had issued only two citations for bicycle violations. The year following the course, each officer wrote an average of three to five citations. These numbers do not include citations to motorists for bicycle safety-related stops or contacts that did not result in a citation. Those types of enforcement activities are believed to have increased as well.

Following their participation in the EBS course, many students have increased their level of participation in bicycle safety activities. Some make more enforcement contacts, others have sought out additional bicycle safety training and have become instructors for this and other courses. One officer now sits on the board of directors for a state bicycle advocacy organization. All of these activities indicate an increased level of awareness and interest among police officers of bicycling issues.

Developing instructors for the course has been difficult. Police officers, or former police officers, seem to be the most credible when teaching other officers. But, because of their workloads and schedules, most police officers have little free time for other jobs. Also, relatively few officers are interested in teaching bicycle safety to other officers. An instructor course was conducted in 1996 shortly after EBS was developed; however, none of the participants had taken the course before and only two graduates went on to teach courses. Another instructor course was conducted in 2001 using only former EBS graduates. The six instructor candidates still need to co-teach with the lead instructor, but then they will be certified.

EBS has gained national recognition. Courses or presentations about the course have been made in Minnesota, Indiana, Iowa, Pennsylvania, Arizona and Washington. Portions of the course recently were incorporated into a new National Highway Traffic Safety Administration course, "Community Bicycle Safety: For Law Enforcement."

## CONCLUSIONS AND RECOMMENDATIONS

The most effective means of introducing bicycle safety knowledge and activities into law enforcement likely is through inclusion of bicycle safety training in police recruit schools and field training for new officers. Until this happens, continuing education training, like EBS, will have to fill the gap. EBS training dramatically improves the knowledge, activity levels, and attitudes of police officers about enforcement for bicycle safety. This type of training should be incorporated into every law enforcement department in the country.

## COSTS AND FUNDING

The cost of the EBS course is $90 to $100 per officer, but departments that sponsor a course receive a discount, usually free spaces in the course. The course is approved by the Wisconsin Department of Justice and training dollars can be used to pay for attendees.

Funding for the initial development of the course in 1995 was provided by the Wisconsin Department of Transportation-Bureau of Transportation Safety (WisDOT-BOTS) using Federal Highway Safety (402) Funds. The cost was about $10,000. WisDOT-BOTS paid approximately $10,000 to revise and update the course materials in 2001.

## REFERENCES

United States Dept. of Transportation. *Traffic Safety Facts, 2001: Pedacyclists.* Washington: National Highway Traffic Safety Administration, 2002.

WE BIKE, *Enforcement For Bicycle Safety*. Wisconsin Department of Transportation Madison. Revised 2001.

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CHICAGO, ILLINOIS #45

# Bicycling Ambassadors and Bike Lane Education

## BACKGROUND

Mayor Daley's Bicycling Ambassadors spent the summer of 2002 teaching safe cycling in Chicago in several different venues, including Chicago Park District day camps, after school programs, neighborhood festivals, block parties, sporting events and large city festivals like the Taste of Chicago and Jazz Fest. The program, based on a similar program in Toronto, Canada, is part of the Chicago Department of Transportation's Bike Program and was initiated the previous summer to educate Chicagoans about safe cycling, as well as to encourage both children and adults to cycle more. One of the Ambassadors campaigns focused on educating motorists on the proper use of bike lanes on Chicago streets.

Chicago has installed 70 miles of new bike lanes on city streets, a majority of those within the past few years. Because these are new facilities, many cyclists and motorists have misconceptions about how bike lanes will affect the safety, capacity, and access of streets. These misconceptions could lead to community disapproval of new bike lanes.

Many cyclists also complained that they did not feel safe using bike lanes because motorists often drive in them, use them as a passing lane and double-park in them, which forces cyclists to swerve into the travel lane. Since bike lanes are on streets that are highly trafficked by both motorists and cyclists, motorists' practices reduced the feeling of safety the bike lanes were meant to engender.

Dave Glowacz, Director of Education, Chicagoland Bicycle Federation
Christine Ranieri, Bicycle Ambassador, Chicagoland Bicycle Federation

## COUNTERMEASURES

The Bicycling Ambassadors canvassed 11 streets where bike lanes had been installed in the last few years. On each stretch, they visited every business and talked to employees about the bike lanes, asking them to encourage their customers not to drive or double-park in the bike lanes at the risk of a $100 fine. At businesses that agreed, Ambassadors left literature for customers about bike lanes, including "Bike Lanes: Frequently Asked Questions" and a flier titled "This is Not a Parking Spot: Bike Lanes are for Bikes" which explained the $100 fine and why it is dangerous for cyclists when motorists drive in bike lanes. Several businesses also agreed to tape the flyers in their storefront windows.

## EVALUATION AND RESULTS

The Bicycling Ambassadors recorded: 1) each business visited; 2) the opinion expressed by the store's employee(s); 3) whether or not they took the literature; 4) whether or not they agreed to distribute it or post it; and 5) any comments the employees may have made about the bike lanes or literature.


Of the canvassed businesses, 48 percent expressed a favorable opinion towards bike lanes and the task of encouraging their customers not to park or drive in them. Twenty-eight percent had no opinion, eight percent had a negative opinion and 19 percent made no comment. Seventy-five percent of the businesses agreed to take the literature, and of that 75 percent, 71 percent agreed to distribute it by either putting it out near their cash registers, in literature racks or by posting fliers. Several businesses were interested in putting bike racks on the sidewalk in front of their shops (the City of Chicago installs racks on city property free of charge) and obtaining loading zones to help eliminate double parking. Negative comments centered on bicyclists' refusal to follow traffic laws. Positive comments centered around: 1) the hope that bike lanes would reduce the number of people cycling on the sidewalk 2) general enthusiasm for safer cycling in the city and 3) the desire to be regarded as a bicycle-friendly establishment.

## CONCLUSIONS AND RECOMMENDATIONS

These results suggest that the business canvassing project should be continued by the Bicycling Ambassadors next summer. It is effective for several reasons. First, the campaign directly educates one or more individuals working in each business. Second, since most bike lanes are on well-trafficked streets with a large number of businesses, customers could see the flyers in every shop they frequent on the block, and realize that respecting bike lanes is a concern for business owners in the area. This impresses cyclists, educates motorists and can only work in the business' favor. Finally, personal contact allows business owners to air concerns and ask important questions about issues such as: loading zone permits, lifts on rush hour parking restrictions, laws concerning cyclists, and how to get a bike rack installed in front of their business. The campaign might be more effective if literature was regularly replenished in the businesses that were amenable to accepting and displaying it. Finally, the campaign would be most effective if the "Bike Lanes: Frequently Asked Questions" leaflet consistently was placed on cars parked along bike lane streets, reinforcing the information seen in the shops.

An obstacle that often came up in this project was not being able to communicate with non-English speakers. While one of the Bicycling Ambassadors spoke Spanish and the two fliers were printed in Spanish, it still was difficult to communicate if the Spanish-speaking ambassador was not present or if another language was spoken. It would be more effective if those who speak the languages of the particular street or neighborhood were hired to conduct the canvassing, and if literature was printed in several languages commonly spoken in the city.

## COSTS AND FUNDING

Funding for the Bicycling Ambassador program predominantly came through a grant from the Illinois Department of Transportation, Division of Traffic Safety and matching funds from the Chicago Department of Transportation, Bureau of Traffic. Office space, training and support came from the Chicagoland Bicycle Federation. Kryptonite Locks, Bob Trailers, American Automobile Association-Chicago Motor Club, and Planet Bike also sponsored the program.

## REFERENCES

Mayor Daley's *Bicycling Ambassadors 2001 Report*

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# A Comprehensive Child Bicycle Safety Program

## BACKGROUND

### BASELINE INJURY INCIDENCE

Preliminary research on bicycle-related injury mortality and morbidity was conducted by the Florida Department of Health's Injury Prevention Program Office (TIPPO) in Duval County during the end of 1994 and the beginning of 1995. Early assessment revealed a disproportionately high incidence of bicycle injuries among the 5- to 14-year-old age population in Duval County. This population group ranked number one with 35 percent of all nonfatal bicycle-related injuries during 1994. Only four of the 115 injured children in the same age group were wearing helmets during the crash event (1). This represents only a 3 percent helmet use rate for the nonfatal injured group and no helmet use among the four fatalities that year.

### BASELINE HELMET USE

In 1996 the Florida Department of Transportation approved a grant for Florida State University to conduct a *Florida Bicycle Helmet Use Survey* (2), which included Duval County. The 1996 survey revealed the overall bicycle helmet use rate for all ages in Duval County to be 19 percent (the second lowest rate among the eight counties in the study). The same report revealed a 14 percent observed helmet use rate for the 5- to 14-year-old age group in Duval County—the same population group that experienced the highest injury rate.

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Radley C. Remo, M.P.H., Coordinator for the Center for Health Statistics, Duval County Health Department, Jacksonville, FL
Carol Conroy, MPH, PhD., Director of Epidemiology Division, Duval County Health Department, FL

## COUNTERMEASURES

### ACTION PLAN

With the problem clearly defined, Florida Department of Health's Injury Prevention Program Office (TIPPO) in Duval County drew up a project design with the aim of increasing helmet use among 5 to 14 year olds in the county as its primary goal. Our goal was formalized and reads, "To increase use of bike helmets in Duval County Public Elementary Schools' aged children to at least 50 percent by December 1999 as measured by baseline and annual observational surveys." A work plan with scheduled milestones and activities was then drafted to track the implementation progress. Three countermeasures to apply to the at-risk population group were chosen based on efficacy studies found in the literature. The three countermeasures were:

- Institutionalizing a school-based bike safety program with emphasis on knowledge-based education and skills training, including proper helmet use;
- Seeking bicycle helmet legislation and policy support;
- And providing and promoting one of the most effective injury-prevention technologies, bike helmets, at discounted or no cost to school-age children.

## ACCESSING HUMAN AND ECONOMIC CAPITAL

To accomplish our objectives, we knew we would need broad community support and a strong coalition of working partners. We were fortunate to gain successful, progressive buy-in from a vast array of disciplines with an interest in mitigating the problem of bicycle-related injuries to children. Both direct financial, and in-kind support, including staff salaries, were and are an important part of this program.

**"Show Me the Money!"**

Primary underwriting has come from the Florida Department of Transportation State Safety Office with approximately 50 percent of the monetary support over the eight-year history of this project. The second largest cash commitment to the project came from Brooks Health Foundation which is affiliated with Brooks Rehabilitation Hospital. (A cumulative summary of the financiers of the project is listed on the last page.)

**In-Kind**

The second critical fiscal support element for this project is in-kind donations. The Duval County School Board and the Duval County Health Department carry the lion's share of day-to-day staff allocation by providing project administration staff and teachers for the bicycle safety curriculum at the 103 elementary schools and 26 middle schools in Duval County, Florida, over the past eight years.

A pivotal position to keep the implementation process in the schools going is the school board's bike contact/project coordinator. This person works full time on making sure that the schools are implementing the bike safety curriculum, scheduling the trailers, conducting instructor trainings, and acts as a liaison for communications between all the core partners. In addition, the Fleet Management Division of the school system is invaluable to the project because they store and transport all the equipment the schools need to conduct the project at their individual schools.

**Garnering Political Will**

A third level of support was sought in the form of coalitions, single organization champions and support groups that would be responsive to the cause of reducing bike injuries in Duval County. At the local level, TIPPO has become an active member in three coalitions that have vested interests in the bicycle-injury problem. These groups are the Jacksonville Pediatric Injury Control System, Duval County Community Traffic Safety, and The Bicycle/Pedestrian Advisory Committee within the mayor's office. These groups provide expertise in the areas of injury prevention among children, traffic-related injury prevention knowledge, and a connection to the local governing body.

**Local Champions**

The other champions on the local scene are too numerous to mention, but are no less important to the whole mission. They comprise individuals with a passion for the problem, private enterprises that are sensitive to giving back to the community in this form, bike clubs, the housing authority, bike shops, the Jacksonville Jaguars football team's foundation, hospitals, service clubs, the city parks and recreation department, law enforcement agencies, rehabilitation hospitals and clinics, brain injury associations, medical associations, law firms, academia, physical education associations, and public health associations.

**State and National Support**

Statewide organizations and state and national agencies including The National Highway Traffic Safety Administration, the Federal Highway Administration and the Center for Disease Control & Prevention have also supported this effort.

## CURRICULUM

TIPPO selected a bike safety curriculum developed by the University of Florida because of its strong emphasis on skills training, a highly rated peer-reviewed curriculum, its perspective on bicycle safety in the context of all traffic safety (pedestrian to pre-drivers education), its two-day certification requirement for all instructors, and the proximity of the University for technical support. The curriculum, the *Florida Traffic and Bicycle Safety Education Program* is grade-specific and is meant to build on the previous years knowledge and skills base (see http://www.dcp.ufl.edu/centers/trafficsafetyed/ for more information). The ultimate project vision and mission is that the knowledge and skills learned in the early years will also transfer to safe motor vehicle driving behaviors when the children get older.


## INSTRUCTORS

Since 1995, over 175 physical education teachers and school resource officers have been trained and certified with the classroom and the on-bike skills qualifications needed to deliver the curriculum to the children during physical education classes in the 103 schools.

## EQUIPMENT

Thirteen custom-designed (by TIPPO) transportable self-contained training modules (trailers) were purchased to house bicycles, helmets, street signs, videos, P.A. systems, curricular manuals, teaching aids, etc. to service and rotate among the 103 elementary schools in the county. The fleet management division of the school system provides transport of the trailers to and from the elementary and middle schools. A school warehouse is used to store equipment between deliveries to the various schools and during school breaks. The school system provides the maintenance of most of the project equipment, but some bicycle repairs are contracted out to local bike shops.

## LEGISLATION AND POLICY APPLIED TO THE TARGET POPULATION

In 1996, TIPPO provided statistical data, cost of injuries, and cost benefit analysis of helmets to inform and educate the state legislators before their vote on bicycle helmet legislation. Florida passed bicycle helmet legislation for children under the age of 16, which took effect in 1997. TIPPO also drafted a Helmet Proclamation, which was adopted and signed by the Duval County School Board President and superintendent of schools. The proclamation then was posted at all elementary schools in 1997. The injury prevention staff worked with the Duval County public school curriculum writers to craft a bicycle safety education standard that served as a countywide mandate to provide the health department's bike safety project in all 103 elementary schools. In 1998 the city of Jacksonville passed a City Council Resolution recognizing the health department's bike safety project.

## PROVISION AND ACQUISITION OF HELMETS APPLIED TO THE TARGET POPULATION

Over 20,000 helmets have been sold and distributed with "hands-on" proper fit training throughout the elementary schools of Jacksonville in the last seven years. A unique system of helmet acquisition was designed to be self-contained and modular like the educational trailer component. Twenty-two kits were assembled that contained samples of the helmets, three types of sales procedures, order forms, and measuring instructions. TIPPO then processes the schools' helmet orders and arranges direct shipment from the vendor to the individual schools. Scholarship programs were also designed for each school, and included in the helmet kit. The health department was able to purchase helmets at low cost through its competitive bid process. Rather than give the helmets away free, helmets were sold to the children for $4 to $5, about half the price that the health department paid. Subsidizing the helmet cost rather than giving them away, enabled the County to provide low-cost helmets to more of the County's at-risk population, approximately 50 percent instead of 25 percent that would have been possible with free helmets.

Other project reinforcement over this period has included:

- Helmet contracts between dentists, kids, and parents conducted in dental offices

- Implementation of a "safety village" in Jacksonville that in 2001-2002 trained 2000 Pre-K to second-grade children during field trips with proper helmet fit and on-bike riding through a miniature town that includes working traffic lights, railroad crossings, etc.

- Production and airing of two helmet public service announcements reaching a viewing audience of over 180,000 households through the local NBC, ABC, CBS, PBS and FOX affiliate TV stations

- Helmet incentive project with school crossing guards rewarding helmeted kids with age-appropriate prizes

- Weekend bike rodeos conducted with our community education trailer that is specially equipped with tricycles, bicycles with training wheels, adult-size bikes and a wide range of age-specific support materials.

All of the above activities and products are specifically planned to raise community awareness of bicycle safety and injury prevention. Therefore, an intensive multifaceted project aimed at the highest risk population combined with a multi-level awareness campaign aimed at creating a community bike safety norm.

## EVALUATION AND RESULTS

### KIDS TRAINED WITHIN THE ELEMENTARY AND MIDDLE SCHOOLS

There have been 115,000 children (the target population is about 64,000 children in any given year) educated and trained in proper helmet fit and pedestrian and on-bike safety skills. Many of these children have received annual bike safety training throughout their elementary and middle school grades. Program reviews and audits suggest that the number of children educated has actually been underestimated.

About 75 percent of the elementary schools have participated in the project at least once, and some annually, while an estimated 25 percent of the schools have not participated in the bike safety curriculum or helmet distribution. Further study to determine possible barriers to school participation, and to gain higher compliance to reporting protocols, are part of TIPPO's on-going quality improvement goals.

We evaluated data from pre- and post-intervention annual observational surveys (1996–2002) to determine if the intervention (bicycle helmet sales and bicycle safety education) increased the use and proper use of bicycle helmets. We also compared experimental schools (exposed to the intervention) against control schools (not exposed to the intervention). Although data were collected on other bicycle safety behaviors (such as scanning, signaling and wearing bright visible clothing), this case study focuses only on helmet use and proper use.

Data were collected at school locations for approximately 45 minutes before school started or immediately after school ended. To maximize the number of observations, schools were observed during the school year's warm weather months (April through June). Three Duval County Health Department employees and one Duval County School Board employee collected the data.

### PRE-INTERVENTION VS. POST-INTERVENTION

In 1996 there were a total of 735 children observed at school sites. Of those a total of 93 wore a helmet (12.7 percent), an even lower percentage than the results from the statewide observational survey. Over the next six years, the bicycle helmet usage rates ranged from as high as 63.9 percent in 1998 to as low as 43.8 percent in 2001. All of these years have shown a greater helmet use rate than the baseline. The number of bicyclists observed for those same years ranged from 409 to 582, each a smaller sample than the baseline year. The methodology used for the surveys was the same year-to-year except for modification of age groups over different years. Middle school children are included in the yearly results even though they were not exposed to the curriculum until 2001. The observed increases in helmet use might, therefore, be understated, although it remains to be seen if middle school students will show the same degree of increase in helmet use as the elementary-aged children.

There was a significant increasing trend in helmet use across all locations (see figure 1). Only children in elementary and middle schools observed riding to or from school are included in this figure. Figure 1 shows a rapid increase from baseline to the next immediate year then shows the rates start to level off at about 44 percent for 2001 and 2002.

Data on proper use of helmets were available from 1997 to 2002. Because the data were not disaggregated by age group and observation location, proper helmet use was analyzed for the total sample (including children and adults) and not by observation location. Baseline data were from the 1996 observational survey conducted by school board transportation specialists. Proper use as a percent of total use among all ages dropped dramatically from baseline to 1997 and then again from 1997 to 1998, from 87 percent to 47 percent (figure 2). Proper use remained about the same for several years, and then climbed dramatically for 2001 and 2002 to 73 and 77 percent, respectively. Although total use peaked in 1998 and gradually leveled off, proper use showed a somewhat counter-trend. If school-aged children showed similar trends to the all-ages data, then the overall result would be an increase in the proportion of children properly wearing helmets from about 11 percent at baseline to 34 percent in 2002. It is likely, however, that children wear helmets improperly somewhat more often than do all ages. Nevertheless, the results are encouraging that there has been an increasing trend in proper helmet use.

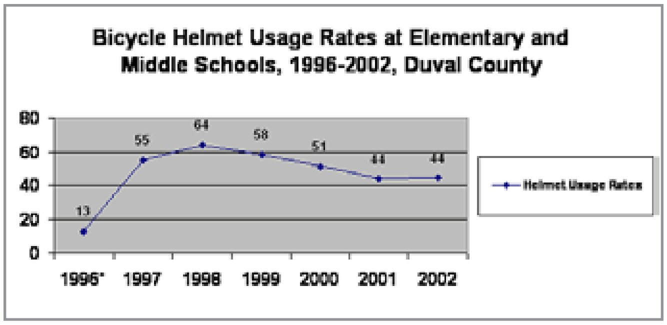


Figure 1. *Note: Bicycle Helmet Use was calculated for both elementary and middle schools over all years even though the first five years of this project targeted only elementary school children. Proper Bicycle Helmet Use, is calculated as percentage of those wearing helmets. 1996 was the baseline year; data from observational survey. Middle school children were not exposed to the intervention until 2001 (2002 survey results).

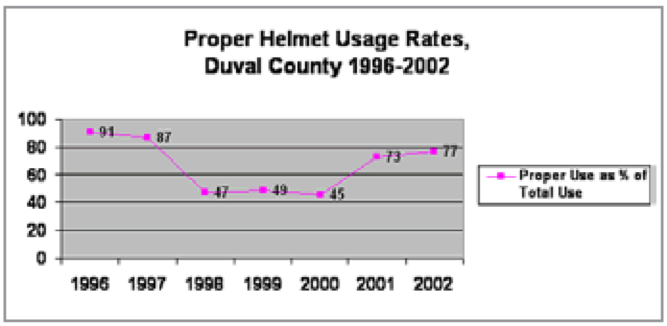


Figure 2. *Note: Proper helmet use is calculated as the percent of those using helmets, for both elementary and middle schools over all years, although the first five years of this project was aimed only at elementary school children. Middle school children were not exposed to the intervention until 2001 (2002 survey results). 1996 is the baseline year.

## CONCLUSIONS AND RECOMMENDATIONS

These results suggest that our multi-faceted bicycle safety program has been successful in increasing helmet use among children. Observations indicate substantial increases in helmet use among children riding to and from school, although rates have leveled off since 1998, possibly due to less enforcement of the helmet law in recent years. The evaluation relates to the effect of implementing a safety program in a community (Duval County) and does not address whether there were changes in behavior in the individual children receiving the safety training. Therefore, additional evaluation aimed at comparing individual changes in behavior (e.g., use of helmets, proper use of helmets, safe riding skills) among children receiving the training and those not trained needs to be completed to more precisely measure the success of the safety program.

Additionally, because there were several components to the intervention (distributing low cost helmets, helmet use education, fitting instruction, and riding safety) it is important to evaluate the different components. There may be other factors, including a helmet law that went into effect January 1, 1997, and a school proclamation endorsing helmet use that also contributed to the increase in helmet use. Considering these factors would be an important next step to evaluate the success of this safety program.

The results of the comprehensive community-wide effort are promising and illustrate the need to continue the safety program while conducting a more rigorous evaluation.

From 1995 to the present, the health department's Injury Prevention Office has gained a progressive list of collaborators who are making a difference that likely would not have been achieved by any single agency or entity. All the contributors, great and small, are equally important to the success of this project. Our philosophy is that the smallest contributor could be the difference between life and death with a child that they directly or indirectly affected.

## COSTS AND FUNDING

| Summary of all financial support, 1995 - 2002 | |
|---|---|
| FDOT Grants (1995-2002) | $440,000 |
| TIPPO Project Director (DCHD In-kind) | 75,000 |
| TIPPO Project Implementation (DCHD In-kind) | 43,000 |
| BROOKS Health Foundation Donation | 100,000 |
| Helmet Sales Revenue (1995-2002) | 93,000 |
| Duval County School Board (in-kind) | 140,000 |
| Center for Disease Control Grants | 60,000 |
| Port of Jacksonville Pilot Club | 5,000 |
| Misc Donations | 20,000 |
| Grand Total | $976,000 |

Note: Duval County Health Department and Duval County School Board in-kind figures are conservative estimates. Helmet sales revenues are reinvested for continuous helmet procurement. Miscellaneous donations include, but are not limited to, such support materials as surgical caps for prevention of lice transmission, field markers, volunteer service hours, etc.

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VICTORIA, BRITISH COLUMBIA, CANADA #47

# Share the Road: Motorist/Bicyclist Traffic Education and Enforcement Programs

## BACKGROUND

Most conflicts and collisions between motor vehicles and cyclists result when either a driver or cyclist violates a traffic rule or law, including rules that motorists must observe that reflect cyclists' right to use public roadways. Common violations that can cause these problems include failure to stop or yield when required, following too closely behind another vehicle, illegal turns and passing, and cycling at night without adequate lighting. Traffic rule violations by cyclists reduce respect for cycling as a legitimate form of transportation, and can result in public policies that prohibit or discourage cycling under certain conditions. Traffic rule violations by motorists discourage people from cycling.

This situation suggests that one of the most effective bicycle safety countermeasures, and a way to increase respect for cyclists and encourage cycling, is to implement "Share the Road" programs and materials which provide bicycle traffic safety information and enforcement directed at both motorists and cyclists. The goals and objectives of such programs are to:

- Improve drivers' and cyclists' knowledge and observance of traffic rules as they apply to cycling.
- Reduce conflicts and collisions between motorists and cyclists.
- Increase respect and courtesy between motorists and cyclists.
- Increase understanding of cyclists' right to use public roads.

This case study summarizes some of the best practices in "Share the Road" programs and materials that teach and enforce bicycle-related traffic rules. Many organizations have developed "Share the Road" traffic education and enforcement programs and materials. These may include:

Todd Litman, Director, Victoria Transport Policy Institute

- Brochures and booklets.
- Cycling route maps that also incorporate "Share the Road" information.
- Training workshops.
- Mass advertising messages (billboards, radio, television, etc.).
- Special police training and bicycle law enforcement programs.

Sponsoring organizations include government agencies, bicycle clubs, transportation advocacy organizations, children's safety programs, and various combinations of these. Since traffic laws are established at the state or provincial level, and sometimes have local variations, such materials are usually implemented at the state, provincial, or local level.

The quality of these programs and materials varies, depending on the perspective, knowledge, and resources of sponsoring organizations. Important factors include:

- Accuracy—materials reflects current rules and laws.
- Clarity—the important concepts are easy to understand and apply.
- Accessibility—programs/materials are attractive and easily available to the intended audience.

As much as possible, information should be presented in a positive manner. For example, rather than conveying the message, "Cycling is dangerous. Watch out!" it is better to emphasize that "Cycling can be easier and safer if you follow the rules when you ride." A "Share the Road" brochure is most effective if it is physically attractive with interesting graphic images and simple but accurate wording that explains key concepts in a friendly, non-threatening manner. Such a brochure must be widely distributed so that the information disseminates through the community.

Materials should target both motorists and cyclists. For example, some "Share the Road" brochures have information for motorists on one side and information for cyclists on the other. Of course, many people will read both sides, because they are interested in both perspectives. Special materials may be necessary to target particular groups, such as children or people who speak a different language.

Occasionally, motorists or public officials assume that cyclists have less right to use public roads than motorists, either because bicycles are smaller and more vulnerable, because they are used by children or because they do not pay fuel taxes and vehicle registration fees. Litman (2000) and Hill (1986) respond to these claims. They point out that:

- The Uniform Vehicle Code (UVC, the basis for most traffic laws) states, "Every person propelling a vehicle by human power or riding a bicycle shall have all the rights and all the duties applicable to the driver of any other vehicle."

- Most traffic laws do not differentiate between bicycles and other vehicles.

- Because motor vehicles impose significant risks to bicyclists and pedestrians, the UVC gives drivers the responsibility to "avoid colliding with any pedestrian or any person propelling a human-powered vehicle and …exercise proper precaution upon observing any child or any obviously confused, incapacitated or intoxicated person."

- Cyclists pay an equal portion of local taxes that are used to fund local roads, which is where the majority of cycling occurs. Since cycling generally takes less road space, causes less wear-and-tear on roads than motor vehicles and imposes relatively small external costs, cyclists tend to pay more than their fair share of roadway costs as calculated by roadway cost allocation methodologies (Litman, 2000).

## COUNTERMEASURES

Following are examples of some exemplary brochures and print materials and education and enforcement programs for helping motorists and cyclists better share the road.

### BROCHURES

The *Drive Right/Cycle Right* brochure developed by the Insurance Corporation of British Columbia (ICBC, 1999) is a good example of "Share the Road" material that provides information for both drivers and cyclists. The brochure has "Drive Right" on one side and "Cycle Right" on the other, with simple drawings that illustrate these concepts (http://www.icbc.com or http://www.richmond.ca/services/ttp/cycling/news/driveright.htm).

Another good example of this type material is the "*Sharing the Road" tips* developed by the League of American Bicyclists, available at http://www.bikeleague.org/action/sharetheroad.php.

### TRAFFIC LAW ENFORCEMENT—BICYCLE DIVERSION PROGRAMS

Appropriate traffic law enforcement can also help prevent conflicts and collisions between bicyclists and motorists and can instill lifelong traffic safety habits in young people. Children who spend years violating bicycle traffic laws with impunity are being poorly prepared to become responsible car drivers.

Safety experts recommend targeting the following cycle traffic rule violations:

- Motorists failure to yield or stop for pedestrians and cyclists when required by traffic law
- Excessive motor vehicle speed
- Intoxicated drivers and cyclists
- Cyclists failure to yield when required by traffic law
- Cyclists riding in the wrong direction, against traffic
- Cyclists riding at night with inadequate lighting

An effective enforcement program must overcome various barriers. Police officers may be unfamiliar with traffic rules and laws as they apply to bicycles, cyclists' rights to use the roadway, or how to effectively enforce bicycle traffic laws. Nonmotorized traffic violations, particularly by children, tend to be considered a low priority by officials and the general community. Standard traffic fines may appear excessive or inappropriate for children. Cyclists and pedestrians may ignore citations unless police departments develop a suitable processing system.

A bicycle "diversion" program allows offending cyclists to take a cycling safety workshop as an alternative to paying a traffic fine (i.e., they are "diverted" from the court system). Police departments can run such workshops internally or contract with an outside expert. Such programs are popular because they emphasize safety rather than punishment and help develop cooperation among police, parents, and bicycle safety advocates. Scout troops, school groups and parents often voluntarily attend the safety workshops.

Examples of communities with well-established and effective bicycle diversion training programs include Tempe, AZ; University of California at Davis through Transportation and Parking Services; and Huntington Beach, CA; as well as Walnut Creek and Brentwood in Contra Costa County, CA. Here is how such programs typically work:

- Cyclist is ticketed for violating a traffic law.
- If the cyclist is a child, police send a standard letter to their parents describing the violation, emphasizing the importance of observing bicycle traffic laws for the sake of safety, asking the parent to bring the child to a bicycle safety workshop (typically offered monthly or semi-monthly) within a specified time period (such as three months), and inviting the parent to contact the program coordinator if they have any questions.
- If the cyclist attends the workshop the traffic ticket is void.
- If the cyclist fails to attend the workshop in the specified period, the ticket is processed.
- Police and courts coordinate to allow efficient processing of cyclist traffic tickets.

## CONCLUSIONS AND RECOMMENDATIONS

Many conflicts and collisions between motorists and cyclists result from inadequate understanding and observance of bicycle traffic rules, including rules that cyclists must follow, and rules that motorists must observe that reflect cyclists' right to use public roadways.

"Share the Road" programs have the potential to improve awareness and respect of cyclists' right to use the roads and compliance with rules and laws affecting bicyclist safety by both motorists and cyclists, and may therefore help to reduce conflicts and collisions between cyclists and motorists.

## COSTS AND FUNDING

Costs vary depending on the type of program and materials. Most bicycle traffic safety education programs require staff time for planning, plus resources to produce brochures and other outreach materials. Some offer training courses. Most traffic law enforcement activities are included in existing police budgets.

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# Hitching Posts for Bicycle Parking

## BACKGROUND

### BRIEF HISTORY

The 1968 Santa Barbara State Street Plaza project removed on-street parking from the Downtown Commercial area, resulting in a two-way, two-lane road with right-turn pockets and bike lanes for a length of 914 m (3000 ft). Street furniture such as fountains, planters and benches was installed along long reaches of the project. A significant increase in bicycle traffic and insufficient bicycle parking supply were attributed to this project and the later striping of bike lanes. By the early 1980s, 240 bicycle parking spaces of various types, including front wheel racks and hitching posts, were available on sidewalks in the mall to meet the average daily demand of 2000 bicyclists. They were perceived as a nuisance by local business persons, and created a hazard to pedestrians. Furthermore, the imbalance between supply and demand resulted in bicycles regularly blocking the sidewalks.

An additional problem faced was gaining approval from the Historic Landmarks Commission. The Landmarks Commission was formed in May 1960 to ensure that the area within El Pueblo Viejo District would retain its unique early-California Spanish character and atmosphere through careful city planning and development. It is an advisory group to the city Council that approves, disapproves, or approves with conditions plans for exterior alteration, relocation or demolition of locations within the district. Unable to find a balance between aesthetics and functionality, the Historic Landmarks Commission for the area generally disapproved of the installation of bike racks on State Street, finding bicycles inconsistent with the landmarks in the historic district.

Drusilla van Hengel, Ph.D., Mobility Coordinator,
City of Santa Barbara

Figure 1. Bicyclists choose to park against street furniture or trees rather than use substandard parking.

Although this decision was successfully appealed, the conflict lasted several years, with interim designs including the installation of eyebolts into sandstone pillars or planter walls. Finally a hitching post design was approved for the area. In some locations, more aesthetically pleasing solutions that integrate sandstone pillars or ironwork have been required instead of hitching posts. These decisions have resulted in locations where bicycle parking goes unused and bicyclists park against trees or trash receptacles instead of parking in substandard racks, as shown in figure 1.

The practice of providing bicycle racks on the sidewalk is best employed where bicycle and pedestrian volumes are low to moderate and where sidewalk widths are adequate. At the time, neither of these prerequisites applied. The sidewalk bicycle parking was decreasing the available sidewalk width in an area with many pedestrians, and the bicycle volumes were high, with nearly 50 percent of the bicyclists to the downtown responding to a local survey indicating that they parked their bike downtown three to five times per week.

Through public outreach, city staff learned that the removal of bicycle parking from the sidewalk along State Street likely would lead to a large number of bicyclists parking illegally on the sidewalk. This outreach was conducted by leaving surveys on parked bicycles with self-addressed reply cards. Bicyclists were asked, "If parking your bike on the sidewalk on State Street were made illegal, but bike racks were provided in parking lots, on side streets or along State Street at mid-block locations, what would you do?" Although many indicated that they would continue to park illegally on the sidewalk, the use of racks provided at midblock received the most favorable response.

Fortunately, since that time, several sidewalk improvement projects have been undertaken on State Street, and hitching posts are now a standard street furniture accessory with a goal of providing one hitching post, or two bicycle parking spaces, in front of each business door.

Figure 3. Bicucles parked at hitching posts adjacent to curb.

### GOALS

The goal of the project is to provide bicycle parking in the public right-of-way where demand warrants. Removing destination barriers is a key element of the city's 1998 Bicycle Master Plan, and this ongoing project provides convenient parking for downtown customers arriving by bicycle. Additionally, the bike parking solution was needed to prevent bikes from blocking pedestrian traffic or being left in planters or locked to trees.

## COUNTERMEASURES

In 1983, a hitching post design was approved for State Street. This design continues to be used with slight modifications, such as a protective ultraviolet thermal-resistant sleeve that protects the bicycle frame. The rack provides parking opportunity for two bicycles, with each bicycle having two points of contact with the rack. The design is reflective of the hitching posts historically available to customers arriving downtown on horseback. The success of the State Street hitching post program has been a model for safely providing public bicycle parking spaces citywide. In addition to periodic inspection of the business area, individual requests for parking trigger a field investigation to evaluate the space available for hitching post-style parking. A traffic technician reviews the proposed location for the racks and marks the acceptable location on the concrete. A minimum of 1.8 m (6 ft) of sidewalk clearance must be maintained for pedestrian access, and placement is made so that passengers exiting parked cars may avoid swinging their doors into the rack or parked bicycles.

Figure 2. Hitching post.

The metal post is 1 m (40 in) high, with rings placed at 0.5 m (20.5 in) (figure 2). The ring placement allows for the front wheel and frame to be easily locked to a ring. The post is attached to the sidewalk using four expansion bolts. The posts are set adjacent to the curb line so a bicyclist may park immediately after exiting the street. The goal here is to reduce the distance a cyclist must walk with the bike in order to park and to discourage cyclists from riding on the sidewalk (figure 3).

It is extremely important to orient contractors and staff installing the posts to the subtle difference between orienting the rings parallel or perpendicular to the curb because the bicyclist naturally wants to park the bike perpendicular to the rings, and therefore the ring orientation will affect the footprint of the bicycle on the sidewalk and may even prevent the bicyclist from parking correctly (figure 4).

Figure 4. Properly installed hitching posts create orderly parking areas.

## EVALUATION AND RESULTS

The project is evaluated periodically by staff. The bicycle parking count on State Street provides information about the need for more hitching posts, and also confirms what percentage of bicyclists are using the bike parking. Surveys are conducted by counting bicycle usage of available hitching posts during two midweek afternoons. The total number of bicycles parked is also counted.

To date, there are 128 hitching posts in nine blocks of State Street, providing space for 256 bicycles. Thirty percent of the posts are in use at any one time. Although this number shows only a slight increase in bicycle parking availability, census figures over the period between 1980 and 2000 show a general decline in cycling for the journey to work, so the numbers probably represent a real increase relative to the demand. Because there are some locations where the sidewalk is too narrow to permit hitching post installation, we sometimes find bicycles leaned up against buildings or street furniture. However, 82 percent of the bicycles parked in the Plaza are using the hitching posts provided, improving the safety of pedestrians and bicyclists alike.

## CONCLUSIONS AND RECOMMENDATIONS

This treatment works extremely well. The hitching posts are easy to store in the Public Works Yard and therefore immediately available for installation. The program accommodates the need to be aesthetically appropriate in this historic area, yet also provides a functional place for short-term bicycle parking. The rack is relatively easy to install, and additional posts are provided whenever the demand warrants and space permits.

Providing appropriate levels of well-sited bicycle parking reduces barriers to bicycling, encourages bicyclists to use the parking and should reduce conflicts between bicyclists and pedestrians or with parked motor vehicles and their occupants.

## COSTS AND FUNDING

Hitching post fabrication is completed by our staff welders for an approximate cost of $100 per post. The project is funded through our ongoing bicycle improvements capital program. Installation is provided by the concrete crew of the street maintenance division of the Public Works Department.

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# Bicycle Access on Caltrain

## BACKGROUND

Caltrain bicycle accommodation is the San Francisco Bay Area bicycle success story, making it the least restrictive and most accessible rail system in the United States for bicycles.[1] Caltrain runs 124 km (77 mi) southeast from San Francisco through Silicon Valley to San Jose, CA (and Gilroy during peak-hours). It operates 75 bi-level (gallery) car trains each weekday (27,200 riders per day) and provides more limited weekend and holiday service. It is one of the few U.S. rail systems to carry bicycles on all trains.

A September 1997 count showed almost 2,000 bicycles carried (7.5 percent of the total riders), not including cyclists denied boarding due to capacity constraints. Increased ridership because of cyclists repaid the startup costs within six months and is now a revenue source.

## COUNTERMEASURES

In 1977 the Southern Pacific Railroad (SP) filed for abandonment of its San Francisco–San Jose commute line. From 1977 to the early ’80s, the campaign for bicycle access (other than encased folding bicycles) and continuance of train service, was led by two bicycle advocates, Ellen Fletcher and Darryl Skrabak (of the Silicon Valley and San Francisco Bicycle Coalitions, respectively). By arguing that bicycle access would increase ridership and by submitting petitions with 2,500 signatures, they helped defeat the abandonment. The state and three counties of the San Francisco-San Jose Metropolitain Area began subsidizing the train service.

In 1980, the California Department of Transportation (Caltrans) assumed management of the line, renamed Caltrain, and contracted operations to the SP. Bicycle access was still denied, but cyclists continued their campaign, resulting in a four-month demonstration program in 1982. Twelve off-peak trains permitted up to five bicycles at the conductors’ discretion. SP refused to continue bicycle access without payment for additional liability insurance.[2] (Later research in 1987 showed that no insurance claims were filed against any U.S. railroad because of bicycle transport.)

Peter S. Tannen, Bicycle Program Manager City & County of San Francisco


Three years after this demonstration’s success (up to 100 bicycles per week), Caltrain began a year to a year-and-a-half review of the 1982 demonstration, contacted the 12 North American rail operators with bicycle access, spoke to local bicycle groups, reviewed literature and took bicycles on board out-of-service trains. Caltrans’ Roger Hooson completed an in-depth report in 1987 supporting bicycle access and recommending another demonstration, providing groundwork for the current program, while acknowledging a key capacity constraint. Bringing bicycles through the narrow vestibules of commuter rail cars increases train dwell times at stations.

A Metropolitan Transportation Commission study also supported bicycle access, stating that “allowing bicycles on trains could increase the utilization of rail for short trips where bicycle access represents a reasonable alternative to the car.”[3] To the north and east, bicycle access al-

ready was provided by the Bay Area Rapid Transit District and bay ferries. SP access would add two counties to the five with existing bicycle-on-transit access.

By July 1992, the Peninsula Corridor Joint Powers Board was formed by San Francisco, San Mateo, and Santa Clara counties to purchase Caltrain and contract operations to Amtrak. Caltrans oversaw operations and planning and the San Mateo County Transit District managed the line. Bicycle access still was not provided. After a 1992 meeting of more than 200 people, a Bicycle Advisory Committee was formed.[4] Cyclists attended hearings, wrote letters, and the Caltrain Citizens Advisory Committee approved resolutions.

At the request of Peninsula Rail 2000 (a Caltrain commuter's advocacy group) and the Citizen Advisory Committee, language was included in Caltrain's Short Range Transit Plan requiring bicycle access. After more lobbying, a second demonstration project began in September 1992. Four bicycles were permitted in the aisle on all but peak hour trains. Free permits were required.

Through the efforts of the Bicycle Advisory Committee and another dedicated bicycle advocate, Lawrence M. "Cap" Thomas, bicycle access was expanded in 1994. Seats were removed to allow installation of four-bicycle racks with securement cords, based upon Cap's design. When he first approached the Joint Powers Board with this idea, they rejected it because of the lack of funds. Cap asked if the project could be implemented if he secured funding and was told yes. He obtained $30,000 of San Francisco's bicycle and pedestrian funds, and the installation of the racks began. Additional racks were subsequently funded by the city of Menlo Park and the Joint Powers Board. Cap was the recipient of a Metropolitan Transportation Commission Transportation Award and a Caltrain Silver Spike Award for his efforts.

Bicycle areas identified by car-exterior graphics were created in 52 cars. Caltrain decreased the peak-hour bicycle restrictions in steps as experience showed no major problems. By May 1995, when the permit requirement was dropped, more than 9,600 permits were issued and twelve bicycles (four in each of three cars) were allowed on specified trains. Some trains (generally reverse-commute expresses) lacked capacity. Increasing numbers of bicyclists were left to wait for the following local train. In July 1996, timetables were adjusted slightly to account for bicycle loading and unloading at popular stations, evidence of further bicycle accommodation.

## EVALUATION AND RESULTS

Racks have been consolidated to fewer cars. All trains now have at least one special bicycle car. Twenty-four bicycles are stored on racks in the front of the bicycle section (four bicycles on each of six racks). Cyclists sit in the rear on remaining seats on the lower or upper levels, in sight of the bicycles. Signs request non-bicyclists sit in other cars. The window information sheets explain bicycle stowage procedures.

Some cyclists have been turned away in past years when trains regularly reached bicycle capacity, especially reverse-commute trains. In response to high demand, an extra bicycle car is sometimes added to some of these trains (used by San Francisco residents with jobs in Silicon Valley), increasing capacity to 48. Caltrain identifies the usual trains that have two bike cars and strives to offer two bike cars on these trains as consistently as possible. Since the main San Francisco station is about a mile from Market Street (the downtown transit corridor), many San Francisco residents would have to take two buses to reach the station. At the work end of the trip, transit service is less fre-

quent with less coverage, since this area is suburban. Therefore, bicycle access for most reverse-commuters is ideal. Without it, many of these reverse-commuters would probably drive cars.

Major rules include: first come, first serve bicycle space for clean, single-rider bicycles; no conductor loading assistance; cyclist at least 16 years old; bicycles secured by bungee cords (provided) and closely attended by rider; boarding and detraining quickly upon arrival at station after passengers exit; conductor's authority is final; and use of destination tags is strongly encouraged. Cyclists never have been charged extra for bicycles.

Thirteen percent of responses to a November 1994 Caltrain passenger survey stated they use the bicycle-on-board program and 43 percent of these reported no problems. Commonly cited bicycle-related problems (decreasing response frequency) included: inadequate capacity, interactions with conductors, adequate seating, inadequate information, bicycles in aisles or vestibules, and "bicycle conditions." Eighteen percent said more bicycle access would enable them to use a bicycle as part of their trip.

Bicycles were counted as part of annual ridership counts since 1994, all conducted during the same period. Although February 1998 shows a drop in bicycles, it was during the height of the area's second rainiest winter. A September 1997 count showed 1,961 bicycles carried on 65 trains (one train omitted) averaging 17 bicycles per train. Five northbound and five southbound trains exceeded capacity.[5] Cyclists unable to board because of bicycle capacity limitations were not counted.

Besides transportation, cyclists are brought together in one car with an opportunity for conversation, creating a sense of community. Arranging bicycles in first-out in-front order creates a reason to talk and interact. When regular bicycle commuters see first-time bicycle car users, they explain the bicycle stowing procedure. Caltrain facilitates this process by providing bicycle destination tags. Many bicycle commuters are also bicycle activists, so their commute gives them a meeting place for discussions and follow-up e-mails.

## CONCLUSION AND RECOMMENDATIONS

The major problem with this program is its success and peak demand. Cyclists are sometimes denied access during peak commute times because of lack of bicycle space. Caltrain could try to obtain additional funds to secure more bicycle cars or retrofit more cars with racks so more bicycles can be carried per train. Neither is likely in the near future. Caltrain acquired additional cars in 1999 but replaced older cars in need of overhaul. However, more trains will be operated beginning in 2004, resulting in additional bicycle capacity.

The Caltrain Bicycle-on-Board Program shows what can be accomplished by dedicated bicycle activists and a cooperating transit operator. In 1977, at a Public Utilities Commission SP abandonment hearing, a staff attorney said that these trains could become "a national model." He did not have bicycle transportation in mind, but in that realm, Caltrain has become a national model.

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[1] *The State of Caltrain Report*, Fall 1996, Caltrain

[2] Caltrans paid SP an extra $73,200 (or more than $100/bicycle trip) in insurance costs for the four-month bicycle demonstration. At the time, Caltrans was paying SP $400,000 annually for general liability insurance.

[3] Peninsula Route 101 Study, Metropolitan Transportation Commission, Oakland, CA, September, 1984

[4] The Caltrain BAC meets at least quarterly and includes cyclists from each county, JPB staff, Amtrak/Caltrain management, and conductors. It provides bicycle access technical guidance.

[5] Caltrain Bicycle Program Memo, Caltrain, October 1, 1997

# Bike and Bus Program

## BACKGROUND

The Santa Barbara Metropolitan Transit District (MTD) has promoted bike and bus programs for over 30 years. The goal has always been the same: to help cyclists extend their travel via buses. Over the years, MTD has sought to achieve this through the use of trailers towed behind buses, bicycle lockers, bicycle parking at bus stops, and bicycle racks mounted directly on the bus.

In 1975, MTD acquired a 4.3 m (14 ft) bicycle-capacity trailer from San Diego State University. Towing it behind a 6.1 m (20 ft) bus, MTD targeted the cycling behavior of college students and placed the bus on an eight-mile express service between downtown Santa Barbara and the University of California at Santa Barbara. The regular, one-way bus fare in 1975 was 25 cents, and cyclists paid an additional 15 cents to transport their bicycles. Initially, six percent of all passengers on the route brought their bicycles. This quickly improved to 30 percent.

Within a few months, daily use had fatigued the trailer's springs, causing the axle to bend and the wooden frame to break. The program was temporarily suspended until 1977 when MTD enhanced the trailer design to include a sturdier metal frame, supports that gripped the bicycles' tires, and individual bike ramps for easier loading. The bus and trailer were placed back in service on the express route, the 15-cent bike fare was dropped and the project began to attract national attention.

In 1978, MTD was awarded a $182,000 Urban Mass Transit Administration grant, which provided for six newly designed, heavy-duty steel trailers, 150 bicycle racks and 12 bicycle lockers.

Lynnette Coverly, Marketing Manager, Passenger Relations

1970s bicycle trailer.

In September 1979, all six bicycle trailers operated on various routes throughout the community. The routes were chosen for their distance between destination points and service to local colleges. MTD carried an average of 105 bicycles on weekdays, 44 on Saturdays and 28 on Sundays on these routes. The service continued to be free.

With the continued growth of the bicycle trailer program and the opening of MTD's new Park & Ride Facility in Goleta, which included new bicycle lockers, MTD embarked upon a large multi-media campaign centered on familiarizing the public with the bike and ride program. The campaign, "Signs of the Times," included print, radio and bus advertising and bus stop signs promoting the Bike 'n Ride and Bus 'n Bike programs.

In 1982, MTD replaced its 6.1 m (20 ft) mini-buses with 12.2 m (40 ft) buses to handle the increasing passenger loads. Consequently, the trailers could not legally be towed behind the new vehicles and the bicycle trailer program was discontinued.

In 1984, MTD mounted bike racks on the rear of its buses. Each rack was capable of holding two bicycles and the buses were available on five routes, including service to local colleges, far-reaching neighborhoods and an outlying community to the south. The bike-bus service continued to be free.



Promotional materials supporting bike and bus program.

By June 1985, the rear-mounted racks were posing significant problems in the areas of risk management (rear mounting resulted in accidents and theft) and mainte-

1980s rear-mounted rack.

nance (the racks had to be removed before each wash because of damage experienced in the bus washer). In 1987 the bike-bus program was terminated.

## COUNTERMEASURES

Almost 10 years later in 1995, MTD partnered with the local Air Pollution Control District (APCD) to purchase 20 front-mounted racks capable of holding two bicycles each. The APCD funded the capital cost of the racks up to $30,000 and MTD installed, maintained and marketed the program. Front-mounted racks were chosen partly because of the driver's ability to easily observe bicycle installation and removal, thus minimizing safety and security issues.

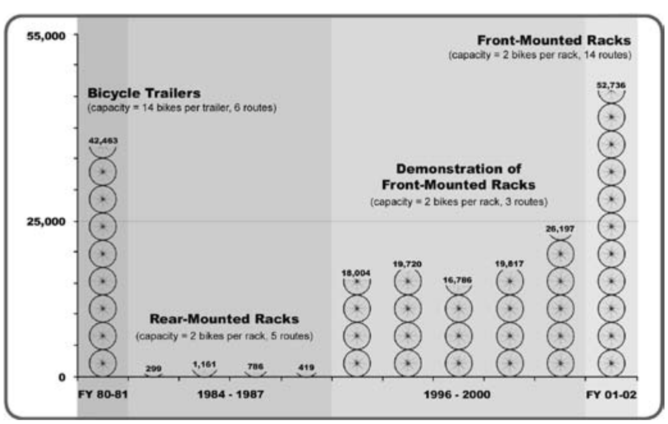
For the next six years, a successful demonstration program ensued. MTD placed the rack-equipped buses on three routes, two serving outlying communities and the other serving the local university. The routes were chosen for their distance between origin and destination points and for the high percentage of college students, many of whom use bicycles to extend their travel once on campus. The buses operating on these three routes carried over 87,000 bicycles from 1995 to 2001 at no additional charge to the passengers. The program was marketed via a brochure distributed to all local bicycle shops as well as exterior advertisements on the vehicles and display advertising in the university newspaper.

In 2000, MTD and the APCD again cooperated to expand the Bike & Bus Program to MTD's entire fleet of 12.2 m (40 ft) buses (53 vehicles). The purchase of 35 racks (33 plus 2 spares) at a cost of $571 per rack (including all brackets, adapters, etc.) came to $20,000. The APCD again supported the capital expense of purchasing the additional racks—up to $15,000. MTD paid the difference plus the cost of installation. Additionally, MTD continues to maintain the racks.

## EVALUATION AND RESULTS

Bike trailer and rack usage is recorded by the bus driver. In the early years of the bike trailer manual tallies were kept, which was made easier by an express route that had just two stops. In the 1980s, with the rear-mounted racks, data collection became more difficult as drivers frequently were unable to see a passenger loading or unloading their bicycle. Passengers' current use of the front-mounted racks is tallied via the farebox, which has a code that the driver can easily input for bikes carried per trip. Since the inception of the front-mounted bike rack program, including both the demonstration and expansion, MTD has carried about 153,000 bicycles.

The chart below lists years and corresponding numbers of bicycles carried. Note that between 1984 and 1987 bicycle ridership was much lower than previous years, partly because of the difference in what the racks were capable of carrying—two bikes on the racks compared to 14 bikes on the trailers. Additionally, when the front-mounted racks initially were installed in the latter half of the 1990s, MTD ridership was much greater, reflecting a sharp rise in bike rack use. The fully implemented Bike & Bus Program beginning in February 2001 resulted in a sharp increase between fiscal years 2000–2001 and 2001–2002.




The 12.2 m (40 ft) buses are allocated to the routes carrying the largest percentage of passengers and are equipped with bike racks. Thus 14 of MTD's most populated routes are also guaranteed to provide bike-bus service. The four routes most utilized by cyclists (accounting for 75 percent of bike rack usage) are popular because they travel long distances that may be unattainable by bicycle alone and have destinations that prove useful for bicycles, such as the local university (Lines 6, 11, 12, and 20).

- Line 6: Trunk service traveling along a main business corridor, about 17.7 km (11 mi)
- Lines 11 and 12: Express service to local university, about 12.9 km (8 mi)
- Line 20: Connector service between Carpinteria and Santa Barbara, about 24.1 km (15 mi)

MTD does not have plans to remove the bike racks from buses on lesser performing routes for operational reasons. As stated, 12.2 m (40 ft) buses are allocated to a specific group of routes depending on passenger volume and freeway travel. On any given day, a 12.2 m (40 ft) bus could be assigned to any of the 14 routes. The program is more easily marketed to passengers by ensuring that all 12.2 m (40 ft) buses have racks. Therefore, all routes served by 12.2 m (40 ft) buses are guaranteed the service. The routes are marketed as bike-bus routes via an icon in the bus book, at the bus stop and on the Web site.

Table 1 depicts the percentage of bicycles carried as compared to total ridership of the most utilized bicycle routes: 12, 11, 20, and 6. While the bike-bus program is successful, it does represent a very small percentage of bus passengers overall. MTD gives this serious consideration when reviewing any potential expansion of the bike-bus program.

The following two tables, based on the fully implemented bike-bus program, depict the monthly average of bicycles carried compared to monthly bus ridership, service hours and service miles. Although Lines 11 and 12 carry the most bicycles on average per month (see table 1), Line 13, while not carrying as many bicycles, is the most productive in terms of bicycles carried per hour (see table 2). Line 13 performs well in the bicycles per 100-mile category as well. In fact, 6.6 percent of its ridership is composed of bicycling passengers. It is important to note that both the 13 and the 26 are commuter services with just one morning trip and one afternoon trip daily, thus explaining the low number of bicycles carried overall.


## CONCLUSIONS AND RECOMMENDATIONS

With 30 years of experience, it seems that MTD has found a bike-bus pairing that works for passengers, MTD and the community. There are challenges that MTD continues to review, but for the moment, the program is successfully doing its part to help with multimodalism in the greater Santa Barbara community.

MTD's current Bike & Bus program continues to be a popular service with a regular ridership. The trend analysis confirms an increasingly steady usage of the racks among

Table 1. Comparison of Bicycles Carried to Ridership on an Average Month

| Route | Avg Monthly Bicycles Carried | Avg Monthly Bus Ridership | Avg Monthly Bicycles Carried per 100 Passengers | % of Cycling Passengers to Non-Cycling Passengers |
|---|---|---|---|---|
| 12 | 1,112 | 57,908 | 1.9 | 1.92% |
| 11 | 1,088 | 80,636 | 1.3 | 1.35% |
| 20 | 601 | 38,049 | 1.6 | 1.58% |
| 6 | 555 | 46,138 | 1.2 | 1.20% |
| 1 | 365 | 112,380 | 0.3 | 0.32% |
| 23 | 250 | 29,813 | 0.8 | 0.84% |
| 8 | 224 | 18,358 | 1.2 | 1.22% |
| 15 | 177 | 12,678 | 1.4 | 1.40% |
| 21 | 176 | 10,518 | 1.7 | 1.67% |
| 13 | 22 | 334 | 6.6 | 6.59% |
| 18 | 16 | 3,181 | 0.5 | 0.50% |
| 26 | 2 | 408 | 0.5 | 0.49% |
| TOTAL | 4,588 | 410,401 | 11 | 1.12% |

Table 2. Comparison of Bicycles Carried to Service Hours/Miles on an Average Month

| Route | Avg Monthly Passengers Carried per Hour | Avg Monthly Service Hours | Avg Monthly Bicycles Carried per Hour | Avg Monthly Service Miles | Avg Monthly Bicycles Carried per 100 Miles |
|---|---|---|---|---|---|
| 13x | 21.5 | 20 | 1.10 | 592 | 3.72 |
| 12x | 53.8 | 1,203 | 0.92 | 27,958 | 3.98 |
| 11 | 46.8 | 1,877 | 0.58 | 26,014 | 4.18 |
| 6 | 47.0 | 1,066 | 0.52 | 12,811 | 4.33 |
| 20 | 37.1 | 1,192 | 0.50 | 20,152 | 2.98 |
| 15x | 43.1 | 382 | 0.46 | 10,863 | 1.63 |
| 21x | 24.2 | 433 | 0.41 | 8,465 | 2.08 |
| 8 | 24.1 | 640 | 0.35 | 13,600 | 1.65 |
| 23 | 42.0 | 873 | 0.29 | 11,291 | 2.21 |
| 1 | 63.2 | 1,868 | 0.20 | 15,792 | 2.31 |
| 18 | 27.6 | 110 | 0.15 | 1,890 | 0.85 |
| 26x | 25.3 | 20 | 0.10 | 20,152 | 0.01 |
| TOTAL | 42.38 | 9,684 | 0.47 | 169,580 | 2.71 |

University of California at Santa Barbara routes as well as with the heavy working trunk and connector routes.

The expansion of the program to include all vehicles has provided for a much more marketable, more reliable program. Passengers are guaranteed bicycle racks on all routes with 12.2 m (40 ft) buses allocated to them, currently 14 lines. Passengers easily know which routes these are simply by looking for the Bike & Bus icon within printed materials and on MTD's Web site.

Bike & Bus is a successful program based on passenger benefit and administrative and safety standpoints. But the popularity of the program also is its drawback. Because each rack can only hold two bicycles, passengers sometimes wait to load their bike at a stop, only to find the approaching bus with a full rack. Proposed solutions include bringing back the trailers, installing rear-mounted racks in addition to the front-mounted racks, providing bicycle racks or lockers at bus stops and allowing bicycles on the bus. All of these solutions have drawbacks. Trailers are outdated now that large 12.2 m (40 ft) buses must maneuver increasingly busy and narrow streets. Rear-mounted racks have proven difficult to maintain with increased liabilities. Bike racks and lockers provide a new set of security issues, and with the high cost of bicycles, passengers are less inclined to leave their bikes at an unattended location such as a bus stop, where the risk of theft is great. Finally, allowing bicycles on board the bus seems unfair and unsafe for the 98 to 99 percent of bus passengers that do not use this service and who must maneuver around a bicycle in the aisle.

A recent technological innovation holds some promise. A popular bike rack manufacturer has developed a prototype of a rack that is capable of holding three bicycles. Concerns over the fully deployed rack extending further than the legal vehicle-length limit appear to be addressed. The manufacturer claims that this new rack does not extend any farther than the two-bicycle rack counterpart that MTD uses. While it may be too early to call, the prototype rack is being tested at a few transit properties in the western United States and has been successful thus far. It seems that another potential solution to carry at least one additional bike per bus is in the works.

It does not appear that all of the answers are available at this time on how best to administer and grow a successful bike-bus program that is beneficial to everyone. The Santa Barbara MTD has, however, shown that with perseverance, support and continued research, bicycles and buses can help extend people's travels while leaving their motor vehicles at home.

## COSTS AND FUNDING

The capital costs of the front-mounted bike racks, as mentioned earlier, were covered by a grant from the local APCD. The rest of the program costs are covered by MTD. Initially there were marketing costs to advertise the new program, however all costs now are associated with the maintenance of the racks.

### BREAKDOWN OF ANNUAL MAINTENANCE COSTS ASSOCIATED WITH BIKE & BUS PROGRAM

| 1. Annual parts replacement costs | | |
|---|---|---|
| Support Arm Grips | \$11.50 x 2/mo x 12 mo | \$276 |
| Bracket Bolts/ Bushings | \$17.00 x 2/mo x 12 mo | \$408 |
| Decals | \$10.00 x 4/mo x 12 mo | \$480 |
| Total | | \$1,164 |

| 2. Annual preventative maintenance costs (safety inspections) | | |
|---|---|---|
| Basic Labor | 82.4 hr/year x \$35/hr | \$2,884 |

| 3. Annual bike rack repairs (straighten damaged bike racks) | | |
|---|---|---|
| Basic Labor | 120 hr/year x \$35/hr | \$4,200 |

| 4. Annual rack replacement costs | | |
|---|---|---|
| There were 9 racks that were in need of replacement due to accidents. | | |
| Cost of racks | \$376/rack x 9 racks | \$3,384 |
| Labor | \$35/hr x 2 hr/rack x 9 racks | \$630 |
| Total | | \$4,014 |

| 5. Road calls | | |
|---|---|---|
| In the event of a vehicle requiring towing (about 24 times per year) the front section of the rack must be removed to facilitate maneuverability, adding about five minutes per road call. | | |
| Labor | 5 minutes x 24 calls = 2 additional hours per year \$35/hr x 2 hrs | \$70 |

| 6. Annual increased bus washing costs | | |
|---|---|---|
| Bus washing time is increased by 30 seconds per bus or 30 minutes per night because of the necessity of deploying each rack, soaping the front of the bus and stowing the rack before driving through the bus wash. This time is down from two minutes during the pilot program. | | |
| Labor | 30 minutes/night x 362 nights = 181 hours<br>181 hr x $12/hr | $2,172 |

| Total annual operational costs: | |
|---|---|
| Parts Replacement | $1,164 |
| Preventative Maintenance | $2,884 |
| Bike Rack Repairs | $4,200 |
| Bike Rack Replacements | $4,014 |
| Road Calls | $70 |
| Bus Washing | $2,172 |
| Total | $14,504 |
| * Note that due to the large front window on Nova buses, the bicycle racks were obstructing the driver's view. MTD's maintenance department came up with a way to lower the racks. Therefore, when MTD procured the racks originally, a retrofitting took place to lower the racks at a cost of $456 per rack ($176 in parts and $280 in labor). | |

## CONTACT

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# Mapping for Bicyclists

## BACKGROUND

One of the most common questions a bicyclist asks is, "Where can I ride my bike safely?" A good bicycle map will answer this question. Bicycle maps can provide information to guide novice cyclists to less-traveled routes, help an experienced cyclist get around unfamiliar parts of town, or identify suitable routes for touring cyclists. A bicycle map can be a tool to promote alternative transportation, improve cyclists' safety, or provide a guide to recreational opportunities.


The North Carolina Department of Transportation Division of Bicycle and Pedestrian Transportation (DBPT) has a long history of developing bicycle maps. In mid-1975 the Bicycle Program, as it was then called, initiated a project to design and map a cross-state bicycle route. The map was in response to the Bicycle and Bikeway Act of 1974 that charged the NCDOT with the responsibility of developing a statewide "bikeway" system. The goal of this initial effort was to select and map a route that provided access to the major population centers of the state, linking them to state parks, historic sites, and other points of interest via the more lightly-traveled roads of the extensive secondary road system.

The NCDOT effort was pioneering a new arena. At that time, guidelines for selecting and designating bicycle routes did not exist. Only one other state had produced a bicycle map. Few North Carolina cyclists had long-distance touring experience or knowledge of roads outside their immediate area. No funds had been set aside for such a project. Fortunately, existing resources of the department could be tapped to undertake the tasks. Bicycle program staff, experienced in bicycle touring and mapping, developed route selection criteria, designed and drew the maps, and utilized the DOT print shop to produce the maps (see Yates and Meletiou, 1978).

Mary Paul Meletiou, Program Manager for Planning and Safety, NC Department of Transportation Division of Bicycle and Pedestrian Transportation

In the ensuing years, the "Bicycling Highways" system grew to nine discrete routes covering more than 4,023 km (2,500 mi) (See http://www.ncdot.org/transit/bicycle/maps/maps_highways.html). In the 1980s the Division began to produce county and regional bike route system maps as well as urban route and suitability maps. Funds for placing signs on both "Bicycling Highways" routes and local routes became available in 1987. Twenty-two local and regional maps are now available with three additional maps nearing completion. These maps detail approximately 2,000 mi of designated routes. Requests for 20 more maps are being handled as time permits.

## COUNTERMEASURES

The 1,126 km (700 mi) Mountains to Sea Route was the first route to be mapped and was completed in June of 1976. A set of sixteen trip-tic maps, each covering 64.3 to 80.5 km (40 to 50 mi) of the route, was developed. The 0.2 m by 0.2 m (8 by 8.5) inch maps were designed to fit in the map pocket of a front handlebar bag when folded, providing easy access for cyclists while riding. All maps were hand-drawn and designed to provide information of interest to cyclists. Narrative information accompanied each segment and included a general description as well as information on terrain, any hazardous areas, roadway conditions, available services, and points of interest. A separate listing of campgrounds with contact information was provided. The strip maps were packaged in a jacket that provided general information on bicycle touring in North Carolina, a description of the overall route, a guide to using the maps, basic weather information, and a list of resources for obtaining additional information.

As noted above, additional cross-state routes were developed from 1976 to 1985, creating a 4,023 km (2,500 mi) system of "Bicycling Highways." In 1983, the DBPT completed the first county bicycle map, showing a 241 km (150 mi) system that connected towns and points of interest via low volume scenic roadways. Local cyclists were involved in developing the routes and providing input on map design. In 1987, federal funds became available to place signs along the routes. The 321 km (200 mi) north/south Carolina Connection, which had received American Association of State Highway and Transportation Officials (AASHTO) designation as U.S. Bike Route 1, was the first to receive signs.

In 1991, the DBPT worked with local cyclists, staff, and consultants to create the first two suitability maps. Unlike route selection maps, which recommend a "best route" between two points of interest, bicycle suitability maps provide information on a broader selection of roadways, with the goal of helping cyclists make good choices about where to ride based on their own level of cycling ability and traffic handling skills. Although suitability maps had been created for localities in other parts of the country, the DBPT refined the process of data collection and application of suitability ratings to reflect conditions in each community. Each North Carolina community is unique, and whether producing a route map or a suitability map, the DBPT strives to reflect these unique characteristics and cycling opportunities.

Over the past 28 years, the route selection, mapping and signing activities of DBPT have continued in response to high local demand for such products. The annual allocation for map and sign projects is now $200,000, set aside from Transportation Equity Act for the 21st Century (TEA-21) funds. Communities can request a project to develop a route or suitability map for their area through the biannual Transportation Improvement Program. Such requests are generated through local planning departments, parks and recreation departments, chambers of commerce, regional agencies, and advocacy groups. To receive funding authorization, requests must be endorsed and submitted to the NCDOT by a local governing agency such as a city council or county commission.

## EVALUATION AND RESULTS

Evaluation of these projects is mostly subjective except for a survey of "Bicycling Highways" map users conducted in 1980. This survey was undertaken to collect demographic information on users and to poll their opinions on the safety and appeal of the routes and usefulness of the maps.

Verbal or written feedback is provided to DBPT staff periodically from requesting agencies noting local response to maps and perceived usage of routes. Individual cyclists, local cycling groups and bicycle shop personnel also provide feedback in the form of praise for the product or constructive suggestions for improvements or revisions to routes.

Although information on the effectiveness of map and sign projects is primarily anecdotal, it is clear that bicycle maps and signs increase bicycle usage and the visibility of bicycling. Following are some examples to support this statement.

- The DBPT distributes more than 25,000 bicycle maps annually and fields thousands of phone calls and e-mails requesting additional information on where to ride.

- An additional 25,000 to 35,000 maps are distributed locally each year by communities for which bicycle maps have been produced.

- The North Carolina ferry system's annual passenger/vehicle counts consistently show significant usage by bicyclists. Several mapped routes make use of this ferry system.

- Informal discussions with proprietors of bed and breakfast accommodations throughout the state show that many guests bring bicycles with them or arrive by bicycle.

- DBPT staff frequently field phone calls or e-mails from visitors to the state noting that they chose to come to North Carolina because of the bicycle mapping program because it provides an abundance of touring information.

- Cycle North Carolina, an annual cross-state event initiated in 1999, is a direct outgrowth of the state's emphasis on mapping for bicycles.

- Each year since 1980 the DBPT has produced a calendar of major bicycle events. The listing has grown from twenty events to more than 200. Many of the ride promoters use the mapped routes for their rides. Local bicycle clubs regularly use the mapped routes in their areas.

Other positive results involve roadway improvements along sections of designated bicycle routes. The route selection process often reveals barriers to bicycling such as bridges with inadequate width or low railings and roadways that need bicycle improvements such as bike lanes, wide curb lanes, or wide paved shoulders to provide a continuous safe corridor of travel. Over the years, by working through ongoing processes of the NCDOT, many significant improvements have been made to roads and bridges identified through these activities.

## CONCLUSIONS AND RECOMMENDATIONS

Bicycle map and sign projects provide a low-cost way to improve the safety of cyclists by directing them to roads that are better for bicycling. Bicycle maps are also an excellent tool for promoting cycling. The appointment of a local committee of planning and engineering staff, interested elected officials, and citizens to guide the mapping project creates greater awareness of other bicycling needs and often leads to future planning efforts or facility improvement projects.

## REFERENCES

*North Carolina Bicycle Facilities Planning and Design Guidelines*, NCDOT Division of Bicycle and Pedestrian Transportation, 1994.

*Bicycling and Walking in North Carolina: a Long-Range Transportation Plan*, NCDOT Division of Bicycle and Pedestrian Transportation, 1996.

"North Carolina's Bicycling Highways," Curtis B. Yates and Mary Paul Meletiou, Bicycle Program, North Carolina Department of Transportation, *Transportation Research Record* 683, 1978.

http://www.ncdot.org/transit/bicycle/maps/maps_intro.html

## COSTS AND FUNDING

Costs of mapping projects vary greatly depending on the format, area covered, number of colors, size of finished product, number of copies printed and whether the work is done in-house or through the services of a consultant. Cost for the trip-tics (strip maps) for the original "Bicycling Highways" maps were minimal – just ink and paper. Recent updates include digitizing the information, undertaken by a consulting cartographer at an average cost of $1,000 per segment for two-color artwork. The four-color map/brochures for county route systems, produced by outside cartographers and graphic designers, cost $20,000 for production and about $.50 for each printed copy. Urban maps produced by outside cartographers and graphic designers have ranged from $30,000 to $60,000 for production and $.34 to $.78 per copy for printing. These costs do not reflect staff time spent in administering the projects, developing routes, coordinating with local committees, preparing text, or reviewing and proofing the product throughout the production process.

## CONTACT

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# Commuter Coach: Commuter Bicyclist Recruiting

## BACKGROUND

Traffic congestion and air quality are problematic in Fort Collins. With the population projected to increase by 43 percent within the next 20 years, it is imperative that our community make use of alternative sources of transportation and do so safely. Since most commuters live within 4.8 km to 11.2 km (3 to 7 mi) of their workplace, the bicycle is a very viable source of transportation for many. In addition, there may be improved "safety in numbers" in terms of the number of bicyclists that use the road and bicycle facilities. [See case study #54, references (page 346), for studies that document this phenomenon.] Our mild climate, relatively flat terrain, and about 402 km (250 mi) of bike lanes, trails and routes, make commuting by bike an easy option. Additionally, our annual Bike to Work Day research shows that people will commute by bike if given the opportunity and the right incentives.

The goal of Commuter Bicycle Coach was to recruit individuals to ride their bikes one day a week for five months instead of driving alone. In return, they would receive incentives upon reaching specific milestones. By encouraging riding for a period of time, our hope was to change people's transportation habits.

## COUNTERMEASURES

Commuter Bicycle Coach is an intensive bicycle commuter recruiting program that provides support, education and incentives to beginning and existing commuters. Developed and implemented in 2002, Commuter Coach presents cycling as a fun and easy way to commute to work. Bicycle commuting provides the freedom and individuality we enjoy, while easing traffic congestion and improving air quality.

Betsy Jacobsen, Bicycle & Pedestrian Marketing Specialist, City of Fort Collins SmartTrips™


By targeting selected companies that had previously participated in SmartTrips™ programs, we recruited a "Commuter Coach" within their organizations who would become the liaison between our office and theirs. They in turn would recruit individuals for the program as well as assist in tracking mileage and distributing incentives. We would provide the incentives, as well as support their recruitment efforts with graphic and educational materials on safety, clothing, routes (such as bike maps), etc. We also would be available for free presentations and clinics related to commuting.

Prospective coaches (about 30 company representatives who were Bike to Work Day Coordinators) were invited to an informational breakfast where the program was described and incentives were shown. Information also was shared among the group on the best practices of recruiting individuals within the workplace.

From that initial breakfast, we enlisted seven coaches of varying cycling experience. Some were regular commuters; others were infrequent riders. Their companies ranged in size from just a few employees to close to a hundred. Once the program started, word of mouth spread to other companies until we had a total of 15 coaches and 237 participants in the program. Budget limitations required that we stop taking participants at that point.

Our incentives included a cyclometer to provide mileage information, as well as other items that help make commuting safer and easier such as headlights, rear racks and tire pumps. (We learned that many beginning bicycle commuters don't have the equipment to make commuting safe and easy.) Additionally, we selected non-bike incentives that could be enjoyed by anyone, such as free movie passes, ice cream cones, restaurant certificates, etc.

We developed a simple electronic spreadsheet in Excel that the "Coach" posted on his or her company computer network so each participant could easily track the miles and days they rode each month. At the end of the month, the coach would then forward the spreadsheet to me, and I would distribute the milestone incentives.

## EVALUATION AND RESULTS

Throughout the program we tracked both mileage and the number of days participants commuted by biking or by walking. This gave us basic information about the frequency and distance participants were commuting.

At the end of the program we distributed a follow-up survey to all Commuter Coaches and asked them to forward the surveys to their participants. Of the 237 enrolled in the program, we received 60 responses—a 25 percent response rate. The survey simply asked if they commuted by bike or walking more, less, or the same amount because of the program.

Our original expectation was to attain 100 bicycle participants the first year, including coaches. We exceeded that goal and achieved 237 participants, including 15 coaches from 15 organizations. Because of budget limitations (the cost of incentives), we stopped taking new participants and created a waiting list for 2003 (when our next budget was to be released).

In addition to bicycle commuters, we also had 15 pedestrian commuters. When the program began, several interested walkers asked to have a program developed for them, so under the same umbrella of Commuter Coach, we implemented a walking component. Walkers were required to walk at least one day a week for five months and were given pedometers to track their mileage. They also were given different incentives.

Since June, the start of the program, we have tracked 46,414 miles and 6,238 days of commuting as of January 31, 2003. Unfortunately, the vacant position of Bicycle & Pedestrian Marketing Specialist, City of Fort Collins SmartTrips™ could not be filled, and the program was not continued.

Of the 237 participants in the program, more than half (127) finished the program; and another 50 completed at least half the program. Injury, cold weather and darkness were cited as reasons for not completing the program. Additionally, more than half of the participants completing the survey (38) stated the program motivated them to increase the amount they were commuting by biking or walking.

## CONCLUSIONS AND RECOMMENDATIONS

Based on the number of participants enrolled in the program and the high number that completed it, this appears to be a successful program that at least introduces bicycle commuting as an alternative transportation choice. However, there certainly are aspects that need to be addressed:

While participants were asked to bike or walk one day a week, bike participation was also tied to distance, meaning that a biker could complete the program in 20 days or 322 km (200 mi). The latter goal caused some of them to do all their riding in a shorter amount of time instead of the anticipated five months. As we moved into 2003, we adjusted the incentive milestones so participants were required to log at least four days a month in order to receive their incentives, and we no longer tied incentives to distance.

Cold weather and lack of daylight were hindrances as we moved into the colder months. While 2002–2003 has still been one of the warmest and driest winters on record, people perceive it to be winter and therefore stop riding. We started the program earlier the second year (March instead of June) in hopes people would form their habit of riding as the weather warms instead of cools.

Clearly, in the companies where the Coaches were more involved (providing hands-on support, internal motivation, prompt distribution of incentives, etc.) the participants did much better. Because of that, we have been more specific regarding the expectations we have of coaches. Additionally, we're working more closely with them at the onset of the program.

## COSTS AND FUNDING:

While we were able to receive discounts on many of the incentives we purchased, the cost per participant is roughly $100. That includes administration of the program as well as incentives. In 2002, funding was made available through the city. In 2003, it will be combined funding from both the City and Federal CMAQ (Congestion Mitigation and Air Quality) funds.

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# Bike to Work Promotion

## BACKGROUND

The Capitol Region Council of Governments (CRCOG) based in Hartford, CT, completed its Regional Bicycle Plan in April 2000 with the vision that by the Year 2010, residents and visitors to the region would be able to conveniently and safely bicycle wherever they need or want to go. The Plan included a variety of recommendations to reach this vision, including a mix of facilities, education, enforcement and encouragement. But there were two major findings during the study indicating that it would be unreasonable to expect meaningful implementation of the plan's recommendations:

- A staggering lack of understanding throughout the region that bicycles are to follow the vehicle code and do, in fact, belong on the road.

- A desire on the part of most of the region's towns to accommodate bicyclists, but strictly on separate, multi-use trails.

These issues are not extraordinary, but they do give some indication of where the Hartford, CT, region resides in the spectrum of becoming a bicycle-friendly community and the amount of basic education that needs to be done.

Shortly after the plan was adopted, the CRCOG staff decided to kick off the implementation of the Bike Plan with an all-out effort on National Bike to Work Day in May 2000. A committee was formed, activities and an event were planned for a park in downtown Hartford on the morning of Bike to Work day, gifts for cyclists were obtained and breakfast was ready. Unfortunately, Bike to Work Day 2000 was extremely rainy, and only 12 intrepid souls attended the event. The planning committee felt the momentum created by the event needed to be maintained, and a decision was made to continue Bike to Work Day on the last Friday of each month throughout the summer.

Sandy Fry, Principal Transportation Planner, Capitol Region Council of Governments

From this start, the region embarked upon a regular Bike to Work promotion, with monthly events through the spring, summer and fall. The events have been designed to:

- Educate bicyclists and others that the bicycle is a sensible and beneficial means of transportation;
- Make basic information on bicycle commuting available to potential riders;
- Encourage people to try bicycle commuting; and
- Increase the general public's awareness of and respect for bicyclists.

## COUNTERMEASURES

The Bike to Work program has grown since the first event in May 2000. In 2000 the events were low key and informal—one or two staff members set up a card table in a downtown park and served juice, coffee and donuts to bicycling commuters on the last Friday of the month. A new location was selected in the second year of operation, but the major change in the program was the addition of a raffle. In 2002, the location was changed to a more central downtown spot and the events were expanded to run from April to October. In May, eight towns in the region hosted their own events. The following sections describe the features of the program.

## ORGANIZATIONAL STRUCTURE

The Bike to Work Planning Committee, now named Bike to Work—Capitol Region, is chaired by a staff member of the Capitol Region Council of Governments (the area's Metropolitan Planning Organization). Organizations represented on the Committee include state agencies (the Departments of Public Health, Environmental Protection, and Transportation) and advocacy groups (the Connecticut Bicycle Coalition, the Sierra Club, the American Lung Association and All Aboard!, a transit advocacy group.) The MPO provides overall administrative support with other agencies contributing time and funding as they are able.

## PROGRAM FEATURES

Bike to Work has evolved to be a once-monthly activity running from April through October. Commuting cyclists are met at a central location where they are provided with free breakfast, a small gift and the opportunity to meet other cyclists. Cyclists fill out a form at the event which makes them eligible for a drawing held at the end of the year. Those commuters who work in locations other than downtown Hartford can still enter the raffle by submitting a raffle form for each event day that they bicycle to work. Other towns in the region are encouraged to sponsor their own events, and their participants are entered into the regional raffle.

## PUBLIC/PRIVATE COOPERATION

To date, the events have been strictly low-budget. A small fundraising campaign, targeted at bicyclists, provides $500 to $1,000. Agencies on the Bike to Work Planning Committee have contributed to the effort in various ways. In 2002 the Department of Public Health provided funds from a cardiovascular health grant to cover the cost of producing and displaying Bike to Work signs on transit buses


($8,500). The Department of Environmental Protection covered the cost of printing and distributing a payroll insert announcing the Bike to Work program, which went to all state employees (at a cost of about $500) in 2001 and 2002. Gifts for cyclists attending events are donated by bike shops.

In addition, the year-end raffle is for a bicycle that is provided by a manufacturer's representative at wholesale price. A bike shop fits the bike and builds it for the winner. The cost of the breakfasts is covered through donations (primarily from members of the planning committee) and some funding available through the Council of Governments. In 2002, one of the monthly events was sponsored by a large downtown employer, who provided the food and manpower required.

## PROMOTIONAL EFFORTS

Promotion of Bike to Work has several aspects:

- Getting the word out
- Helping novices give it a try
- Encouraging bike commuting as a continuing habit

CRCOG maintains a Web site (http://www.crcog.org/biketowork2005.htm) that has monthly updates on the program. Each month press releases are distributed widely to create interest in the program, a payroll insert goes to all state employees (one insert each year) and brochures are distributed (including distribution to noontime crowds at a center city park). A large e-mail address list of those who have participated in Bike to Work or who have shown an interest in it is maintained, and they are sent e-mails monthly. The Committee also works with large employers, requesting that they send e-mails to their employees about the event each month. The placement of advertising signs on buses in 2002 significantly boosted the program's visibility.

To encourage those who have never tried bike commuting, a ride coordinator system has been developed. The coordinators are individuals who bike to work regularly and have volunteered to meet cyclists on their trip or to help them plan their commutes. They are listed on the Web site with contact information, trip origin and destination, and frequency.


To encourage bicyclists to continue biking to work, each month we select one individual as our area's Super Bike Commuter with recognition in the monthly press release, on our Web site, and at the monthly event. Selection is based upon dedication to commuting by bike and ability to inspire others to give it a try. This recognition has received significant press attention.

Other features of the program are designed to generate public interest. At each event, cyclists can select a gift (generally related to bike maintenance or safety) and enter a raffle. Monthly raffle prizes are awarded, and the year-end raffle includes a new, high-quality bike with an approximate retail value of $900. In 2002, a T-shirt was given to the first 50 participants and then made available for sale.

In 2002 the Big Wheel award was created to recognize towns that exhibit a commitment to integrating safe bicycle travel on their roads. (This award was presented only once during the promotion, as only one town, Windsor, CT, exhibited progress warranting the award.)

### SAFE CYCLING

Safe cycling has been a continuing theme of the events. A Share the Road brochure was developed for the initial event in May 2000 and has been available at all events. The brochure contains tips for both bicyclists and motorists on how to share the road safely. All cyclists are encouraged to take a copy of the brochure, and since the brochure is targeted to motorists also, passersby are encouraged to pick up a copy.

Cyclists are also given an opportunity to report any hazards they find on their commute. These are reported on a postcard designed for this purpose and returned to CRCOG. CRCOG then forwards the concern to the appropriate road department (state or town) for resolution. Some of the comment cards are returned with specific maintenance issues (debris on the road, potholes) while others note longer-term issues, like the need for bike lanes or paths.

## EVALUATION AND RESULTS

The success of Bike to Work events can be measured in a number of ways:

- How many people attended the events?
- Did the events encourage people to try bike commuting for the first time?

But most importantly for our events:

- Did the events raise community awareness of the role that bikes can play in the transportation system?
- Is there a greater understanding of the fact that bikes do belong on the roads?

A database was developed to measure attendance and characteristics of bike commuters. In the first year (2000), approximately 25 attended the Bike to Work events, but little was known about their commute trip. In 2001 and 2002, a raffle form was designed to provide information on each participant's bike commute and the database was created using this information.

Community awareness has been measured with a surrogate—how many news articles covered the event each year. A survey of the public would provide a more accurate understanding of changes in public perception and attitudes, but presence of news articles indicates that the information is going out to the public, and that opinion-makers such as the media view the topic as important.

An analysis of the database indicates that the program is having some impact in convincing individuals to try bike commuting. In 2001, 15 percent of the participants were trying bike commuting for the first time (see table). In 2002, the number dropped to just over 10 percent. The diminishing numbers of new bike commuters is somewhat expected. Those who first try biking to work tend to have schedules, work locations and skills most amenable to biking to work. Once the "low-hanging fruit" joins in the program, a greater effort is needed to encourage those who may have more difficult schedules or whose work locations lack suitable facilities to try biking to work. In addition, to continue to attract new commuters, the region's roads need to feel safe to bicyclists with a wide variety of skill levels. At this point, the Bike to Work program has not been accompanied by widespread introduction of new bike facilities (e.g. bike lanes, parking racks, showers, lockers.)

Record of Participation in Bike to Work Events

| | 2000 | 2001 | 2002 |
|---|---|---|---|
| Number of individuals participating throughout promotion | 25 | 201 | 236 |
| Highest attendance at a single event | 20 | 95 | 153 |
| Number of first timers (biked to work for the first time on the day of an event) | NA | 30 | 25 |
| Percent of participants who were first timers | NA | 15% | 11% |
| Annual bicycle commute miles reported by participants | NA | 204,000 | 225,000 |
| Notes<br>NA = not available<br>2002 peak attendance includes attendees at one downtown event and 8 regional events. | | | |

Follow-up work is required to determine whether those who tried biking to work as a result of our program have continued to bike to work and if so, how often.

The evaluation has indicated that the program is having some impact in convincing people to try bike commuting, but the numbers are still very small. Feedback from cyclists and those who have considered biking to work, but have not, indicates that new commuters are discouraged by the lack of bicycle facilities (there are no trails or bike lanes leading into downtown Hartford) and that many of them lack the confidence needed to ride in traffic. The ride coordinator program is designed to help build confidence for novices, but it is not being fully utilized. To date no one has ridden with any of the ride coordinators, but they have been contacted for information regarding preferred routes. In the future the Committee will work to strengthen this program, adding coordinators and improving publicity.

The hazard-spotting program is an effort to improve conditions for bikers, but implementation is still difficult. Some maintenance departments take the complaints seriously and respond immediately. Others are less prompt. The challenge to the Bike to Work Committee is to get the commitment of all the towns and the state to respond promptly to concerns. Other successful bike hazard-spotting programs in the country have been developed from the top down and there is a management directive to implement the program. In this case, the implementation is from the users, and this bottom-up approach will require time before it is fully institutionalized.

The region has not seen a sudden increase in development of bike facilities as a result of the Bike to Work promotion, but there have been some positive signs. The town manager of Windsor, CT, has directed his Public Works Department to examine every street scheduled to be repaved to determine if bike lanes can be designated on the street. The city of Hartford has undertaken a major citywide traffic calming project, and bike lanes are being considered on several major arterials. The town of East Hartford has been working diligently to get funding in place for a piece of bike trail that will link the eastern suburbs with downtown Hartford.

Media coverage has increased each year, and the tone of articles has changed from a focus on trails and paths to a greater emphasis on bicycling as a means of transportation. This indicates a significant change in attitude about the role of biking in the transportation system, at least among the opinion makers of the region.

It does appear that the program has been successful in raising the profile of bicycling as a legitimate part of the transportation system, as evidenced in the increase in media coverage. In addition, the mere presence of a number of bicycle commuters one day each month reinforces the idea that bikes do belong on the street. It is unclear if the message that bicycles should follow the vehicle code has been conveyed. There is no evidence to indicate that more bicyclists and motorists are properly sharing the road.

## CONCLUSIONS AND RECOMMENDATIONS

The Bike to Work promotion has played a role in raising the profile of cycling as a means of transportation in the Hartford region, and it appears that it can play a role in reinforcing the idea that bicycles follow the vehicle code. The program will continue next year with an emphasis on providing support to those who are considering biking to work but are hesitant. This will include expanding the ride coordinator program and providing tips and demonstrations for bike commuters, such as how to dress, how to make a safety check of your bike and how to repair a flat. Further outreach to employers to encourage them to support bike commuting will be undertaken. In addition, more information will be collected from cyclists to better understand how effective the program is and to learn more about the impediments to biking to work.

With the Big Wheel award, the program will continue to recognize towns, to encourage them to consider bike needs on their roadway system. This will dovetail with the MPO's adoption and implementation of the U.S. DOT Policy on Integrating Bicycling and Walking into the Transportation Infrastructure. Also, it is hoped that many of the region's towns will agree to sponsor at least one Bike to Work event next year. Continued dissemination of "Share the Road" information will be an important part of the continuing program.

We consider our program a success in meeting our goals, and expect that by continuing the program we will continue to see benefits. Our advice to others contemplating a similar program is to start simply, add to the program over time and share the responsibilities with partner organizations.

## COSTS AND FUNDING

| | |
|---|---|
| Event | |
| Food (7 events at $60 each) | $420 |
| Publicity | |
| Banner: 2' X10' (reused year to year) | 120 |
| Banner: 3' X 20' (reused year to year) | 360 |
| Brochure printing | 500 |
| Payroll Insert | 500 |
| Signs on Buses | 8,550 |
| Gifts/Prizes | |
| T-shirts (250) | 1,530 |
| Bicycle to raffle | 500 |
| Total | $12,480 |

Notes:

- For several of the events, the food was actually donated by the host.
- The brochure cost covers the cost of printing the Bike to Work brochure.
- The Share the Road brochure printing cost ($2,200) was covered under another program.
- The cost of the payroll insert was donated by the CT Department of Environmental Protection.
- The cost of the signs on buses was covered by the CT Department of Public Health.
- 85 shirts were given away, the rest were available for sale at $14.
- The bicycle is provided to the project at close to the manufacturers cost so we pay $500 for a $900 to $1,000 retail value bike.

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MISSOULA, MONTANA #54

# Free Cycles Program

## BACKGROUND

Free Cycles Missoula was formed in 1996 as a non-profit to address the following issues:

- projections of future increased congestion and air pollution
- lack of community access to affordable bicycles
- broken bicycles being thrown away

Before Free Cycles Missoula began operations, roughly 500 bicycles a year were going to the local recycling center and landfill. These "throw-away" bikes presented an opportunity to increase access to bicycles by all citizens, especially low-income individuals. The act of giving away bicycles also provided increased opportunities to distribute safety information to individual citizens and to the community at large.

An umbrella advocacy organization helps monitor and advocate for bike facility.

The decision to start the project by providing 'free-roaming' green bikes was based on the perception that people would gladly donate unused bikes and broken bikes to an organization that would get the bikes back to the community in working order. Another factor to start the project was the knowledge that many short motor vehicle trips could be replaced by bicycle trips (40 percent of local motor vehicle trips are less than two miles) if convenient alternatives existed.

While community awareness existed about these issues, overall there seemed to be a general sense of frustration that motorized traffic was increasing unabated and that cycling conditions were deteriorating. A just-completed Long Range Plan for Missoula County (population 90,000) earmarked several roads to be reconstructed with additional lanes for motorized vehicles as a way to relieve congestion. Yet, it seemed that bicycling was being overlooked as a legitimate mode of transportation that could be planned for and encouraged. No bike lanes existed at the time, which often forced an awkward and dangerous sharing of road space on arterial roadways.

Bob Giordano
Executive Director,
Missoula Institute for Sustainable Transportation
Program Director, Free Cycles Missoula

One justification for not spending more resources on bicycle infrastructure was that cycling made up a small portion of the local mode share. To the founders of Free Cycles this seemed to be a "catch-22" situation: without safe facilities bicycling might not grow, but without bicycling growth, the safe facilities may not be supported by decision-makers.

### GOALS OF THE PROJECT

At the start of the project, a primary goal of Free Cycles Missoula was "to obtain old, unused bicycles, give them a paint job, fenders, reflectors, and a wire basket, and place them in public places around Missoula" (MIST Web site, 2005). Community involvement in building and maintaining the bikes was also an important goal. By making rebuilt bicycles widely available throughout the city (the bike is ridden, and then parked at any public rack) it was thought that the sheer numbers of bicyclists and bicycle trips would increase.

Longer term, a goal of the project was to embark on a process that would eventually lead to elevated community awareness about, and utilization of, bicycling as a legitimate mode of transportation. By creating a better cycling atmosphere in the city, more facilities and thus more cyclists would eventually exist. Overall, the project aimed to initiate a positive feedback loop that would release and create the latent demand for bicycling.

Several research studies indicate that safety for bicycling increases when more bicyclists are on the street. One paper found an inverse relationship between the number bicyclists on the street and the number of crashes involving bicyclists being hit by motor vehicles (Jacobsen, 2003). Another study similarly found that the risk of a cyclist incurring a severe injury is decreased when numbers of bicyclists increase (Robinson, 2005).

## COUNTERMEASURES

In the spring of 1996, 50 green bikes were released to the community. At the end of the riding season, twenty-five had "survived." While this survival rate peaked at 83 percent in 1999 (MIST Web site, 2005), it became apparent from the middle of the first year of the project that a multi-faceted approach with a variety of community cycling programs would be needed in order to meet the project goals and objectives.

This multi-faceted approach had already been conceived in the Green Bike Proposal that had circulated throughout the city prior to the initial green bike release in April, 1996. This approach reads:

> Free Cycles Missoula will be responsible for continually bringing in additional bikes, maintaining the ones in use, conducting seminars on education and safety, working with the city in improving bicycle corridors, and monitoring the success of the program (MIST Web site, 2005).

Years two and three of the project (1997–98) saw an evolution to four more programs:

- the expansion of the green bike release day into a full Festival of Cycles focused on community building and bike building,
- the creation of a second generation of public bicycles (a lending library called Checkout Missoula),
- the spread of an outreach and education program called Pedal Education,
- and the transformation of the green bike repair shop into a formalized gathering place called the Community Bike Shop.

In 2000, in order to address research, design and advocacy for better bicycle systems and, more generally, better transportation systems, an umbrella group, the Missoula Institute for Sustainable Transportation (MIST) was formed. And finally, 2003 saw a 6th program added to Free Cycles — Pedal Technology. The aim of Pedal Technology is to extend the reach of what the bicycle is capable of being used for (i.e. load carrying, protecting the rider from the weather, improving efficiency) and increasing the availability of existing bicycle attachments (i.e. trailers and racks) to more people through inexpensive fabrication (utilizing a stock of 1,000 recovered bikes for parts).

## EVALUATION AND RESULTS

One of the outcomes of this project has been the successful recovery of over 5,000 broken and unused bicycles from the community and region. 2,500 of these bicycles


The bike lane was originally striped too narrow and then fixed a few days later. The new line to the left makes for a proper bike lane. The old lane was only 30 in wide, forcing cyclists too close to the gutter pan seam. The city engineer originally wanted to wait a year until the paint wore off to correct the problem but, under direction from city council, fixed the problem within days. MIST was effective at advocating for bicyclist safety.

have been given away to those in need. The recipient of the free bike learns the skills to fix the bicycle at the community shop and learns the skills to ride the bicycle safely either at the shop or at a variety of workshops taught throughout the community. In addition, over 10,000 individuals have interacted with the community bicycle shop in the form of getting information, getting parts, or using tools. Efforts are made by shop personnel and volunteers to ensure that some element of safety is expressed to these shop participants. These efforts take the shape of:

- pointing out safe routes in the community with maps and guides
- encouraging safe riding skills through hands-on demonstrations or through brochures
- ensuring safe mechanical functioning of the bike through one-on-one classes and group discussions

Other outcomes of the project include a successful Festival of Cycles that has run continuously for eight years with average attendance of 1,000 people, approximately 1,000 bicycle checkouts from the bike library (Checkout Missoula program), and several successful bicycle facility improvement projects run by the umbrella organization, MIST. One particular project by MIST improved a bike lane that had been inadvertently narrowed to under three feet by the city of Missoula. The bike lane was restriped at a more proper five foot width within one week of the mistake due solely to the engagement of MIST with the Missoula City Council.

Finally, the original project goal of increasing bike trips by providing free green bikes to citizens was successful in that over 10,000 trips are estimated to have been taken by this method of transportation (primarily in the years 1996–2000). It is unknown how many of these trips replaced an auto trip, a walk trip, or another bike trip. However, there has also been substantial positive feedback from citizens on the effectiveness of the green bikes with respect to 1) providing a fun alternative to driving and 2) spawning a whole range of bicycle and transportation programs aimed at getting more people bicycling as a form of transportation. Further research would need to be conducted to obtain more detailed numbers on the overall effect of all Free Cycles and MIST programs on mode share and bicycle safety.

## CONCLUSIONS AND RECOMMENDATIONS

In hindsight, starting with a very simple, highly-visible community-based program with the willingness and intention to change, grow, and expand, has proved very effective. Recommendations for other communities include:

- Begin a community bicycling program with a community shop. This entails finding space (1000 to 3000 square feet), a coordinator (volunteer or paid) and the support of other local cycling organizations.
- Give away free bicycles, sell some bicycles to cover some expenses, and retain a small fleet for loaning bikes out.
- Get involved in the design and advocacy for better facilities (bike lanes on all arterials, connected multi-use trails, and regaining or maintaining calm neighborhood streets).
- If starting a public bicycle system, compliment a 'free-roaming' program with a 'checkout' program.
- Emphasize safe riding, safe facilities, and safely-tuned bikes in all programs.

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## COSTS AND FUNDING

Free Cycles started with $2,500 in local business donations. The budget has grown approximately $1,000 a year, mainly through fundraisers, bike sales, fees for services (workshops and classes), and local private donations.

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# Bicycle Destination Signing System

## BACKGROUND

The city of San Diego began developing a systematic network of bikeway destination signs during the late 1980s. This network went beyond the guidance provided by the *Manual of Uniform Traffic Control Devices* (MUTCD) and the American Association of State Highway and Transportation Officials (AASHTO) section on bikeway design. Using the principles of the California Department of Transportation's Traffic Manual, selected bikeway corridors received consistent and comprehensive destination signs.

Freeways and other major highways define much of the roadway transportation network in San Diego that link neighborhoods and major activity centers within the city and its adjacent neighbors. Many of San Diego's bikeways parallel freeways. In addition numerous arterial, collector and local streets and shared use paths are designated bikeways. Collectively they form a bicycle transportation network.

Disparate roadway and trail segments are used by bicyclists to travel within San Diego. The bikeway destination sign system was established to alert current and potential bicyclists of communities and major activities with bikeway signs that would not necessarily be evident. For example, a resident of the San Diego community of Pacific Beach wishing to travel to downtown San Diego might drive there using Grand Avenue, Interstate 5 and Front Street. If that person wished to cycle to downtown it may not be so evident that they could get there via Grand Avenue, East Mission Bay Drive, and Pacific Highway. Destination bikeway signs make finding the way via bicycle much


easier and safer. Anecdotal reports have shown that visitors and residents alike find the destination signs helpful in their cycling travels.

Michael Jackson, Director of Bicycle and Pedestrian Access, Maryland Department of Transportation
Kathy Keehan, Executive Director, San Diego County Bicycle Coalition.

## COUNTERMEASURES

Generally at least two different destinations were posted on a sign (one line per destination) as the thinner, one-line signs were more susceptible to being bent. Bikeway destination signs were green with white lettering. The signs are 24 inches wide to match the width of standard 18 x 24 inch BIKE ROUTE signs. Sign height varied according to the amount of information provided. Arrows accompanied each destination line. Arrows indicating straight ahead and left turn destinations were placed to the left of the destination name and destinations requiring right turns had arrows placed on the right side of the destination line.

Destination signs are always accompanied by a BIKE ROUTE or BIKE LANE sign. Destination signs are always placed beneath BIKE ROUTE signs on the premise that people read from left to right and from top to bottom.
The "control city" concept was utilized to alert bicyclists to the ultimate destination of a bikeway. For example

northbound travelers on Interstate 5 leaving downtown San Diego are alerted they are going toward Los Angeles. Los Angeles serves as the "control city" and orients travelers to their general direction of travel. Intermediate exits are listed on those freeway guide signs as well to provide supplemental information about the immediate surroundings.

In the case of the bikeway destination signs a major activity center, community or an adjacent city served as the control city and intermediate neighborhoods or major activity centers were also listed. For example a bikeway in South Bay lists Tijuana, Mexico as the "control city" and San Ysidro as the intermediate destination. Another example is the destination signs facing northbound traffic on Pacific Highway out of downtown. Pacific Beach would serve as the "control city" and Mission Bay Park as the intermediate destination.

## EVALUATION AND RESULTS

Bikeway destination signing was set up to address the following issues:

- Inform existing bicyclists of how to safely reach major points of interest in San Diego.
- Encourage more bicycle trips by informing would-be bicyclists of destinations that can be reached by bicycle from various locations.
- Provide additional meaningful information to BIKE ROUTE signs.
- Inform all roadway users that the city of San Diego recognizes the legitimacy of bicycling by providing guidance signing.


A small-scale survey of bicyclists in the San Diego area did not elicit sufficient responses to consider them being representative of the collective viewpoints of San Diego's bicycling community. The majority of responses were, however, generally supportive of the signs. The primary benefits appear to be that the signs confirm direction when one is already on a trip; the signs alerted some bicyclists of potential destinations or routes that are accessible by bicycle that they hadn't thought of; and some bicyclists felt that the signs could at least alert motorists that bicyclists are legitimate road users, although others felt that motorists might not notice the signs. A few bicyclists also felt that the signs could help to encourage new bicyclists to try a bicycle trip, if the system was well documented.

## CONCLUSIONS AND RECOMMENDATIONS

Bikeways destination signing, while not replacing bike route maps and other resources to assist in trip planning, can provide on-the-road assurance of direction (or distance, if provided), if located on routes likely to be used by bicyclists. Bicyclists should therefore be engaged in the process of choosing preferred routes to sign. The signs may help to alert bicyclists to other potential destinations, and alert motorists that bicyclists are expected users of the roadways, which may contribute to a safer bicycling environment as well as a more supportive one. The sign concepts (such as "control city") and signed routes should be publicized and explained in other publications (such as bike maps) to help bicyclists understand the information provided in the signs.

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# Urban Forestry

## BACKGROUND

The mission of Seattle's Urban Forestry Program is to administer, maintain, protect and expand the city's urban landscape in street rights-of-way for Seattle's residents and businesses so that environmental, aesthetic, and safety benefits are maximized. Most of Seattle's trees are less than 30 years old and more than 50,000 new trees have been planted in the past 10 years through various city programs. The Urban Forestry Program is part of the city's effort to create a better bicycling and walking environment, to provide a buffer between vehicular and pedestrian traffic, thereby improving comfort and safety, to discourage vehicular parking on planting strips, and to improve air and water quality. When combined with other treatments, street trees also contribute to speed management on residential and arterial streets, creating a better bicycling and walking environment. The posted speeds of most arterial streets in Seattle are 30 or 35 miles per hour.

## COUNTERMEASURE

New trees get planted in a variety of ways. They are routinely included in roadway reconstruction projects and sidewalk projects, and are required as part of the development or redevelopment of property. Trees are installed as part of neighborhood tree planting projects, planted by individuas, and the Urban Forestry Program has some funds to plant trees on targeted arterials.

The success of the Urban Forestry Program can be attributed to the successful partnership between the city and the citizens of Seattle, to maintain, protect and expand the trees in Seattle's street rights-of-way.

### STEWARD PROGRAM

Seattle's Steward Program trains residents to help care for street trees. Classes on tree maintenance and planting are provided. Residents are trained to take inventory of the trees, to seek planting opportunities in their neighborhood and to organize neighborhood tree-planting projects.

### HERITAGE TREE PROGRAM

Since 1996, Seattle has listed 20 trees with the Heritage Tree program. Heritage trees may be on either City or private property and must have the owner's approval. Trees can be recognized for their size, age, historic association with a place or event, or be a community landmark. Each tree is identified by a plaque and is part of a Heritage tree tour.

### CITYWIDE TRAFFIC CIRCLE GARDEN CONTEST

The landscaping on Seattle's traffic circles is maintained by nearby residents. Every year, there is a citywide contest to determine the best-maintained traffic circles. Up to 10 awards are given each year, often with good media coverage.

Shane DeWald, Landscape Architect
Liz Ellis, Program Manager
Peter Lagerwey, Pedestrian and Bicycle Program

Certain tree species are not recommended or are even prohibited due to fruiting characteristics, brittle wood or root growth traits.

More information, including tree selection and planting guidelines, is available at the Seattle Urban Forestry Web site at http://www.seattle.gov/transportation/treeplanting.htm.

## EVALUATION AND RESULTS

The Urban Forestry Program is evaluated by the health and survival rate of trees, the level of public involvement by the Steward and other programs and the number of new trees planted.

The Urban Forestry Program is a success by all measures. The city has been recognized by the national Arbor Day Foundation as a Tree City USA for 16 years and as a Tree Growth City for nine. Public involvement has been and continues to be high and over 50,000 new trees have been planted in the last 10 years.

Landscape guidelines, such as set back and pruning requirements, help maintain visibility and a safe multi-modal environment while the trees contribute to a healthier, more aesthetically pleasing environment.

## CONCLUSIONS AND RECOMMENDATIONS

After years of focused efforts to maintain, protect and expand the city's urban landscape in street rights-of-way, the program has been successful in making Seattle a more livable, walkable, and bikeable community. The results include improvements in aesthetics, safety and air quality that benefit all road users. Additionally, Seattle residents enthusiastically support the program through their volunteer efforts.

## COSTS AND FUNDING

Multiple funding sources acquired through "piggybacking" on other projects and volunteer contributions.

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# Raising Funds for Bicycle Safety Programs through Specialty License Plates

## BACKGROUND

Florida has one of the highest bicycle injury and fatality rates in the nation. To help reduce the number of bicycle crashes, an ongoing dedicated funding source was needed to help make Florida a safer place to cycle. There had been a variety of short-term state and federal grants and appropriations, but securing sustained financial support was imperative to support quality bicycle safety programs.

Florida is one of the many states that offer motorists an opportunity to purchase a specialty license plate instead of the standard state license plates for their motor vehicle. Each specialty plate in Florida serves as a funding mechanism for a nonprofit organization in the state. The specialty plates cost the consumer an additional fee that is collected by the Department of Highway Safety and Motor Vehicles. The fees are collected every year that the individual possesses the specialty plate and forwarded to the nonprofit organization that sponsors the plate.

Each state has different laws and procedures regarding the specialty license plates and some states do not have any specialty plates for their citizens. Contact your Department of Highway Safety and Motor Vehicles for more information on specialty license plates in your state (see appendix A for information on Florida's statute).

Florida's requirement began with an official application to the Division of Motor Vehicles requesting the establishment of a new specialty license plate. Next, a survey sample of 15,000 registered vehicle owners or registrants stating their intention to purchase the proposed specialty license plate was completed. An application fee of $60,000 was then submitted to defray the department's cost to review the application and develop the specialty license plate. The last step in the application process was to submit a marketing strategy outlining short-term and long-term marketing plans for the proposed specialty license plate (see appendix B).

T.J. Juskiewicz, Executive Director of Bike Florida and the Share the Road Campaign, Florida


Once the application requirements have been met, Florida law requires that legislation be submitted to the House and Senate Transportation Committees. The proposed legislation would detail the cost of the proposed plates, the purpose in creating the proposed plate and how the funds would be spent (see appendix C).

Upon approval by the legislature, the organization must submit the proposed art design for the specialty license plate. Completion of the design, development, production and distribution of each new specialty license plate shall occur within one year after the legislature's approval of the plate (see appendix D).

## COUNTERMEASURES

The process in Florida to create the "Share the Road" specialty license plates began in 1997. A few bicycle advocates were determined to create a new specialty tag in Florida to bring attention to the safe sharing of the Florida roadways following the tragic death of Margaret Raynal. Raynal and a colleague were killed in 1996 while cycling on a rural road in north Florida. Margaret was an avid cyclist and advocate who worked at the Florida

Bicycle and Traffic Safety Education Program at the University of Florida in Gainesville.

Linda Crider and Jimmy Carnes of Gainesville and Henry Lawrence of Panama City were some of the key individuals involved in the creation of the project. They enlisted the support of the Florida Governor's Council on Physical Fitness and Sports to collect signatures and raise the funds required to create the "Share the Road" specialty license plate. Various bicycle clubs and advocacy groups throughout the state also pitched in by collecting the needed signatures. After two years the required signatures were gathered and the funds were in place to proceed.

The "Share the Road" license plate legislation in Florida was filed and sponsored by Representative Bob Casey (House Bill 601, 1999 Legislative Session) from Gainesville and Senator Donald Sullivan (Senate Bill 280, 1999 Legislative Session) from St. Petersburg. During the 1999 legislative session, both the House (113 to 4) and Senate (38 to 1) approved the "Share the Road" license plate. On June 8, 1999, the governor signed the "Share the Road" specialty license plate bill into law (see appendix E).

During the 1999 legislative session, Senate Bill 1566, Chapter 99-251 provided for the Florida Sports Foundation to absorb many duties currently assigned to the Governor's Council on Physical Fitness and Amateur Sports.

The bill originally distributed the annual user fees of the license plates to the Governor's Council on Physical Fitness and Amateur Sports. A portion was to be used for marketing and promotion of the "Share the Road" concept and license plate. The remaining funds were to be divided equally between Bike Florida, Inc. and the Florida Bicycle Association, Inc. Bike Florida and Florida Bicycle Association, both non-profit organizations founded to promote safe bicycling, had mutually agreed, before passage of the bill, that Bike Florida would administer the marketing and promotion of the specialty license plate and after expenses, split the proceeds. Representative Casey filed a bill to distribute funds directly from the "Share the Road" specialty tags to Bike Florida, Inc., instead of the Governor's Council on Physical Fitness and Sports. After several changes, House Bill 571 and Senate Bill 768 were presented and passed. In July, the Governor signed the bill making it law.

## EVALUATION AND RESULTS

Florida's Department of Highway Safety and Motor Vehicles (DHSMV) is the main entity with which Bike Florida works regarding the "Share the Road" license plates. The DHSMV receives updates on tags sold and funds collected from county tax collectors and tags sold directly through the state office. The DHSMV transfers funds collected through these agencies and mails a paper check to the Bike Florida office. The DHSMV also sends a monthly report of tag funds collected by each county and the state office. The funds typically are distributed by the DHSMV many months after they are collected.

Once Bike Florida receives the funds from DHSMV, Bike Florida calculates 25 percent of each check and deposits that amount into the Share the Road Promotion Account. The remainder is split equally between Bike Florida and the Florida Bicycle Association. The funds are distributed to the Florida Bicycle Association on a quarterly basis.

In 2000, the "Share the Road" specialty license plates generated $37,245 in revenue. In 2001, $75,511 was generated. It is projected that well over $100,000 in revenue will be produced in 2002.

## CONCLUSIONS AND RECOMMENDATIONS

The "Share the Road" license plates project has exceeded expectations to date. The goal was to secure an on-going funding mechanism to promote bicycle safety in Florida, which was accomplished. The revenues generated should eclipse the $100,000 mark for years to come, which will be extremely beneficial to bicycle safety programs throughout Florida.

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## APPENDIX A

### FLORIDA LAW

Section 320.08053, Florida Statutes outlines the requirements an organization must meet to request that a new specialty license plate be created. Section 320.08056, Florida Statutes provides the responsibilities of the Department of Highway Safety and Motor Vehicles in developing and issuing specialty license plates when legislation authorizes a new specialty license plate to be established.

## APPENDIX B

### APPLICATION REQUIREMENTS

Initial contact must be made with the Division of Motor Vehicles before an organization can begin the process.
Legislation must be enacted to establish a new specialty license plate design. Proposals for specialty license plates may be considered by the legislature only upon compliance with the following conditions and requirements. An organization that seeks to establish a new specialty license plate, for which an annual use fee is to be charged, must submit to the department:

1) A letter of request for the specialty license plate describing the proposed specialty license plate in general terms. The letter must include the purpose for creating the specialty license plate.

2) The results of a scientific sample survey of 15,000 or more registered vehicle owners or registrants who state their intent to purchase the proposed specialty license plate. The sample survey must be performed independently of the requestor and be conducted by a organization that does sample surveys as a normal course of business. Additional prerequisites regarding the survey and its content are outlined.

3) An application fee of $60,000, payable to the Division of Motor Vehicles, to defray the department's cost for reviewing the application and developing the specialty license plate. If the specialty license plate requested by the organization is not approved by the legislature, the application fee shall be refunded to the requesting organization.

4) A marketing strategy outlining short-term and long-term marketing plans for the proposed specialty license plate. The marketing strategy also must include a financial analysis outlining the anticipated revenues and the planned expenditures of the revenues to be derived from the sale of the proposed specialty license plates.

## APPENDIX C

### LEGISLATIVE PROCESS

When a proposal has been submitted, the department will notify the House and Senate about whether the application requirements have been met. When the proposed legislation is submitted to the House and Senate Transportation Committees, a copy will be provided to the applicant of the proposed plate. The proposed legislation will be generic to be consistent with all other existing specialty license plates and will:

1) Require that the plate be developed, manufactured and distributed within one year.

2) Provide for the specialty license plate to be issued to the owner or lessee of any motor vehicle, except for a vehicle registered under the International Registration Plan, a commercial truck required to display two license plates or a truck tractor.

3) Specify the amount of the annual use fee for the use and distribution of the fee.

4) Describe the basic design specifications of the plate and provide for the plate to be personalized.

5) Provide for this department to annually retain, from the first proceeds derived from the annual use fees collected, an amount sufficient to defray the department's costs directly related to issuing the specialty plate.

6) Specify audit requirements.

7) Provide for de-authorization and discontinuation of the specialty license plate if the license plate does not meet statutory requirements.

## APPENDIX D

### DESIGN, DEVELOPMENT, MANUFACTURE & DISTRIBUTION

When the new specialty license plate is approved by the legislature, the organization must submit the proposed art design for the specialty license plate to the department within 60 days.

The Division of Motor Vehicles is responsible for coordinating the design and development of the specialty license plate. Completion of the design, development, production and distribution of each new specialty license plate shall occur within one year after the legislature's approval of the specialty license plate.

Specialty license plates must bear the design required by law for the appropriate specialty license plate and the design and colors must be approved by the department. In addition, the produced specialty license plates may bear the imprint of numerals from 1 to 999, inclusive, capital letters "A" through "Z" or a combination thereof. The department shall determine the maximum number of characters including both numbers and letters. All specialty license plates must be of the same material and size as standard license plates.

The organization that requested the specialty license plate may not redesign the specialty license plate before the end of the fifth year, unless the inventory of those plates has been depleted. However, the organization may purchase the remaining inventory of the specialty license plates from the department at cost.

### DE-AUTHORIZATION & DISCONTINUATION

The department must discontinue the issuance of an approved specialty license plate if:

1) Less than 8,000 plates are issued by the end of the fifth year of sales or any subsequent five-year period.

2) The plate's recipient organization no longer exists, has stopped providing authorized services or has requested discontinuation.

### DESIGN SPECIFICATIONS

In addition to the plate design requirements previously mentioned, the following specifications would apply to the design based upon its location on the actual license plate.

### CENTER DESIGN

1) The plate size must be 30.5 cm by 15.2 cm (12 in by 6 in).

2) The center graphic must be no larger than 6.4 cm by 7.6 cm (2.5 in by 3 in).

3) The background must be limited to three colors.

4) If the lettering of "Florida" which is placed at the bottom or top depending upon the design of the license plate, is to be embossed, it must be the same color as the license plate characters. In addition, a specialty license plate may bear an appropriate slogan.

5) The license plate number must have three characters to the left and three to the right of the centered graphic design. The range of license plate numbers assigned will consist of three alpha followed by three numeric or three numeric followed by three alpha characters.

### LEFT SIDE DESIGN

1) The plate size must be 30.5 cm by 15.2 cm (12 in by 6 in).

2) The graphic must be on the left side of the license plate and be no larger than 7.6 cm (3 in) in diameter.

3) The background must be limited to three colors.

4) If the lettering of "Florida" which is placed at the bottom or top depending upon the design of the license plate is to be embossed, it must be the same color as the license plate characters. In addition, a specialty license plate may bear an appropriate slogan.

5) The license plate number is limited to five digits with one alpha character and four numeric characters.

## APPENDIX E

### 2001 FLORIDA STATUTES

Title XXIII – Motor Vehicles
Chapter 320 – Motor Vehicle Licenses
Statute 320.08058 – Specialty License Plates
(31) SHARE THE ROAD LICENSE PLATES
(a) The department shall develop a Share the Road license plate as provided in this section. The word "Florida" must appear at the top of the plate, and the words "Share the Road" must appear at the bottom of the plate.
(b) The annual use fees shall be distributed to Bike Florida, Inc., up to 25 percent of which shall be used for marketing and promotion of the "Share the Road" concept and license plate. The remaining funds shall be divided equally between Bike Florida, Inc., and the Florida Bicycle Association, Inc., to be used for:

1. Education and awareness programs, for bicycle safety and motorist safety, with emphasis on sharing the roadway by all users.

2. Training, workshops, educational materials, and media events.

3. The promotion of safe bicycling.

# A Transit Oriented Development Financial Incentive Program—A Tool to Encourage More Bicycling and Walking

## BACKGROUND

There are two primary obstacles to using non-motorized transportation for personal, shopping, and commuting trips: lack of facilities and longer than reasonable trip length. People will bicycle and walk more if the proper facilities are provided and their destinations are within a relatively short distance.

The 2002 National Survey of Pedestrian and Bicyclist Attitudes and Behaviors noted that the average trip length on a bicycle was 6.3 km (3.9 mi) and 38.6 percent were 1.6 km (1 mi) or less. The average trip length for walking was 1.9 km (1.2 mi) and 26.9 percent were shorter than 0.4 km (0.25 mi). Unfortunately, as a result of land uses in San Mateo County, CA, and many communities throughout the United States, distances from residential housing locations to employment and shopping destinations are typically greater than the average trip lengths noted in the 2002 survey.

Use of land and its specific location, as determined by local governments throughout the United States, is traditionally targeted to maximize sales tax revenue. The focus on increasing tax revenue results in a greater tendency for land development projects such as office and retail space, while creating a disincentive to develop residential projects. This often produces an environment where employment, shopping and housing are separated by distances that are much greater than the average bicycling and walking trip distances. In addition to discouraging non-motorized trips, this land use pattern also burdens the motorized transportation infrastructure and reduces air quality.

To further complicate the issue, land use decisions generally are made by local jurisdictions while transportation decisions are made by regional coalitions. Such regional coalitions might be, for example, Metropolitan Planning Organizations or Congestion Management Agencies (such as the San Mateo City/County Association of Governments (C/CAG).

Felicia Leonard, Bicycle and Pedestrian Coordinator, City of Clearwater, Florida


PHOTO COURTESY OF C/CAG

Phase 1 of the Franklin Street Project, near completion. The project received $1.2 million in TOD Incentive Program funds.

The goals of this program are not only to promote local land use decisions that reduce the distances between residential units and employment and shopping land uses, but also to provide an alternative source of funding for transportation projects, including non-motorized projects. In addition, efforts to increase the numbers of people or amounts of bicycling and walking may improve individual safety through a phenomenon of improved "safety in numbers." [See case study #54, references (page 346), for studies that document this phenomenon.] Promoting transit-oriented development may therefore help to improve safety for bicyclists by increasing the numbers of people able to bicycle.

## COUNTERMEASURES

In order to influence land use decisions that would create shorter trip lengths and provide funding for adequate facilities, the San Mateo C/CAG has sought to implement a tailored Transit Oriented Development (TOD) Program. In general, TOD programs seek to develop shared-

use, higher-density neighborhoods that take advantage of proximity to transit alternatives. The resulting development encourages more walking and bicycling by offering shorter trip distances between origins and destinations.

Using the TOD concept as a foundation, the San Mateo C/CAG has developed a unique initiative that provides a financial incentive to influence their local jurisdictions (20 cities and the county) when these jurisdictions develop and implement a critical component of Transit Oriented Development: higher density residential uses that are close to transit locations. To fund this financial incentive program, the San Mateo C/CAG allocates up to 10 percent of its State Transportation Improvement Program funds.

Through the program, the San Mateo C/CAG distributes incentive funds to a local jurisdiction for a development that meets the program's basic criteria. To achieve eligibility for the program, the development must include housing that is located within 0.5 km (0.3 mi) of a rail transit station, and density must be at least 40 residential units per acre. Local jurisdictions receive the incentive funding upon the start of construction.

The local jurisdiction typically receives up to $2,000 per bedroom that is located in the eligible project. Funds are then used to support improvements either on-site or off-site, as determined by the local jurisdiction. In addition to transportation improvements such as non-motorized transportation projects, many general improvements such as landscaping, lighting, plazas and recreational projects are also allowed. The funding or incentive goes to the land use agency to use as they wish on transportation projects. It many times is used on the qualifying project but is not required. It could potentially be used to address a neighborhood concern of the project to help sell it.

## EVALUATION AND RESULTS

Since October 1999, the San Mateo City C/CAG has allocated $5.2 million to the TOD Incentive Program, supporting the development of 3,689 bedrooms in 15 projects. The resulting projects promote more bicycling and walking by providing acceptable trip lengths between origins and destinations. These projects also have provided adequate facilities for bicycling and walking by offering flexibility in the expenditure of the financial incentives.

This innovative TOD Incentive Program, as crafted by the San Mateo C/CAG, has resulted in linking land use and transportation decisions that encourage trip lengths that are suitable for walking and bicycling. In addition to providing an alternative funding source for bicycling and walking facilities, TOD developments reduce traffic congestion and improve air quality.

## CONCLUSIONS AND RECOMMENDATIONS

This program truly has provided a link between local land use and transportation decisions. The TOD incentive program has resulted in the creation of shared use, higher-density development in San Mateo County. The higher-density uses in these developments create shorter, acceptable trip lengths for bicyclists and pedestrians. In addition to encouraging more non-motorized trips, the program also provides an alternative funding source that local jurisdictions can use for bicycle and pedestrian improvements.

This program is easily replicated, having already been duplicated in the San Francisco Bay Area through the Metropolitan Transportation Commission's Housing Incentive Program, which has already allocated $9 million for such uses.

This program was also the recipient of the Environmental Protection Agency's Smart Growth Award in 2002.

## REFERENCES

*2002 National Survey of Pedestrian and Bicyclist Attitudes and Behaviors*, U.S. DOT and Bureau of Transportation Statistics

## COSTS AND FUNDING

The San Mateo C/CAG allocates 10 percent of its State Transportation Improvement Program to fund the TOD

Incentive Program. However, a new program could start with less funding.

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