BIKEWAY DESIGN, CONSTRUCTION AND MAINTENANCE PRACTICES

INTRODUCTION

The cyclist’s experience riding Portland’s bikeway network is largely defined by the physical conditions on the road. What types of facilities are built and how they are built are essential to the creation of an attractive and comfortable environment for bicycling. Once a bikeway feature is established, maintaining its level of quality and performance becomes equally important.

The Portland Office of Transportation (PDOT) is the primary architect of the city’s bikeway network. PDOT uses several standard design, construction and maintenance practices to build and maintain its bikeway network. The guidelines and standards developed for design, construction and maintenance of bikeway facilities ensure that both public and private improvements within the public right-of-way are uniform citywide, function properly and conform to the Bicycle Master Plan and other City requirements.

The City’s Bikeway Design and Engineering Guidelines established as Appendix A of the 1996 Bicycle Master Plan serve as a manual for the design, construction and maintenance of the city’s bikeway network, including bicycle lanes, off-street paths, bicycle boulevards, and shared roadways. These design practices and guidelines were based on two main source documents: the American Association of State and Highway Transportation Officials (AASHTO) manual “Guide for the Development of Bicycle Facilities 1999,” and the 1996 Oregon Department of Transportation (ODOT) “Oregon Bicycle and Pedestrian Plan.” The ODOT plan is currently being updated. A third document, the Manual on Uniform Traffic Control Devices (MUTCD) also informs bikeway design in that it regulates the implementation of traffic signs, signals and pavement markings.

As Portland’s bikeway network is developed, city-specific construction specifications are implemented by the Engineering Services and Development Services Divisions of PDOT. The Bureau of Maintenance protects the investment of public funds in bikeways by implementing maintenance practices, which ensure that existing facilities function as intended and remain safe for cyclists.

In addition to these standard practices, Portland has a reputation for implementing innovative designs that are not found in any domestic bikeway design manual. These innovations, ranging from signal treatments, bicycle lane treatments, and other striping marking and civil designs, have
been employed in a spirit of determination to solve problems for which standard design treatments will not suffice. This chapter will present in detail some of these innovations, as well as standard designs, following the discussion of construction and maintenance practices that are particularly relevant to bikeway construction and operation. Not all designs and issues are addressed. Appendix A of the 1996 Bicycle Master Plan still holds as the design guide for the 90 percent of bikeway elements that are easily and clearly implemented.

Construction Practices Relevant to City Bikeways

Since adoption of the Bicycle Master Plan, PDOT has successfully incorporated much of the guidance outlined within the Design and Engineering Guidelines (Appendix A) as standard construction practices within the City. As the City’s bicycle facilities have grown significantly over the past 15 years, standard designs have been implemented for bike lane widths, right-turn lane configurations, curb cuts and many other roadway treatments.

As the bikeway network had developed, a number of issues have surfaced that merit further clarification or more detailed consideration. These issues are presented below:

Storm Water Catch Basins (Inlets) and Gutters within Bicycle Lanes

A catch basin is an inlet to a storm drain system that typically includes a grate where storm water enters, and a basin to capture sediment, debris, and associated pollutants. Care must be taken to make sure that grates installed on city bikeways are suitably designed to allow for bicycle safety. There are three issues with them:

- The grate itself must be bicycle-friendly and not catch wheels
- The slope of the roadway leading to the inlet must not be too severe, and
- The inlet and accompanying concrete box must not extend too far into the bicycle lane.

The Engineering Services Division is responsible for designing bicycle-friendly catch basin grates. This section addresses the design of storm water inlets.

Inlets in the curb face (type CG-3 grates), rather than street-surface grates (such as CG-1 &CG-2), are the preferred catch basin for streets with curb-tight bicycle lanes (see Figures XX-XX). CG-3 is a curb-opening inlet with no grate in the roadway. The maintenance access to the inlet is in the sidewalk corridor (typically in the furnishing zone) through a vault cover. CG-3 inlets are called for in the Contracts Database in the presence of a bicycle lane. On rare occasions, placing the inlet in the curb face has been precluded by utilities behind the curb.

There is some debate as to which inlet types are easier to maintain. CG-2 grates have long been considered easier to maintain. However, Bureau of Maintenance staff responsible for maintaining inlets states that there is not significant difference between a CG-1 and CG-2. One trade-off associated with clearing out these types of inlets is that a CG-2, because it includes a larger volume, often requires service by a large, and expensive piece of equipment to vacuum out any obstructions. A single crew who clears obstructions by hand can often maintain CG-1 inlets. For cyclists the discrepancy is significant as CG-2 inlets stick further out into a bicycle lane and almost ensure that cyclists will ride across the grate.
Depending on the slope of the roadway, depression may be needed to cause water to shift course. A gutter pan is often placed around the grate to provide a downward slope directing storm water into the inlet. The total depressed area includes the grate width plus three feet on both sides of the inlet along the curb.

Depression around inlets may be exaggerated following a pavement overlay. According to the Bike Master Plan, drainage grates should be raised to within one-quarter inch of the new paved surface. If this is not possible, the pavement must taper into the inlet. The City has recently performed some retrofits using a trial riser ring around the grate to eliminate abrupt edges. There is interest at PDOT in revisiting this pilot technique.

The Bicycle Master Plan calls for four-feet clear between a longitudinal joint and the bicycle lane stripe. While this is true for asphalt seams as well, it is particularly important for an asphalt-concrete joint, as is found when a concrete gutter pan is included in a roadway design. Because the two materials have different qualities, over time a pronounced “lip” will develop along that seam. This presents a potential crash hazard to cyclists.

Standard gutter pans are 18-inches wide. PDOT has addressed this in one of two ways: either using 12-inch gutter pans with five-foot bicycle lanes, or 5.5-foot bicycle lanes with 18-inch gutter pans. A third approach was employed by ODOT in their reconstruction of NE Sandy Boulevard between 102nd and 122nd avenues. Unable to construct a wider bicycle lane, and not willing to use a narrower gutter pan, ODOT instead extended the concrete gutter pan to the width of the bicycle lane. While this eliminated any type of longitudinal joint in the bicycle lane, it created a rougher ride. Cyclists feel every regular bump in the concrete caused by the seams created by how the concrete was poured. Nonetheless, this practice has promise for similar situations if the concrete can be poured and scored in a manner that does not create a bumpy ride. This practice is also worth pursuing because the wider concrete, contrasting with the darker asphalt, visually narrows the travel lanes, which is considered to have a slight traffic calming effect on automotive traffic.

Construction on Streets with Bike Lanes

On occasion, temporary advance construction signs to warn motorists of work zones are placed within the bike lane. Best practices, and the Bicycle Master Plan design and construction guidelines call for placing these signs either within the planter strip or half on street and half on the roadway and half on the sidewalk (if no planter strip is present). From the construction crew’s perspective, the bicycle lane offers the best place to locate these construction signs, as it doesn’t interfere with either the travel lane or on street parking, or the sidewalk corridor. In addition, it is difficult to stably balance a tripod supporting a sign partially on the street and partially on the sidewalk.

Where temporary motor vehicle detours are in place, it is dangerous to permit cyclists to bypass the construction zone, either along the curbside or the center of the roadway. Current practice is to close the street to the curb, so
crews do not have to work between traffic. If cyclists were allowed to pass a construction zone along the center of the roadway, they may encounter construction materials spilling over or machinery swinging out into the street.

Metal plates covering construction holes or depressions can create dangerous conditions for cyclists. A temporary asphalt lip is required around all steel plates on city roadways to serve as a ramp onto and off of the plate for bicycles. The Bicycle Design and Engineering Guidelines state that “plates may not have a vertical edge greater than one inch” to accommodate bicyclists.

In order to avoid having an asphalt seam in a bike lane where utility trenches are cut and later backfilled, it is now practice within the City to cut the entire width of the bicycle lane, even if the specific trenching needs do not require such a wide cut. While asphalt-to-asphalt seams are not necessarily as hazardous as asphalt to concrete seams, they still create a roadway condition that cyclists will attempt to avoid when riding. This tends to push cyclists toward one side of the bicycle lane or other and discourages cyclists from using the entire width of the bicycle lane, if necessary. Asphalt trenches and cuts are backfilled to be flush with the original pavement surface. Construction standards related to backfilling are contained within City of Portland Standard Construction Specifications and PDOT’s Moratorium Street Cut Replacement Guidelines.

Maintenance Practices Relevant to City Bikeways

The condition of the roadway surface is particularly important to those riding a bicycle, as debris, pot-holes or seams in the pavement can have a significant and negative effect on them. Inadequately maintained bicycle facilities can create hazardous conditions on the roadway and disrupt connectivity of the bikeway network.

As with the City’s construction practices, many guidelines related to bike facility maintenance contained in the Bicycle Master Plan have been incorporated, over time, into standard maintenance practices within the City. Some key maintenance issues that have surfaced with the implementation of the Bicycle Master Plan are presented below:

Street Sweeping

The Bureau of Maintenance implements the City’s Street Cleaning Program that is aimed at removing dirt and debris from City streets to protect water quality, prevent physical damage to pavements, and minimize the burden on the sewer system from surface debris.

The City of Portland cleans only streets with curbs. Due to the profile of the street and the fact that vehicle movement scatters debris to the edges of traffic lanes, most debris settles between the vehicle travel lane and curb. This also happens to be the area where bicycle lanes are positioned; thus reinforcing the importance of cleaning streets with bicycle lanes.

Currently, the general schedule for sweeping streets within the City is as follows:

- Residential streets are typically swept six to eight times per year. NW Portland is swept only 3 times per year because of the effort involved in removing parked cars.
• Arterials streets are cleaned every 15 to 20 working days
• Downtown streets are swept every ten working days. This includes all streets in the Central Business District plus streets in the “North Core”, which includes Old Town out to 14th Avenue. Street sweeping crews work in the downtown five days of the week.

In addition to streets, the Bureau of Maintenance also sweeps the roadways on most bridges within the city with the exception of the St. Johns Bridge, which is a state facility, and the Sellwood Bridge, which is weight restricted.

In addition to routine maintenance, the City has a program to respond to incidental requests for small-scale, low-cost maintenance, such as spot sweeping, repairing potholes, and replacing unsafe grates. Requests are received in a number of ways:

• Via an on-line maintenance request form from PDOT’s web site
• By phone calls to one of several numbers, including the bicycle “hot-line”, the Maintenance Bureau’s 24-hour line, the Maintenance Bureau’s pothole line, and
• By email directly to city staff.

If a sweeping crew is scheduled to be near the area of a sweeping request, BOM will redirect them to clean the site generally on same day or evening in which the request is received.1 If there is no crew in the general proximity of the site, a supervisor will often make a site visit. If the debris can be swept by hand, it will be moved to curb until the sweeping crew can sweep it up. This practice also reduces wasted effort, since it can take a good deal of time for a sweeping crew, with its large, slow-moving street sweeper, to reach a destination for spot sweeping. Occasionally, once they reach the site there is no debris to be found. Some locations are regular problem areas, and it would be inefficient to revisit the site on a daily basis.

Gravel Cleanup Following Storm Events

During a snow or ice event, more than 60 city trucks are used to broadcast gravel onto city streets. The Bureau of Maintenance follows a map of primary and secondary routes to prioritize streets for gravel crews to visit.

Following the event, gravel left in the roadway can present serious hazards for cyclists, particularly for those riding in the bicycle lanes where gravel tends to accumulate. Clean-up crews are sent out to recover the gravel

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1 Most of the city sweeping crews operate at night.
from the roadways. In contrast to the 60 plus broadcast vehicles, there are only a maximum of six to eight sweepers in operation to recover the gravel. These sweepers operate in three recovery convoys, comprised of: a flusher to spread water on the roadway, a mechanical sweeper (big brush sweeper: Elgin), and then a vacuum sweeper (air machine: Tymco). Each convoy is accompanied by two dump trucks to haul away the swept gravel.

Often, gravel recovery requires multiple passes by the crew for each roadway, depending on the length of the snow event, temperatures, etc. In addition, automobile tires will pick up and carry gravel for days, with gravel slowly falling back to the roadway; thus requiring subsequent sweeping passes. Up to ninety percent of the gravel placed on the roadway is recovered. Following a snow event in January, 2007, maintenance recovered roughly 3,500 cubic yards of gravel.

Recognizing the disproportionate impact gravel has on cyclists, BOM prioritizes gravel recovery on streets with bicycle lanes. Recovery first focuses on arterial streets with bicycle lanes within four miles of the Burnside Bridge and then targets arterials with bicycle lanes outside that radius. This strategy is based on the assumption that because bicycle use is more concentrated in the Central City, focusing first on those facilities benefits the greatest number of cyclists the soonest.

### Pavement Overlays and Substandard Drainage Grates

As time allows, maintenance crews patrol the city identifying substandard inlets, focusing primarily on roadways with bicycle lanes. They are primarily looking for “tire-catching” inlets with openings parallel to the direction of travel. After years of practice retrofitting such grates with straps so that bicycle tires cannot fall into them, PDOT believes few, if any such grates remain in bicycle lanes in the city.

As previously mentioned, the entire inlet sinks below the surface of the roadway following a pavement overlay project, which typically adds two inches of asphalt to the existing roadway surface. Prior to development of an inlet “riser ring”, raising grates to grade was very labor-intensive and costly. The inlet would have to be substantially rebuilt, requiring that the Bureau of Maintenance first bust out the catch basin and replace the entire unit. A riser ring—which can be placed on top of the existing concrete box and under the grate itself—has proven to be a substantially less costly but still effective alternative. However, given the dimensions of the ring, an overlay must add two inches of asphalt to the roadway for the ring to be effectively used. Although overlays are typically two inches of pavement, the space above the grate may be less due to grinding or catch basin configuration.

Based on bicycle considerations, prioritization for substandard grate replacement first addresses streets with bike lanes (particularly with CG 2 type grates), then other arterial streets without bike lanes, and finally local streets.

The Bureau of Maintenance does not have a preferred type of drainage grate for certain classifications of streets. An appropriate grate is selected based on site-specific conditions. As described earlier, CG-3 type grates are a curb-opening inlet with no grate in the roadway. The maintenance access to the inlet is in the sidewalk corridor (typically in the furnishing zone) through a vault cover. CG-3 inlets are called for in the contracts database in the
presence of a bicycle lane. However, since catch basins are often situated near corners, ADA access and vault cover stability issues may preclude this option.

According to Maintenance Bureau staff, there is not significant difference in the maintenance needs of the two common “street surface” type grates, i.e. CG-1 and CG-2. One trade-off associated with clearing out these types of inlets is that a CG-2, because it includes a larger volume, often requires service by a larger and more expensive piece of equipment to vacuum out any obstructions. A single crew who clears obstructions by hand can often maintain CG-1 inlets.

**Transition to Thermoplastic Striping**

The City is currently in the process of completely switching over from paint striping to thermoplastic on city roadways. This transition has occurred over the past three years, and it is estimated that the entire city will be converted to thermoplastic within another three years. To date, over one-third of city streets have been striped with thermoplastic.

Because they last so much longer, there is a significant benefit to cyclists with thermoplastic striping. Striping applied with the former standard roadway-grade paint, had to be applied two to three times per year. Typically, bicycle lane stripes would disappear sometime between the time of the last striping in the fall before the rains begin, and the first striping of the spring, once the rains have reliably stopped. This created uncomfortable situations for cyclists as streets striped with bicycle lanes for nine months of the year would generally be lacking striping between January and April.

The equipment needed to perform thermoplastic striping is relatively expensive. However, the lifespan of thermoplastic (three to five years) is considerably longer than paint, which typically wears away after the first winter. The durability of the thermoplastic depends greatly on how clean the surface was, and the weather conditions on the day it is applied.

Thermoplastic is applied in two ways: a long-line striper is used for roadway travel lane striping; crosswalk stripes and back lines on bicycle lanes are applied with a pushcart applicator. Back lines, which visually separate the bike lane from on-street parking, are applied by hand to avoid painting the tires of parked cars. Subsequent applications of all existing thermoplastic striping are applied as a thinner layer to reduce lines building up in height.

Since the conversion to thermoplastic began, there have been no major issues reported by cyclists concerning lack of traction or stripe build up. Cyclists may benefit from a two-foot break in crosswalk line to eliminate a potential bump. This practice could be considered in future applications of crosswalk stripes.

**Roadside Maintenance**

In addition to cleaning roadways, the Bureau of Maintenance also maintains some areas adjacent to the street as part of its Roadside Maintenance Program. The City’s Roadside Maintenance Program is responsible for managing vegetation in ditches, storm water facilities, off-street bike paths, pedestrian areas, and rights-of-way.
Managing vegetation along our roadways increases public safety and enhances the natural environment by:

- Eliminating sight distance problems and providing areas for pedestrian and bicycle traffic, as well as safe pull-off areas for motorists;
- Ensuring an appropriate flow in the open storm water system, erosion control, restoration of disturbed areas after maintenance activities, improves water quality, management of noxious weeds, and provides habitat for birds and butterflies; and

Roadside maintenance is managed with a full complement of methods: mechanical (tractor mowing), cultural (hydroseeding and planting appropriately), biological, and chemical (such as spraying invasive plants to slow growth and allow for cutting before problems arise).

BOM is aware of common problem areas for bicycles, i.e., those areas where weeds and shrubs overgrow and intrude into the bicycle lane during periods of peak growth. The Roadside Maintenance Program intends to address some of the more problematic areas with a three-pronged approach:

- Spray early to retard growth
- Spray late to kill growth
- Mechanically cut as necessary.

Pavement Overlay Practices

An overlay refers to laying a new asphalt layer on a roadway stretching from the curb to curb across the street. In the past, overlays had been the Portland Office of Transportation’s standard procedure for replacing worn pavement. This process typically required initial grinding and profiling of the roadway to be overlaid. “Grinding” and “profiling” refers to the practice by which the existing layer of asphalt is ground down in order to provide enough room for the new asphalt layer below the existing curb and so as to not create a roadway that had too high of a “crown” in the center of the road. A single machine has the capacity to pave an 11-foot travel lane and 5-foot bike lane in one pass.

Grinding and profiling can occur several months in advance of the overlay since it is not weather-dependent and also because it takes significantly longer to grind and profile than it does to lay down the new asphalt. As a result, roadways scheduled for overlays could be in poor cycling conditions for some time in advance of the actual overlay.

The current practice is to no longer to perform a “curb to curb” overlay but to simply replace the worn asphalt just in the area of wear—typically only the travel lane. This process, referred to as a “plug”, does not require significant grinding and profiling in advance as neither the roadway crown nor the area near the curb is affected. To perform a plug, the Maintenance Bureau grinds the top two inches in a travel lane and replaces it with two inches of pavement, typically on the same day.

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1 Some of the more notorious areas include: Terwilliger, Capitol Highway east of Hillsdale, Interstate Avenue climbing the hill to North Portland.
This new practice of performing a “plug” rather than an “overlay” generally does not affect the bicycle lane as the work ends at the outside stripe of the bicycle lane. However, a transition/joint may be created when the travel lane is ground down and the roadway is repaved.

There is a potentially significant issue with this new practice. Overlays provide a “blank slate” on the roadway in terms of striping, and offer the opportunity to efficiently and cost-effectively restripe a roadway with bicycle lanes. Plugs, because they are working on one travel lane at a time, and operate between the lane striping, may no longer allow for this relatively inexpensive reconfiguring of City Bikeways to provide bicycle lanes.

If the Bureau of Maintenance has to cut into the bike lane, standard practice is to replace the entire lane to the curb. This eliminates the need to mitigate for a longitudinal seam within the bike lane with techniques such as “feathering” the new asphalt by working it into existing asphalt by decreasing the thickness of the new asphalt over a certain distance until it blends into the existing layer.

For newly paved shoulders, the Bike Master Plan guidelines recommend a “saw cut” joint to avoid ragged joints at the edge of the existing pavement or “feathering” a fine mix of new asphalt onto the existing pavement.

**Surfacing Roadways with Chip Seal**

Chip seal is a roadway surfacing material that is less expensive than, but also considered inferior to asphalt. Chip seal has a shorter life expectancy than asphalt, it does not hold up as well to heavy traffic, it tends to ravel (i.e., small pieces continually break off) and produce dust, and thermoplastic striping does not adhere well to it.

For cyclists, chip seals leave a rough riding surface, varied textures, and ragged edges in the shoulder. This surface can also be painful to fall on if a crash occurs. If chip seal is used it must be capped with slurry to mitigate for the rough surface. Currently, the City does not use chip seal to surface its roadways; however, it is commonplace in a number of neighboring jurisdictions.
Design Treatments

Appendix A of the 1996 Bicycle Master Plan serves as the design guide for developing Portland’s Bikeways. With few exceptions these designs require little further elucidation. However, during the past 15 years—and often on a project-specific basis—Portland has identified situations not readily addressed by standard designs. The following pages define and describe a number of bikeway designs that were either not explicitly addressed in the design guide, or that have particular relevance for future conditions for the bikeway network. These designs include:

- Bicycle Activated Signals
- HAWK Signals
- Pedestrian Half Signals
- Scramble Signals
- Bicycle Boxes
- Crossing Treatments
- Traffic Diversion
- Bicycle Lanes
- Blue Bicycle Lanes
- Shared Lane Pavement Markings
- Hawthorne Bridge Pathway Markings
- Bikeway Signing and Markings

INSERT DESIGN SHEETS
BIKEWAY DESIGN TREATMENTS

CHAPTER 9

BICYCLE-ACTIVATED SIGNALS

A bicycle-activated signals detect the presence of cyclists at a signalized crossing and provide adequate intervals in the traffic stream where they can cross safely.

The city of Portland uses inductive signal loop detectors (metal sensitive wires in the road) to detect traffic at most traffic-actuated signals. Sensors may be set so bicycles trigger the signal when they pass over the inductive loop. Fully-actuated signals have detection on the approaches from all directions; while semi-actuated signals have only detection on the side street or left-turn lane.

These loops are commonly placed in circular loops. There are a few locations where the loop is in the shape of a fifty-foot rectangle with wires also in the middle of the rectangle. These are called quadrupole loops and are usually placed in left turn pockets. For economical reasons, when a quadrupole loop is replaced, the City prefers to install four circle loops placed twelve feet center to center to achieve the same detection area.

Some detection loops which have been tuned to detect bicycles are marked with a thermoplastic bike symbol to position cyclists where detection is most consistent. Loops that have lost there sensitivity are replaced as time and budget permit.

The signal is triggered only as long as the bicycle is positioned over the loop detector. If a cyclists moves away from the detector, the call for a green light will be discarded. Even once a signal has been triggered, the length of the signal cycle may be very long requiring cyclists to maintain their position over the loop detector.

### Detector Pavement Marking

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<th>Purposes</th>
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<tr>
<td>• Allow cyclists to trigger a traffic signal</td>
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<td>• Provide adequate time for bicycle crossing</td>
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<th>Issues</th>
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<tr>
<td>• Loop detectors should be set to detect bicycles</td>
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<tr>
<td>• Sensitivity of detector loops may degrade over time</td>
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<td>• Cyclists may not know the proper placement to get a green light</td>
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![Various Loop Detector Configurations](https://www.bikeplan.com/signal.html)
**HAWK SIGNAL**

A High-intensity Activated Walk (HAWK) signal is intended to stop vehicles on a major street at an intersection with a minor street and provide a safe and comfortable crossing for cyclists (and pedestrians). The HAWK is a type of half signal, where there are main street signals and side street stop signs and pedestrian/cyclist push buttons to activate the signal. Pedestrians and cyclists are not required to use the HAWK signal to cross. It is simply there for their convenience when needed.

The HAWK signal is designed to get the attention of motorists on the arterial street and remains dark, or “off”, until activated. The beacon signal has a triangular arrangement with two red lights over a yellow light. Cyclists and pedestrians have their own signal heads with bicycle-shaped red, green and amber signals, and standard pedestrian shapes, respectively.

Once a cyclist (or pedestrian) pushes the call button, the vehicle signal begins flashing a yellow light; then a solid yellow is given, followed by a solid red light. Shortly following the vehicle “red” indication, cyclists and pedestrians are allowed to cross.

During the pedestrians “don’t walk” indication, the bike and motorist signals change to a flashing red. This allows motorist to proceed with caution once the crosswalk is clear before the light switches back to dark mode.

**Portland Experimentation with a HAWK signal**

There is one HAWK signal installed in the City of Portland at the intersection of East Burnside and 41st Avenue. At the intersection with 41st, Burnside a major east-west arterial crosses an important north-south bikeway. The City is experimenting with the HAWK signal as a way of providing breaks in arterial traffic for safe bicycle and pedestrian crossing.

Seemingly, the advantage of the HAWK signal over the standard pedestrian “half signal” is that it rests in dark mode. The concern with the standard half signal is that motorists,
having only seen a green indication, may no longer pay attention to signal changes. The activation of the HAWK signal from dark to flashing yellow is intended to provide additional warning for motorists at a signal with infrequent display changes.

The concern with the HAWK signal is that there may be confusion during the dark beacon signal, which might be interpreted as a power outage, as well as the flashing red signal, where vehicles may remain stopped once it safe to proceed.

The City will collect and evaluate data on signal compliance and crashes at the intersection. Because of their high cost they are used only when other civil treatments, such as curb extensions and refuge islands, cannot be made to work.
BIKEWAY DESIGN TREATMENTS

CHAPTER 9

PEDESTRIAN HALF-SIGNALS

At unsignalized intersections on arterials with high traffic volumes and speeds, pedestrians and cyclists wishing to cross may have difficulty finding adequate gaps between motor vehicles. Moreover, many bikeways are designated on lower volume neighborhood streets leading to an unsignalized crossing of a major arterial. Many of these low volume streets do not meet current traffic signal warrants. Installing a full signal at this type of intersection may create excessive delays and safety issues to the arterial street or may attract excessive traffic to the low volume neighborhood street.

A pedestrian half-signal allows pedestrians and cyclists to cross a major street with a standard pedestrian signal where it intersects with a stop-controlled minor street. It is called a “half-signal” because only the major street has a traffic signal while the minor street has only stop signs. Pedestrian movements across the arterial are controlled by traditional “walk/don’t walk” signals.

This tool is most effective where the number of pedestrians and bicyclists crossing is high, but motor vehicle traffic on the minor street is low.

This type of signal has not been allowed for use by the Federal Highway Administration (FHWA) since the late 1980’s. A significant concern is that the major street signal rests in green until interrupted by a pedestrian or cyclist seeking to cross. If pedestrians don’t regularly press the buttons to activate the signal, motorists on the major street become accustomed to seeing only a green indication. As a result drivers may, over time, ignore the signal.

Other concerns caused by the mixed traffic control messages are that the side street traffic may be confused when arterial traffic stops, or major street motorists may be surprised when side street vehicles pull out into the intersection while the major street signal is green.

The City of Portland has 48 legacy pedestrian half-signal intersections (with the last one installed in 1985) located throughout the City. These signals serve an important function of creating gaps for safe pedestrian and bicycle crossing. Given Portland’s common short block spacing (typically 200 by 200 foot blocks); it is difficult to simply move crosswalks to a mid-block point away from the intersection. The City is currently experimenting with a High-intensity Activated WalK (HAWK) signal at East Burnside and 41st Avenue as an alternative to the standard pedestrian half signal.

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<tr>
<td>• Provide a controlled pedestrian and bicycle crossing at intersections where a full signal is not warranted.</td>
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<th>Issues</th>
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<tr>
<td>• Minor street traffic crossing with pedestrians/cyclists may not know when major street signal is about to change.</td>
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<tr>
<td>• Minor street drivers may be tempted to activate the pedestrian push button.</td>
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<td>• Major street traffic may become accustomed to having a green light at the intersection causing them to miss future red indications.</td>
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BIKEWAY DESIGN TREATMENTS

 CHAPTER 9

Signal Heads on Major Approaches

Stop Sign on Minor Approach

Intersection Pedestrian Signal (Half Signal)

Source: Transportation Research Board
SCRAMBLE SIGNAL

A “scramble” signal, once activated, stops all automotive movements at an intersection and allows pedestrians, cyclists and others to move in any direction through the intersections.

In April 2004, Portland installed its first bicycle scramble signal (along with accompanying signs and markings) at the intersection of Interstate Avenue and Oregon Street near the east end of the Steel Bridge. The signal features red, yellow and green lights illuminated in the shape of a bicycle.

This scramble signal was designed to both ease and make safer cyclists’ transition from the Eastbank Esplanade, a popular multi-use trail on the eastside of the Willamette River, to the on-street bicycle lanes. Prior to installation of the signal, cyclists wishing to travel north along N. Interstate Avenue were often frustrated by having to perform a “two-phase” crossing (first west, then north).

Cyclists activate the scramble signal by positioning themselves over a “bike loop” marking on the sidewalk. Once triggered, the scramble signal stops all automotive movement through the intersection of N. Interstate, Oregon and Lloyd, and allows cyclists exiting the Eastbank Esplanade to diagonally cross the intersection and access the north-bound bicycle lane on N. Interstate Avenue. Motorists turning right onto Lloyd Boulevard from the Steel Bridge are not allowed to proceed while their signal is red.

An evaluation of data collected before and after implementation found that prior to installation of the scramble signal, approximately 33% of northbound cyclists crossed the intersection illegally. After installation, those crossing illegally dropped to 5% of northbound cyclists.
BIKEWAY DESIGN TREATMENTS

CHAPTER 9

Traffic Light – No Right Turn on Red

Bicycle Signal – Green Phase
BICYCLE BOXES

At a signalized intersection, a bicycle box can be installed to place cyclists in front of queuing motor vehicles and enable them to more easily clear the intersection during the signal cycle. Bicycle boxes require motorists to stop in advance of the crosswalk and allow cyclists to wait in the area (or reservoir) between the cars and the crosswalk. Placing bicycles in front makes them more visible to motorists and allows them to get through busy intersections before the signal turns red.

Bicycle boxes are most useful at intersections with high volumes of automobile and bicycle traffic and where turning conflicts exist. Sites can be evaluated for bicycle boxes based on the frequency of bikes queuing and the rate of left turning movements. Bicycle boxes may be problematic at intersections with high volumes of right-turning traffic.

Clinton Street Bicycle Box
Portland’s only intersection with bicycle boxes (on Clinton Street east and west of 39th Avenue) was put in place in 1999 as part of the development of the Clinton-Woodward Bikeway. Bicycle boxes were installed on Clinton Street because of the relatively short length of the green signal; if cyclists waited in the queue with motorists, they would often miss the signal. The bicycle box allows cyclists to go through first on the green, which is consistent with giving cyclists priority on bicycle boulevards.

Bicycle Box Design
The bicycle box reservoir stretches across the full-width of the travel lane enabling left-turning cyclists to position themselves in the far left side of the lane. The depth of the Clinton Street boxes from the crosswalk to the vehicle stop line is 14 feet (or 4.3 meters). Recommended dimensions for a bicycle box are typically between 4 and 5 meters; however, some places offer cyclists much more space (such as Muenster, Germany which provides 10 meters).
A bicycle symbol is placed in the center of the Clinton Street bike boxes to clearly assign the space to cyclists. In some cities a distinct surface color is also applied to the cycle reservoir to discourage encroachment by motorists. For maintenance purposes, the use of thermoplastic is preferred over faster wearing paint.

A bicycle lane segment on Clinton Street provides a dedicated approach path leading to 39th Ave. for cyclists to pass queuing vehicles along the far-right side of the roadway. Another feature accompanying bike boxes in some other cities is a separate “head start” signal to give cyclists an earlier green light than motorists traveling in the same direction.

**Evaluation**
In 2004, a review was performed on the Clinton Street bike box to evaluate its performance for cyclists traveling eastbound on the bikeway. During the three-hour study, 109 cyclists and 408 motorists crossed the intersection. Of these, 97% of cyclists used the bike box and 16% of motorists encroached upon the designated bicycle area.
BIKEWAY DESIGN TREATMENTS

SAFE CROSSING TREATMENTS

Curb extensions, refuge islands and bicycle center turn lanes are essentially safety improvements to assist bicycles to cross a busy street. These tools may also calm (or slow) traffic, but their primary intent is to reduce exposure, in terms of the time and distance in which a pedestrian or cyclist must share a common space with auto traffic. Traffic signals also assist cyclists at crossings; however, they are addressed as part of a separate information sheet.

With the exception of devices aimed primarily at slowing traffic, such as speed bumps and street signs, treatments to improve pedestrian and bicycle safety are among the most widely used traffic calming devices. Curb extensions and refuge islands can be found throughout the Portland area.

**Curb extensions** are short sections of roadside curb at signalized and non-signalized crossings that have been constructed closer to the centerline of the street, replacing the existing curb. Curb extension are generally placed on streets with heavy traffic and on-street parking.

Curb extensions reduce the distance a pedestrian or cyclist must cross at street level allowing them to pass between shorter gaps in vehicle traffic. In addition, motorist’s visibility of pedestrian and cyclist is increased by moving the curb out closer to the travel lane.

Curb extension have been installed in Portland at signalized and unsignalized, typically as part of a street improvement or a traffic calming project. This treatment is considered at locations where there is more than a one minute wait between gaps in traffic during peak hours or where pedestrians must cross multiple lanes.

On streets with a centerline stripe, cyclists may be forced to veer out into traffic, or motor vehicles will “squeeze” bicyclists as they pass the curb extension. Bicycle Master Plan design guidelines recommend that curb extension be placed such that a 12 to 14 foot outside lane is left at intersections without a bicycle lanes.

<table>
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<tr>
<th>Purpose</th>
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<tbody>
<tr>
<td>Reduce the time and distance required to cross a busy street</td>
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<tr>
<td>Enhance visibility between motorists, pedestrians and cyclists</td>
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<tr>
<td>Encourage pedestrians to cross at designated locations</td>
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<tr>
<td>Visually prompts motorists to slow down</td>
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<tr>
<th>Issues</th>
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<tbody>
<tr>
<td>Must be wide enough to protect cyclists from the travel lanes</td>
</tr>
<tr>
<td>Any landscaping should not compromise the visibility of the crossings</td>
</tr>
<tr>
<td>May impact available parking and larger vehicle turning needs</td>
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</table>
Refuge islands are short medians of full-height curb constructed between the travel lanes. These islands reduce pedestrian and cyclist exposure during crossing by shortening crossing distance and increasing the number of available gaps for crossing. Islands may be installed at intersections or mid-block locations.

Crossing islands allow pedestrians and cyclists to cross a single direction of traffic and pause before continuing across the street. This is particularly beneficial where there are insufficient gaps in the two directions of traffic.

Refuge islands can be found throughout Portland at unsignalized pedestrian and bicycle crossings. As with curb extensions, islands are most commonly installed in Portland as part of a street improvement or a traffic calming project. Preferred locations in Portland are where there is more than a two minute wait between gaps in traffic during peak hours or where pedestrians must cross multiple lanes.

It is important that refuge islands are designed such that they do not squeeze through bicycle movements on the major street. For cyclists crossing the major street, islands should be wide enough so it allows a bicyclist with a trailer to be protected from the travel lanes (i.e. between 8 to 10 feet).

Bicycle-Only Center Turn Lanes provide a refuge for cyclists on bikeways that traverse an off-set intersection. This treatment allows cyclists to cross one direction of traffic at a time while maintaining all vehicle turning movements.

This treatment has been implemented at one location within the City of Portland. The north-south “40’s Bikeway” that runs along SE 41st Avenue is off-set by 35 meters (115 feet) as it crosses SE Stark Street, a minor arterial street. North and south approaches to this intersection along the bikeway are stopped with stop signs.

The City installed a two-way, 10-foot center lane exclusively for cyclists to execute first a right-turn onto Stark and then a left-turn back onto the
bikeway. The only effective alternative would have been a median refuge, which would have prohibited some turning movements from SE Stark to 41st.

The center turn lanes on SE Stark successfully address three issues: the offer 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 served as an inexpensive alternative to conventional civil treatments.
BIKEWAY DESIGN TREATMENTS

CHAPTER 9

TRAFFIC DIVERTERS

Traffic diversion is an auto volume management tool where physical barriers (i.e. diverters) are installed to intentionally direct motor vehicles off a particular street. The intent of traffic diversion is to reduce traffic volumes on a neighborhood street and move non-local traffic onto nearby arterial streets.

Although traffic diverters are effective at reducing automobile volumes, they are primarily used as a tool of last resort and are prohibited on streets classified higher than “local service”. The main concern with diversion is its effect on connectivity, such as significantly increasing the length of vehicle trips, adding time to emergency response, eliminating potential bypass routes, and shifting excessive traffic onto other local service streets. Since diversionary measures are generally permanent physical barriers, they must be appropriate at all hours of the day and night.

The following issues must be addressed when designing any form of traffic diversion:

- How will diversionary measures effect connectivity in the area?
- Will emergency vehicles have access and or experience delays?
- What Impact will diversion have on transit services?
- Is the facility designed to accommodate pedestrian and bicycle passage?
- How much traffic will be diverted to other local service streets?

A variety of diversionary devices may be used to reduce the number of automobiles and the associated noise, pollution, and likelihood of collisions on a street. Traffic diverters found in Portland include the following:

**Semi-diverters**, also referred to as partial- or directional-closures, block only one travel lane to prevent drivers from entering or exiting certain legs of an intersection. Semi-diverters eliminate movement in one travel direction; however, they can be designed to accommodate bicycle, pedestrian, emergency or transit access.

Semi-diverters are typically placed on minor streets at an intersection with a major street. Adequate alternative entry points into the

<table>
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<th>Purpose</th>
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<tr>
<td>Reduce the volume of motor vehicles</td>
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<td>Create a safer and more attractive environment for cyclists and pedestrians</td>
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<th>Issues</th>
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<tr>
<td>Delays to emergency vehicles, transit services</td>
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<tr>
<td>Diverted traffic may move to other local street</td>
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<tr>
<td>The effect on street connectivity</td>
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<tr>
<td>Maintaining pedestrian and bicycle access</td>
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<td>Must be appropriate during all 24 hours</td>
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neighborhood and parallel routes are necessary to ensure connectivity for drivers.

Semi-diverters can be designed to incorporate safe bypass for pedestrians, cyclists and people in wheelchairs. In addition, the facility can integrate stormwater management and landscaping functions.

Semi-diverters are the most common type of diverter used in the City and can be found at 17 different locations Portland sites: SW Boones Ferry at Taylors Ferry Rd, SW Virginia at Taylors Ferry, Clinton at SE 39th (east and west sides), Lincoln at SE 39th (east and west sides), Klickitat & 35th, Weidler and 24th, Arthur and 2nd, NE 18th and Failing, NE 18th and Shaver, NE 17th and Mason, NE 17th and Shaver, SE Ankeny and SE 32nd, NE Jessup and Williams, Tillamook and 39th, Willamette Blvd and Rose Parks.

Diagonal diverters are a barrier placed across a four-way intersection from one corner to the opposite corner. This tool prevents through movements, and motorists are only allowed to turn in one direction. Although through traffic is eliminated, a diagonal diverter does not totally prohibit vehicle passage as would a cul-de-sac. Diagonal diverters significantly reduce conflicts between pedestrians, bikes and motor vehicles and provide a substantial area in the roadway for landscaping or stormwater management.

A diagonally diverter can be designed to permit bicycle and pedestrian passage, as demonstrated at the intersection of NE Tillamook and 16th Avenue. Pavement markings, showing a bicycle and directional arrow, have also been installed at the Tillamook diverter to direct bicyclists through the appropriate curb-cuts.

In order to ensure that traffic problems are not shifted to another residential street, it is important that traffic is diverted (by clustering diverters if necessary) as directly as possible onto a nearby busy street. Adequate signage must be installed to alter motorist of the traffic device, and posted speed must reflect the turning radius if there are no stop signs.

Diagonal diverters can only be found at two locations in Portland, i.e. Houghton Place at Hamlin Ave and NE Tillamook at 16th Ave.

Median barriers are a concrete curb or narrow island that is located on the centerline of a major street across an intersection with a side street. Median barriers prevent through movements on the side street and left turns on some or all streets.
Median barriers can be designed with curb cuts or ramps to allow safe bicycle crossing (as on Ankeny and SE 20th). In addition, they can provide a safe refuge for pedestrians and cyclists from automobiles traveling along the major street. A median refuge is particularly beneficial on multi-lane streets, as on Broadway at NE 30th, so one direction of traffic can be crossed at a time. The median must be wide enough to fully protect the pedestrian or cyclist from the traffic.

If median barriers reduce the width of the travel lane, accommodations may be necessary to ensure bicyclists traveling along the major street are not squeezed out by motor vehicles.

There are four median barriers located within the City, including SE Ladd at Clay, SE 20th at Harrison Street, SE 20th at Ankeny Street, and Broadway and 30th.

**Full-Street Closure or Cul-de-sacs** are barriers extending the entire width of the roadway to close off one end of the street. This treatment is most commonly used on the edge of a neighborhood to eliminate all through traffic on the residential street by completely removing access to the roadway.

Cul-de-sacs can be designed to provide bicycle and pedestrian access to the street through curb cuts and ramps. Another effect of installing a cul-de-sac is that pedestrians no longer have to cross the street once it’s closed.

In general, full-street closures have the most severe impact on emergency vehicle and transit access. While it is possible to design a facility with emergency vehicle passage, these measures might be hindered by inappropriately parked cars.

It is important to clearly warning, such as “no outlet” or “dead end” signs, for motorist of the street closure. Large vehicles may have difficulty turning around once they reach a cul-de-sac.

In Portland, cul-de-Sacs can be found at 11 locations, including NE 32nd at Schuyler, NE 17th at Thompson, NE 28th at Weidler, NE 28th at Halsey, NE 28th at Clackamas, NE 28th at...
Wasco, NE 36th and Brazee, Brookside and 117th, NW Wilson and 29th, NE 14th and Killingsworth, NE 14th and Alberta.

**Forced turn diverter** are raised islands designed to prevent traffic approaching an intersection from making certain movements. This tool deters traffic from cutting-through on a side street by forcing motorist to turn onto a major street.

Forced turn diverters can be designed to incorporate safe bypass for bicycles and wheelchairs and pedestrians benefit from the reduced crossing distance on the side street. While motor vehicles are forced to turn, bicycles should be permitted to maintain a through traffic position.

Reducing the conflicts between motorists at the intersection may result in drivers speeding through the crosswalk area and right-turning vehicles may fail to look for pedestrians crossing on their right.

Forced turn diverters are installed at three locations, including SE Harold and Foster, NE 28th and Schuyler, and Belmont and 25th.
BIKEWAY DESIGN TREATMENTS

CHAPTER 9

BICYCLE LANES

Bicycle lanes, the most common bikeway facility on Portland’s streets, is a portion of the roadway designated by striping and pavement markings for exclusive or preferential use by bicyclists in urban areas. Bicycle lanes are one-way facilities that carry bicycle traffic in the same direction as adjacent motor vehicle traffic and are the preferred facility for urban arterial and collector streets.

Bicycle lanes provide significant benefits to all transportation users. They define a space in which to ride, eliminating the need to weave in and out of traffic or parked cars. They increase the visibility of cyclists and help novice riders feel more confident. Bicycle lanes also help motorists predict where to expect cyclists.

Bicycle Lane Variations

Blue bike lanes, and the accompanying street signs, are used to alert motorists and cyclists at high conflict areas and to assign right-of-way to cyclists. Motorists are required to yield to cyclists in these areas.

A shoulder bikeway is a street upon which the paved shoulder, separated by a four-inch stripe and no bicycle lane markings, is usable by bicycles. Although the shoulder can be used by bicycles, auto parking is also permitted.

Implementing Bicycle Lanes

Bicycle lanes may be implemented through stand-alone bikeway projects, through reconstruction or construction of roadways, and through routine resurfacing of roadways when the street configuration can be modified without parking removal or serious additional congestion.

On some streets where bicycle lanes are the preferred treatment, conditions preclude the installations of the lanes. These conditions include: 1) harm to the natural environment or character of the natural environment due to additional pavement; 2) severe topographical constraints; 3) economic or aesthetic necessity of retaining on-street parking; and 4) crippling levels of traffic congestion that would result from eliminating travel lanes or reducing lane widths. Only if after careful investigations bicycle lanes are proven unfeasible, then traffic calming improvements, a wider outside lane, or alternative parallel bikeways may be substituted.
Bicycle Lanes in Portland

Bike lanes are the preferred treatment for city bikeways on streets with more than 3,000 vehicles per day. As of February 2007, 167.3 miles of bike lanes have been installed on streets across the City. Roughly 41% of the total planned bike lanes within the City have been marked or are already funded. Of all existing bike lanes, 13% are in the Central City, 15% are in North Portland, 14% are in Inner Northeast, 12% are in Southeast, 26% are in Outer East, 6% are in Northwest, and 14% are in Southwest.

Portland “Bike Guys” – bike lane stencil art

Blue Bike Lane Markings and Sign
BLUE BIKE LANES

Blue bike lanes, and the accompanying street signs, are intended to alert motorists and cyclists at high conflict areas and to clearly assign right-of-way to cyclists. As with all bike lanes, motorists are required to yield to cyclists in these areas.

Standards governing the use of traffic control markings contained in the Manual on Uniform Traffic Control Devices (MUTCD) do not provide for the use of colored markings to delineate bike lanes or conflict areas. The City of Portland is testing the use of colors in bike lane conflict areas through a partnership with the University of North Carolina Highway Safety Research Center and the Federal Highway Administration. The color blue was selected based on several factors including conflicting meaning for other colors, color blindness, public support, and evidence from other cities.

In 1998, the City painted blue ten short bicycle lane segments where cars and bikes weave. The ten trial locations listed below were selected to test blue lanes in four different conflict situations (i.e. right-turn lane, entrance ramp, exit ramp and through-right turn):

- Hawthorne Bridge, east end (eastbound)
- S.E. Madison, Sixth to Grand (westbound)
- Broadway Bridge, east end (eastbound)
- East end of the Broadway Bridge (westbound)
- NE Weidler, at Victoria (eastbound)
- NE Broadway, at Williams (westbound)
- Beaverton-Hillsdale Hwy, at Bertha (eastbound)
- SE 7th, at Morrison (southbound)
- SW Terwilliger, at I-5 on ramp (northbound)
- SW Multnomah, at Garden Home (eastbound)

A detailed study of the blue bike lanes was conducted using a video footage from each site both before and after the blue application. In addition, staff conducted a field survey of cyclists and a mail survey for motorists. Key results from this study included the following:

- More drivers yielded to cyclists than before
- More drivers slowed or stopped when approaching than before
- More cyclists followed the recommended path than before
- Fewer cyclists performed a “head check” to look for vehicle traffic
- Nearly 50% of motorists surveyed felt the area was safer
- More than 75% of cyclists felt the locations were safer

Most locations have performed well, although bike-automobile crashes have continued to occur at North Broadway and Williams. Since the original ten installations, the Bureau of Maintenance switched from paint (which wore out completely at all locations following the first winter) to thermoplastic, which lasts several years. The Portland Office of Transportation (PDOT) has recently decided to expand the use of blue bike lanes to other similar intersections.
Before and After: Hawthorne Bridge (east end)
BIKEWAY DESIGN TREATMENTS

CHAPTER 9

SHARED LANE MARKINGS

Shared lane pavement markings, or “sharrows”, are markings used to indicate a shared lane environment for bicycles and automobiles. Sharrows are placed on streets that according to City policies should be striped with bicycle lanes; however, due to either narrow right-of-way, demand for multiple travel lanes, and/or on-street parking, bike lanes are not feasible. This technique is considered a last resort for creating acceptable operating conditions in the absence of bike lanes.

Problems occur when a roadway narrows and bicycle lanes end abruptly, and as a result, cyclists may ride too closely to parked cars (i.e., within the “door zone”), or motorists may pass cyclists too closely.

Sharrows are intended to direct cyclists to better position themselves on the roadway. The message for cyclists is to "take the lane," i.e., to move away from parked cars and ride through the center of the sharrow marking. For motorists the message is expect bicycles to move into the travel lane and exercise patience and caution when sharing the roadway with cyclists. Motorists wishing to pass cyclists should either change lanes or wait until the cyclist turns off the street.

Locations in Portland
Portland is testing shared lane markings in a limited number of locations as part of an experiment monitored by the Federal Highway Administration. Sharrows are not a federally adopted traffic management tool in the Manual on Uniform Traffic Control Devices (MUTCD).

A total of 22 markings have been installed in Portland; including eleven on NW 19th (Hoyt to Burnside), six on NW 18th (Burnside to Everett) and five on SW Alder (Burnside to 16th). The markings are 3 foot 3 inches wide and 9 foot 3 inches tall and are spaced approximately 100 feet apart. If the markings prove effective, the City will slowly expand their use to other, similar locations that meet our guidelines.
## HAWTHORNE BRIDGE SHARED PATHWAY

Among cyclists, the Hawthorne Bridge is the most popular Willamette River crossing (with more than 5,000 daily trips) of the four bicycle-friendly bridges which cross the River in the Central City. Bicycle and pedestrian facilities on the Hawthorne Bridge comprise off-street shared pathways along the north and south sides of the bridge. In 1999, both pathways on the bridge were expanded from six to ten feet wide.

As the bicycle facilities feeding the Hawthorne Bridge were developed between the early 1990’s and 2006, ridership on the Bridge increased by nearly 300%. As the popularity of the Hawthorne Bridge has grown, so have conflicts between cyclists and pedestrians. Recent improvements were made in order to address safety and operational concerns on the Bridge.

In 2005, new markings where painted on the sidewalks to clearly separate pedestrian and bicyclist users by dividing the shared pathway into two lanes. The markings direct pedestrians to use the wider outer portion (right side) of the sidewalk and bicyclists to use the road (left) side portion.

Through operational changes on the bridge were also introduced creating one-way travels for bicycles on both bridge sidewalks. Pedestrians are permitted to travel in either direction on both sides of the bridge.

<table>
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<tr>
<th>Purposes</th>
<th>Issues</th>
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<tbody>
<tr>
<td>• Reduce conflicts between cyclists and pedestrians through separation</td>
<td>• Accompanying signs and markings</td>
</tr>
<tr>
<td>• Improve safety conditions for all users</td>
<td>• Deterring wrong way riding</td>
</tr>
<tr>
<td></td>
<td>• Allowing cyclists to pass</td>
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<tr>
<td></td>
<td>• Addressing excessive bicycle speeds</td>
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### North side of Bridge: facing West

### North side of Bridge: facing East
BIKEWAY SIGNING AND MARKINGS

In 2005, Portland launched a citywide effort to install a comprehensive signing system for its bikeway network. A variety of signs and markings are available to enhance the bicycle environment and make cycling safer.

Portland’s signing system has two components: bicycle boulevard pavement markings and destination signs. The bicycle boulevard pavement markings are white, one-foot diameter circles containing the image of a bicycle. They are placed on the city’s developed bicycle boulevards, i.e. low volume streets without striped bicycle lanes but with improvements to make them work well for cyclists.

The intent of the pavement markings are two-fold: to make bicycle boulevard streets as recognizable to cyclists as are the bikeways striped with bike lanes; and to guide cyclists along the occasional jogs taken by these boulevard routes.

Approximately 800 bicycle boulevard markings, to date, have been installed within the City. Markings are typically placed 50 feet from the intersection and standard spacing between markings is between 600 to 800 feet. A directional arrow is added to guide cyclists through bicycle boulevard twists and turns.

Bikeway destination signs are placed at intersections along all developed bikeways, at key decision points and as guidance through difficult turns. These signs inform cyclists of significant destinations to which different bikeways will lead them. Sign dimensions are 24 by 30 inches with 2 inch tall lettering.

The locations identified on the signs include Portland’s commercial centers, parks of regional significance, transit facilities, and certain institutions. In addition to providing the distance from the sign to the destinations, the sign includes a suggestion of how long it may take to reach the destination by bicycle. The riding times are based on a “no-sweat” pace of 10 mph, or six minutes per mile. Inclusion of riding times is intended to dispel the common misperception that “it takes too long to get there” by bicycle.
As of February 2007, approximately one-half of the planned network signs had been installed. An Oregon Department of Transportation grant will fund the remaining signs in late 2007-2008.

Additionally, there are approximately 500 “bike route” signs located throughout the City. These signs are intended to alert motorists to anticipate the presence of bicyclists on the roadway and prompt them to drive with caution.