CHAPTER 3
Bikeway Facility Design Guidelines

Introduction

Bicycles are legally classified as vehicles by Maryland Vehicle Law and are allowed on most public roads in Montgomery County, with a few exceptions (freeways like I-495 and I-270, Clara Barton Parkway). As such, all roadways should be designed with bicycle use in mind. In this plan, bikeways are designated on roadways where there is a particular need to provide a connection to a major destination. The appropriate bicycle facility for any given roadway, or segment of roadway, depends on the road's classification, pavement and right-of-way width, motor vehicle speeds and volumes, adjacent land uses and expected growth patterns, and other factors. Bikeway selection guidelines are covered in Chapter 2.

Bikeways can generally be divided into two broad categories:

1. On-street facilities generally consist of bike lanes, paved shoulders or shared roadways (with and without wide outside lanes; with or without signing).

2. Off-street facilities consist of hiker-biker trails in parks or shared use paths along roadways.

Shared use paths along roads are generally best used to supplement the on-street bikeway network in corridors not served by roadways and/or along utility, rail, or other linear corridors. However, the county already has an extensive network of shared use paths along roadways. This plan acknowledges these bikeways, and recommends additional shared use paths along county and state roads to supplement and make connections to the existing off-road shared use path network. Shared use paths can best be used to accommodate bicycles on high-speed roadways without driveways and with few intersections (e.g., Great Seneca Highway).

Purpose

The design guidelines are intended to serve as an aid to engineers, designers, planners and others in safely accommodating bicycle traffic in different riding environments and encouraging predictable bicycling behavior. The guidelines also provide the public with an idea of what they can expect to see and experience when a bikeway is actually built or implemented. The guidelines are based primarily on the 1999 Guide for the Development of Bicycle Facilities (AASHTO Guide, see Figure 3-1), published by the American Association of State Highway and Transportation Officials (AASHTO), the Manual on Uniform Traffic Control Devices (MUTCD; see Figure 3-2), published by the U.S. Department of Transportation, and the county's "Roadway Design Manual" published by the county's Department of Public Works and Transportation. The plan borrows additional ideas and concepts from the Oregon Department of Transportation Bicycle and Pedestrian Plan.

The guidelines are a primer on bicycle facilities design along county roads. They are not a stand-alone document and do not necessarily address bikeways along state highways and state roads (see Appendix D for SHA policies governing bikeway design along state highways). These guidelines highlight important issues, but do not cover all of the design details that might be encountered in developing bicycle facilities. This section is not a complete reference, but rather serves as an overview of the possible solutions to problems designers are faced with when implementing bicycle facilities.

Detailed roadway engineering drawings are provided in the county's roadway design standards manual, updated periodically. Furthermore, designs for specific facilities are addressed during project planning (See chapter 4, Bikeway Implementation, for a description of county and state project planning processes). Where details are not

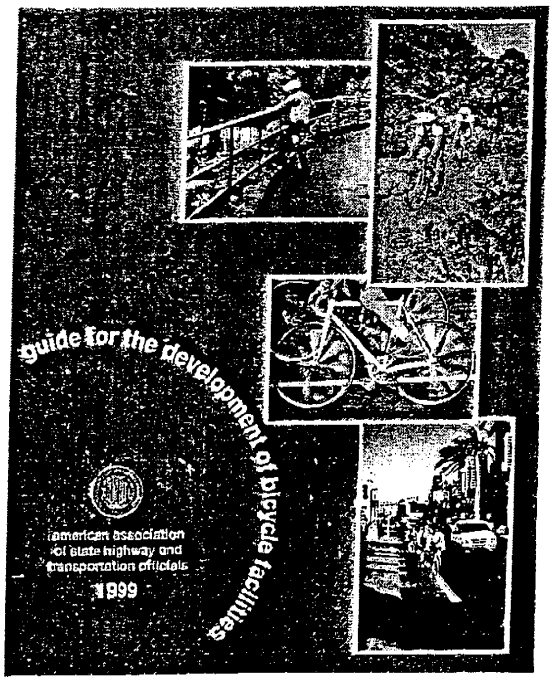

Figure 3-1.
AASHTO Guide For the Development of Bicycle Facilities

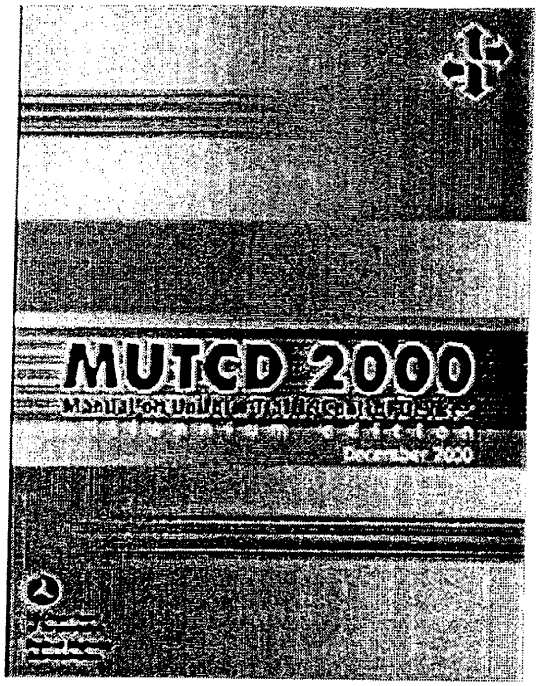

Figure 3-2.
Manual on Uniform Traffic Control Devices (MUTCD)

covered in these guidelines or in the county's design manual, appropriate engineering principles and judgment should be applied during project planning to provide for the safety and convenience of bicyclists, pedestrians and motorists. Additionally, these guidelines will help with updating bikeway design aspects of the county's road code.

Plan Policy Regarding Bicycle Facilities

Chapter 1 of this plan outlines the needs of bicyclists, which include safe, convenient, well-designed bicycle facilities. Since bicyclists are permitted to ride on nearly all roadways, bicycle facilities should be included as part of all appropriate roadway projects unless there is a compelling reason not to include them (e.g., would reduce safety or the cost is excessively disproportionate to projected use). Both the county and the state already currently have policies that reflect this goal.

The Design Bicyclist

Bicycles and bicyclists come in a variety of shapes and sizes and a variety of skill levels. To effectively design bicycle facilities, the range of dimensions and characteristics of common commercially available bicycles and the physical details of the typical bicyclist (e.g., dimensions, speed) should be understood (see Figure 3-3). Bicyclists generally require 3.3 feet of operating width based solely on their profile. Due to steering wobble, bicyclists typically track over at least a 4-foot width. The necessary width is increased to 5 feet or greater for steep hill climbs and descents.

Types of Bikeways

The 2002 Maryland Vehicle Law defines a bikeway as: 1) any trail, path, part of a highway, surfaced or smooth shoulder, or sidewalk; or 2) any travelway specifically signed, marked or otherwise designated for bicycle travel. The basic design treatments used to accommodate bicycle travel on the road are: signed shared roadway; shoulder bikeway (signed or not); or bike lane. Another type of facility is located alongside a road but is separated from motor vehicle travel lanes: shared use path. Another type of bikeway is one that is located within its own right-of-way or located in parkland: a hiker-biker trail. Basic descriptions of each bikeway type are below.

Construction of a bicycle route or restriping a roadway with bicycle lanes has been shown to encourage the increased use of bicycles. However, it would be imprudent to suggest that bikeway facilities are inherently safer than roads without special bicycle-safe designs. Signage and marking can increase a user's level of confidence and provide a more defined, predictable road environment for both the motorist and the bicyclist, however, bikeways cannot ensure a reduced or eliminated risk of a possible accident. Accidents may be caused by so many variables other than facility design, including poor judgment or behavior by either the motorist, the bicyclist or a pedestrian.

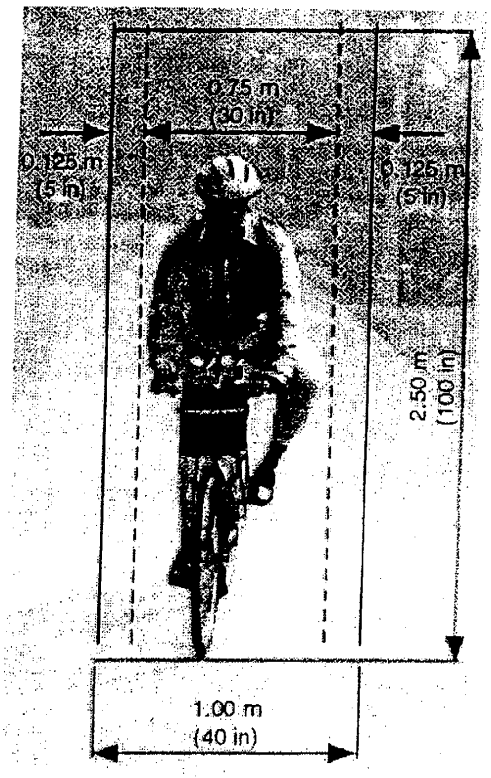

Figure 3-3. Bicycle operating space (Source: AASHTO Guide for the Development of Bicycle Facilities, 1999)

Shared use paths

(class I bikeways)

Shared use paths are two-way bikeways located on one side of a road, typically separated from travel lanes by a three- to six-foot landscape panel. A shared use path also may be located within its own right-of-way. Pedestrians, joggers, rollerbladers and others frequently use these paths, but they are primarily designed and intended for bicycle transportation and should meet AASHTO recommended standards.

The county features an extensive network of existing and proposed roadside shared use paths as well as shared use paths along abandoned or future active transit-ways. In the past, these paths have incorrectly been called hiker-biker trails. Calling them shared use paths more correctly identifies them as transportation facilities. Shared use paths located within parkland--as identified by the 1998 Countywide Park Trails Plan--may continue to be called hiker-biker trails.

In some cases, these bikeways serve as a primary bikeway, meaning the facility is the only existing or proposed bicycle accommodation for a particular segment of road. In other cases, the roadside shared use path supplements an existing or potential on-road bikeway, whether bike lanes, shared travel lane or wide shoulder. Roads with both off-road and on-road bicycle accommodation are said to have dual bikeways.

Examples of shared use paths in the county include: Falls Road, Greencastle Road, Robey Road, Great Seneca Highway, North Bethesda Trail, Georgetown Branch/ Metropolitan Branch Trail.

Shared use paths should not be confused with sidewalks. Sidewalks are designed and intended for pedestrian travel and can be as narrow as 4' depending on the road classification. Sidewalks often include street furniture (benches,

bus shelters, trash receptacles) and other characteristics that are intended to only enhance the pedestrian experience, and serve as dangerous obstacles to bicyclists. Sidewalks also may be located immediately adjacent to the road or curb and often feature twists and turns, some at sharp angles.

General Design Characteristics

- 8-12' concrete or asphalt path
- Located with the right-of-way (ROW) of a road or transitway
- Designed and constructed by, or under the supervision of, a transportation agency (SHA, MTA, DPWT) or municipal agency (Rockville or Gaithersburg)
- May be maintained and/or managed by DPWT or M-NCPPC
- Intended for off-road non-motorized transportation (biking and walking), but may be used for recreation (joggers, roller-bladers, etc.)
- Prohibit motorized vehicles (exceptions include electric wheelchairs and Segeways)
- Should be designed and constructed to AASHTO and MUTCD standards, including appropriate informational, warning and regulatory signs.

Figure 3-4. Shared use path along a major road or highway
(Source: www.pedbikeimages.org/Dan Burden)

Other Design Considerations

Pavement width and clearance zones
AASHTO recommends a pavement width of at least 10 feet. Eight feet is acceptable in areas expecting low to moderate use and 12 feet is recommended for areas expecting intensive use. The 10-foot standard allows two bicyclists to pass each other with a one- or two-foot buffer and minimizes the need to leave the path. Widths less than 10' may be acceptable where right-of-way is limited or for locations with severe site constraints. These decisions can be made during project planning or during subdivision review.

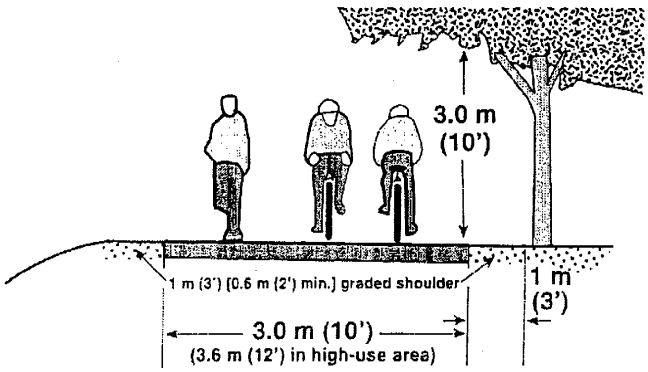

Figure 3-5. Cross section of a typical shared use path (Source: Oregon Department of Transportation)

Where possible, a three-foot wide graded horizontal clear zone should be provided and maintained on each side of the path. Every effort should be made not to install signs, posts, guardrails, fences, and telephone poles or other devices in this clear zone. In addition, the DPWT or municipal agency is responsible for maintaining any vegetation that may encroach into this clear space.

A 10-foot high vertical clearance should be provided and maintained. DPWT and/or municipal agencies are responsible for trimming overhanging tree branches.

Landscape panel

AASTHTO recommends a five-foot minimum buffer between the path edge and the curb. However, the county's roadway design manual requires a six-foot minimum width for the planting of trees. Because trees provide for a more pleasant riding environment and visual barrier to motorized traffic, a six-foot landscape panel width is recommended (the minimum acceptable for trees). Placing the trees in the center of the panel would provides sufficient lateral offset for the path.

One safety aspect is a barrier between paths and the roadway when adequate width for a landscape panel is not possible. Such barriers serve both to prevent path users from making unwanted movements into the motor vehicle travel lanes and to reinforce the path as an independent travel corridor. The barrier should be at least 42 inches high to prevent bicyclists from toppling over it. This is not current design policy and may cause operational problems.

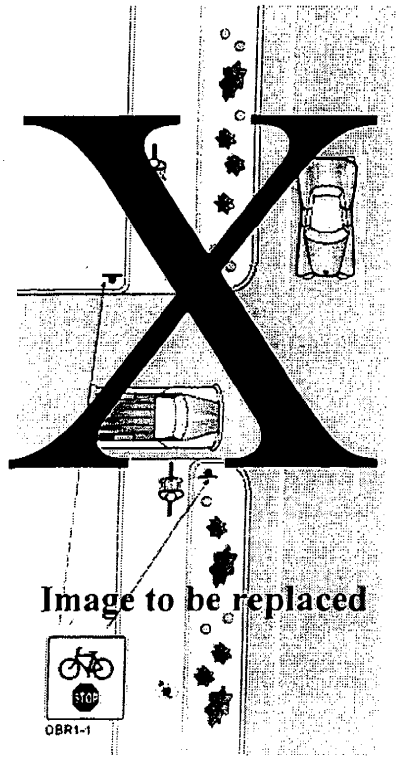

Figure 3-6. Aerial view of shared use path along road with landscape panel (Source: Oregon Department of Transportaton)

Curb cuts and crosswalks

At all driveways and intersections for which a shared use path crosses, curb cuts and crosswalks should be eight-feet wide (as opposed to four or five for a typical sidewalk). Where a path is located adjacent to a sidewalk, crosswalks and curb cuts only should be provided for the path.

Signs for bicyclists

Bicyclists need to be warned of possible conflicts with motor vehicles and with pedestrians. Therefore, all major, non-signalized intersections should be properly signed or marked to warn bicyclists to slow down or stop.

- Appropriate MUTCD-approved signs should be installed at periodic intervals along the path to remind bicyclists to yield to pedestrians and to notify users that the shared use path is also a designated bike route.

- At signalized intersections, appropriate MUTCD-approved signs should be installed to warn bicyclists to stop and use the pedestrian signal to cross.

- Appropriate MUTCD-approved signs also should be installed at all major commercial driveways and locations where the path crosses a residential primary.

- Other appropriate MUTCD-approved signs may be suitable for minor residential or neighborhood roads. Signs and/or pavements markings are not necessary at all independent residential or commercial driveways that may cross the path.

Signs for motorists (driveways/crosswalks)

Motorists need to be notified of the potential presence of bicyclists at intersections and locations where a path crosses a major commercial driveway or residential primary. Appropriate MUTCD-approved signs should be installed at these locations, facing the motorist crossing the path from the outside. Additionally, these signs should be accompanied by the diagonal downward pointing arrow to show the location of the crossing.

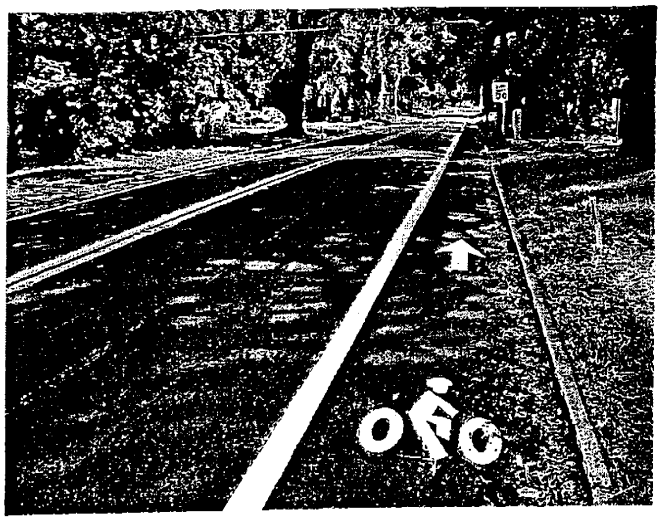

Figure 3-7. Example of a bike lane in Portland, Oregon with logo and arrow.
(Source: www.pedbikeimages.org/Dan Burden)

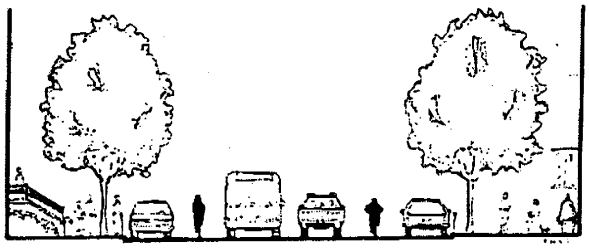

Figure 3-8. Cross-section of a bike lane between travel lanes and on-street parallel parking

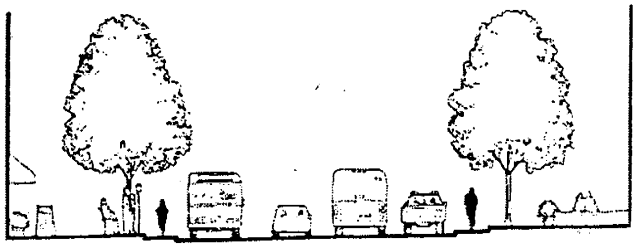

Figure 3-9. Cross-section of a bike lane between travel lanes and the curb

Lighting

If nighttime or twilight time use of the path is expected (i.e., used for commuting), adequate pedestrian-oriented lighting should be provided. Types, locations, intervals and illumination levels can be determined during facility planning. Good lighting is especially needed at intersections. The latest recommendation of the Illuminating Engineering Society of North America (IESNA) should be followed.

Bike Lanes

(Class II bikeway)

Bike lanes provide a designated travel lane adjacent to other travel lanes for the preferential or exclusive use of bicycles. They are one-way facilities that carry bicycle traffic in the same direction as adjacent motor-vehicle traffic. Bike lanes should never be provided on only one side of a two-way street; this may cause confusion and encourage bicyclists to use the bike lanes as a two-way on-street bike path. Motorists are prohibited from using bike lanes for driving or parking, but may use them for emergency avoidance maneuvers or breakdowns.

General Design Characteristics

- 4'- 6' marked lane
- Delineated by 6" wide solid white line to separate it from motor vehicle travel lanes
- Identified by pavement markings (bike logo and arrow (see Figure 3-8)
- Designed and constructed to AASHTO and MUTCD standards, including appropriate informational, warning and regulatory signs.

Other Design Considerations

Width Standards

The AASHTO recommended minimum width of a bike lane is 1.8 m (5 ft), as measured from the center of stripe to the curb or edge of pavement. This width enables cyclists to ride far enough from the curb to avoid debris and drainage grates, yet far enough from passing vehicles to avoid conflicts. By riding away from the curb, cyclists are more visible to motorists than when hugging the curb. The minimum bike lane width is 1.2 m (4 ft) on open shoulders and 1.5 m (5 ft) from the face of a curb, guardrail or parked cars. A clear riding zone of 1.2 m (4 ft) is desirable if there is a longitudinal joint between asphalt pavement and the gutter section. On roadways with flat grades, it may be preferable to integrate the bike lane and gutter to avoid a longitudinal joint in the bike lane.

Bike lanes wider than 1.8 m (6 ft) may be desirable in areas of very high use, on high-speed facilities where wider shoulders are warranted, or where they are shared with pedestrians. Care should be taken so they are not mistaken for a motor vehicle lane or parking area, with adequate marking or signing.

Pavement markings and signs

A bike lane should be marked with pavement stencils and a 6" wide stripe. This width increases the visual separation of a motor vehicle lane and a bike lane. If parking is permitted, the bike lane should be placed between parking and the travel lane, and have a minimum width of 1.5 m (5 ft). The official pavement stencil for all future or renovated bike lanes should be a bike logo and an arrow pointing bicyclists in the direction of traffic.

- Motorists should be alerted to presence of a bike lane using appropriate MUTCD-approved signs ("Bike Lane Ahead) at least 50 feet prior to the beginning of a bike lane, unless at an intersection where it should be placed within 25 feet of the intersection.

- Appropriate MUTCD-approved signs (Bike Lane Ends) should be placed where a bike lane suddenly terminates, whether at an intersection or middle of a road segment.

- Appropriate MUTCD-approved signs (Bicycle Right Lane Only) should be placed every 500 feet on both sides of the road.

- Appropriate MUTCD-approved signs (No Parking, Bike Lane) should be placed every 200 feet on both sides of the road to discourage illegal use of a bike lane by motorists.

- All signs should be installed within 3 feet of the curb or shoulder edge, and be no higher than 10 feet and no lower than 6 feet from the ground. Signs should be visible (unobstructed by poles, trees or bushes) from at least 25 feet away.

Extruded Curbs (parking curb stops)

This plan recommends against the use of extruded curbs. Parking curb stops are often used throughout the U.S. to separate motor vehicle travel space from bicycle travel space. However, these create an undesirable condition; either the cyclist or motorist may hit the curb and lose control, with the motor vehicle crossing onto the bikeway or the cyclist falling onto the roadway. At night, the curbs cast shadows on the lane, reducing the bicyclist's visibility of the surface. Extruded curbs make bikeways difficult to maintain and tend to collect debris. They are often hit by motor vehicles, causing them to break up and scatter loose pieces onto the surface.

Reflectors & Raised Pavement Markers

Raised , reflective pavement devices are also often used throughout the U.S. to separate motor vehicle travel space from bicycle travel space. These can deflect a bicycle wheel, causing the cyclist to lose control. If pavement markers are needed for motorists, they should be installed on the motorist's side of the stripe, and have a beveled front edge.

Two-Way Bike Lane

This plan recommends against the use of two-way bike lanes. Two-way bike lanes essentially function as a shared use path located on-road, adjacent to motor vehicle travel. They create a dangerous condition for bicyclists and encourage illegal riding against traffic, causing several problems:

- At intersections and driveways, wrong-way riders approach from a direction where they are not visible to motorists;

Figure 3-10. Example of a signed shared roadway, wide outside lane (Source: www.pedbikeimages.org/Dan Burden)

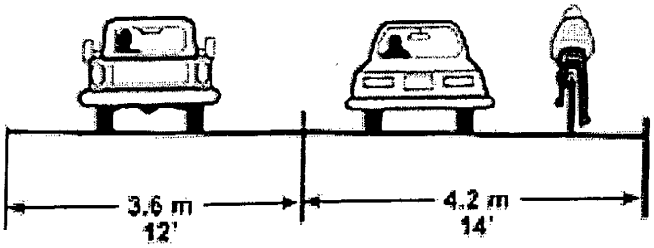

Figure 3-11. Cross-section of a wide curb lane (Source: Oregon Department of Transportation)

- Bicyclists closest to the motor vehicle lane have opposing motor traffic on one side and opposing bicycle traffic on the other, causing confusion; and

- Bicyclists are put into awkward positions when transitioning back to standard bikeways.

- If constraints allow widening on only one side of the road, the centerline stripe may be shifted to allow for adequate travel lanes and bike lanes.

Continuous Right-Turn Lanes

This configuration is difficult for cyclists; riding on the right puts them in conflict with right-turning cars, but riding on the left puts them in conflict with cars merging into and out of the right-turn lane. The best solution is to eliminate the continuous right-turn lane, consolidate accesses and create well-defined intersections wherever possible.

Bike Lanes at intersections

Properly designing bike lanes at intersections and in locations with multiple turning movements is probably among the most difficult design issues for traffic engineers. Pages 25-30 of the AASTHTO Guide as well as pages provide practical, detailed guidance to designing and installing bike lanes at intersections, including proper design of pocket lanes.

- NOTE: For roads with serious space limitations or right of way constraints, a 3-foot striped lane may suffice as an unofficial bike lane (SHA "bicycle areas"); these roads are classified under this plan as a shared roadway, not bike lanes, and do not have to be signed or marked.

Signed Shared Roadways
(Class III bikeway)

The county features an extensive network of proposed signed shared roadways. Mile per mile, shared roadways are the most common bikeway type in the United States and the least complicated and least costly to implement.

To a varying extent, bicycles are used on most county roads and state highways, except where prohibited. In fact, a large percentage of bicycling takes place on shared roadways with no dedicated space for bicyclists. Local streets with low traffic volumes and speeds safely accommodate bicyclists (except young children) without any special treatments.

There are three general types of shared roadways as identified in this plan: 1) Wide Curb Lane; 2) Shoulder Bikeway; and 3) Local Street.

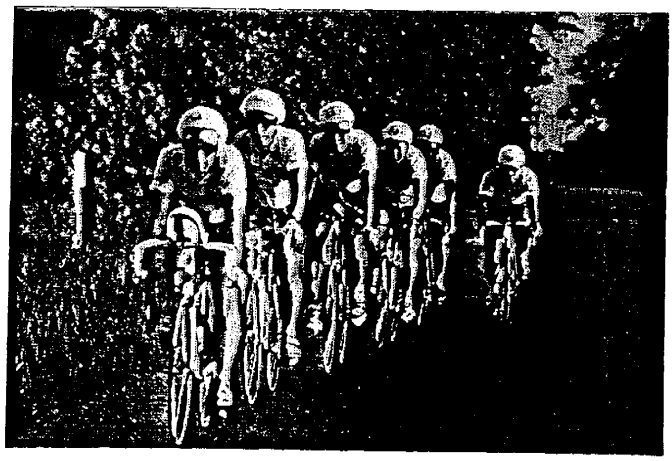

Figure 3-12. Bicycling touring along rural open-section road with no shoulder. (Source: www.pedbikeimages.org/ Dan Burden)

Wide Curb Lanes

A wide curb lane is typically implemented on a closed section (with curb) road. To be effective, a wide lane should be at least 4.2 m (14 ft) wide, but less than 4.8 m (16 ft). Usable width is normally measured from curb face to the center of the lane stripe, but adjustments need to be made for drainage grates, parking and the ridge between the pavement and gutter. Widths greater than 4.8 m (16 ft) encourage the undesirable operation of two motor vehicles in one lane. In this situation, an informal bike lane or shoulder bikeway should be striped. Wide curb lanes more than 14 feet wide should be striped to create an informal 3-4' bike lane.

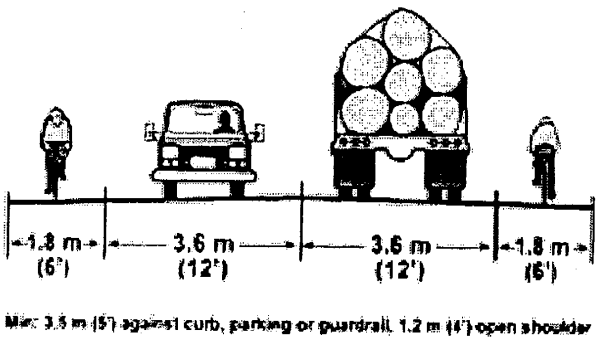

Figure 3-13. Cross-section of shoulder bikeway along two-lane open section road or highway (Source: Oregon Department of Transportation)

Shoulder Bikeways

Paved shoulders provide suitable bicycling conditions for most riders. In general, the eight-foot (8') shoulder widths recommended for open section arterials and major highways in the Montgomery County Roadway Design Manual serve bicyclists well.

When providing paved shoulders for bicycle use, a minimum width of 1.8 m (6 ft) is suitable. This allows a cyclist to ride far enough from the edge of pavement to avoid debris, yet far enough from passing vehicles to avoid conflicts. If there are physical width limitations, a minimum 1.2 m (4-ft) shoulder may be used. Shoulders against a curb face, guardrail or other roadside barriers should

have a 1.5 m (5-ft) minimum width or 1.2 m (4 ft) from the longitudinal joint between a monolithic curb and gutter and the edge of travel lane. On steep grades, it is desirable to maintain a 1.8 m (6-ft), (min. 1.5 m [5-ft]) shoulder, as cyclists need more space for maneuvering.

Local Street

There are no specific bicycle standards for most local signed shared roadways; they are simply the roads as constructed. However, it is important that shared roadways leading to key destinations be signed as a bike route, including arrow signs to help with navigation.

All signed shared roadways should be signed as bike routes and include relevant accompanying directional, distance and informational

Hiker-Biker Trails

Hiker-Biker trails are hard surface paths located on parkland. These paths provide continuous, long distance bicycling opportunities separated from motorized traffic. Existing and proposed hard surface, hiker-biker trails are identified in the 1998 Countywide Park Trails Plan (see Figure 3-9). These bikeways not only offer excellent recreational opportunities, but many also provide direct and convenient access to major local and regional destinations, activity centers and employment centers. A few even provide access to Metrorail and MARC stations. Most of the trails are located within or closely follow stream valleys.

Figure 3-14. Typical hiker-biker trail through parkland (Source: www.pedbikeimages.org/Dan Burden)

M-NCPPC is currently drafting a Trail Implementation Guide that covers the design of hard surface, hiker-biker trails. The Guide serves as a companion document to the 1998 CPTP. It offers general policies and guidelines to direct the design, construction and management of all trails in the Countywide Park System. The Guide is a tool for M-NCPPC staff, consultants, private developers and volunteers to use to assist in designing and developing safe, environmentally sensitive trails. Like this chapter, the guidelines are not requirements, but rather are meant to be adjusted to meet the specific circumstances of each planned facility. Appendix E describes design requirements for hiker-biker trails in more detail.

General Design Characteristics

- 8'-10' asphalt path
- Located in parkland (county, state or federal) or along roads adjacent to parkland for short distances
- Designed, constructed, maintained and managed primarily by M-NCPPC and the National Park Service
- Primarily designed for recreation but may be used for transportation
- Primarily includes recreation-oriented signs, but may include non-regulatory transportation-oriented signs

Examples of hiker-biker trails include Rock Creek Trail, Sligo Creek Trail, Paint Branch Trail, Magruder Branch Trail, Matthew Henson Trail (proposed), the Capital Crescent Trail and C&O Canal Towpath.

Sidewalk Bikeways

State law prohibits the use of sidewalks for bicycling except where allowed by local jurisdictions. Montgomery County allows the use of sidewalks by bicycles. Some early bikeways used sidewalks for both pedestrians and bicyclists. While in rare instances this type of facility may be necessary, or desirable for use by small children, in most cases it should be avoided. Bicyclists travel at a much higher speed than pedestrians, which often leads to conflicts.

Sidewalk bikeways differ from roadside shared use paths. Shared use paths are typically constructed using asphalt and are at least 8 feet wide. Sidewalks, on the other hand,

are typically constructed using concrete, are often five feet wide (sometimes four feet) and may feature twists and turns causing poor sight distances. Sidewalks also may feature street furniture such as benches, bus shelters and trash receptacles, whereas these devices are typically not installed on shared use paths. Sidewalks are designed primarily for pedestrians, while shared use paths are designed primarily for bicycle travel, but can accommodate other users.

Cyclists are safer when they are allowed to function as vehicle operators, rather than as pedestrians. Where constraints do not allow full-width walkways and bikeways, solutions should be sought to accommodate both modes (e.g. narrowing travel lanes or reducing on-street parking). In some urban situations, preference may be given to accommodating pedestrians. Except for short segments that connect two other bikeways, or segments that function as a designated bike route to a local or countywide destination, sidewalks should not be signed for bicycle use - the choice should be left to the user.

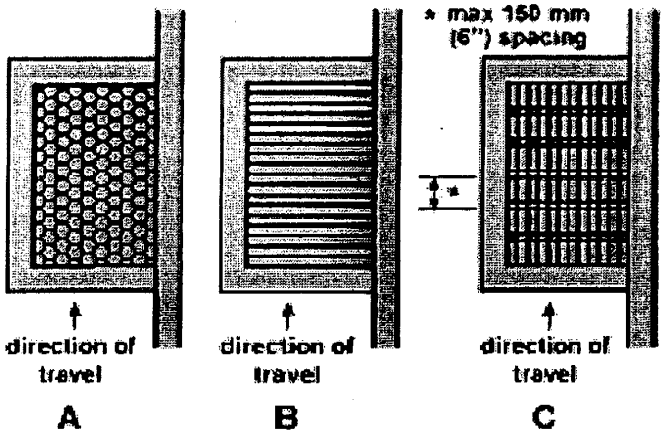

Figure 3-15. Sample designs of safe drainage grates (Source: Oregon Department of Transportation)

Other Design Considerations

All roads in Montgomery County should be designed to safely accommodate bicycling, regardless of whether the roads has been designated as a bikeway or has a shared use path alongside it. The design considerations below should be applied to all roadways in the county, regardless of designation as an official bikeway.

Drainage Grates

Drainage grates are potential obstructions to bicyclists. Grates with slots parallel to the travel lane are especially hazardous; the grate traps the front wheel and throws the bicyclist off the bicycle. Care should be taken to ensure that drainage grates are bicycle-safe, and that they have narrow slots perpendicular to or at a 45-degree angle to traffic.

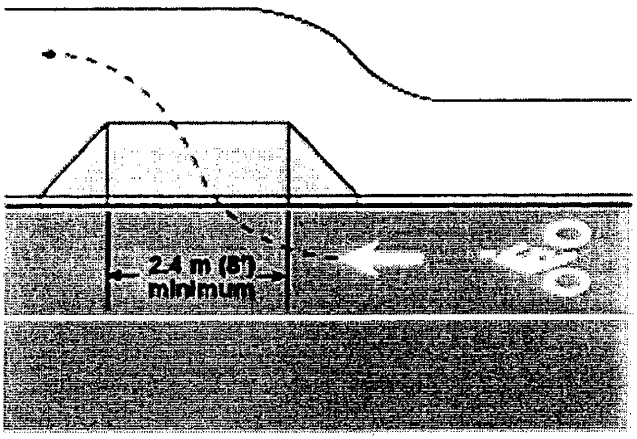

Figure 3-16. Aerial view of a curb cut for bridge (Source: Oregon Department of Transportation)

Railroad Crossings

Special care should be taken wherever a bikeway intersects railroad tracks. This is only an issue for scenic bikeways located in the Agricultural Wedge; no bikeways down county cross railroad tracks at-grade. The most important improvements for bicyclists are smoothness, angle of crossing and flange opening.

Smoothness
Concrete performs best under wet conditions and, when laid with precision, provides a smooth ride. Rubberized crossings provide a durable, smooth crossing, though they tend to become slippery when wet. If asphalt pavement is used, it should be maintained in order to prevent a ridge buildup next to the rails. Timber crossings wear down rapidly and are slippery when wet.

Angle of crossing
The risk is kept to a minimum where the bikeway crosses the tracks at a 90° angle. If the skew angle is less than 45°, special attention should be given to the bikeway alignment to improve the angle of approach, preferably to 60° or greater, so cyclists can avoid catching their wheels in the flange and losing their balance.

Flange Opening
The open flange area between the rail and the roadway surface can cause problems for cyclists, since it can catch a bicycle wheel, causing the rider to fall. Flange width should be kept to a minimum. Note: The combination of smoothness, angle and flange opening create conditions that affect cyclists. By improving smoothness and flange opening, the angle becomes less critical.

Sidewalk Ramps on Bridges
These can help cyclists if the bridge sidewalks are wide enough for bicycle use (minimum 1.2 m [4 ft]). They should be provided where motor vehicle traffic volumes and speeds are high, the bridge is fairly long and the outside traffic lanes or shoulders on the bridge are narrow. Sidewalk railings should be 42" high.

Shared Use Paths on Bridges
Where a shared use path crosses a bridge, the path should have a railing on the traffic side and should be widened by two feet on each side to provide a shy distance from the rail and the bridge parapet (see AASHTO recommendations in Highway Safety Design and Operations Guide). Railings should be 42" high.

Rumble Strips
Rumble strips are provided to alert motorists that they are wandering off the travel lanes onto the shoulder. They are most common on long sections of straight freeways in rural settings, but are also used on sections of two-lane undivided highways. Early designs placed bumps across the entire width of the shoulder, which is very uncomfortable for cyclists.A newer rumble strip design is more bicycle-friendly: 400 mm (16") grooves are cut into the shoulder, 150 mm (6") from the fog line. On a 2.4 m (8 ft) shoulder, this leaves 1.8 m (6 ft) of usable shoulder for bicyclists.

Innovative Designs

These concepts are presented as information, to help M-NCPPC and DPWT come up with new solutions to common problems.

Bicycle Boulevards
The bicycle boulevard is a refinement of the shared roadway concept: the operation of a local street is modified to function as a through-street for bicycles while maintaining local access for automobiles. Traffic calming devices reduce traffic speeds and through trips. Traffic controls limit conflicts between motorists and bicyclists and give priority to through bicycle movement. Bicycle boulevards have numerous advantages and benefits:

- Opportunity - traditional street grids offer many miles of local streets that can be converted to bicycle boulevards
- Low cost - major costs are for traffic control and traffic calming devices
- Traffic calming techniques are increasingly favored by residents who want slower traffic on neighborhood streets
- Bicycle travel on local streets is usually compatible with local land uses
- Bicycle boulevards may attract new or inexperienced cyclists who do not feel comfortable on arterials and prefer to ride on lower traffic streets
- Bicycle boulevards can improve conditions for pedestrians, with reduced traffic and improved crossings.

Thy also have a few disadvantages:

- They are often located on streets that do not provide direct access to commercial land uses and other destinations; some cyclists may have to negotiate a hostile street environment to complete a portion of their trip
- If improperly implemented, they can cause traffic diversion onto other streets
- Failure to provide arterial crossings can result in unsafe conditions for bicyclists
- Traffic signals may be expensive or unacceptable for the traffic condition
- Successful bicycle boulevard implementation requires careful planning with residents and businesses to avoid unacceptable impacts.

Elements of a Bicycle Boulevard include:

- Selecting a direct and continuous street, rather than a circuitous route that winds through neighborhoods. Bike boulevards work best on a street grid system
- Turning stop signs towards intersecting streets, so bicyclists can ride with few interruptions
- Placing motor vehicle traffic diverters at key intersections to reduce traffic volumes (the diverters should be designed to allow through bicycle movement)
- Placing traffic-calming devices on streets to lower traffic speeds
- Placing directional signs to route cyclists to key destinations, to guide cyclists through difficult

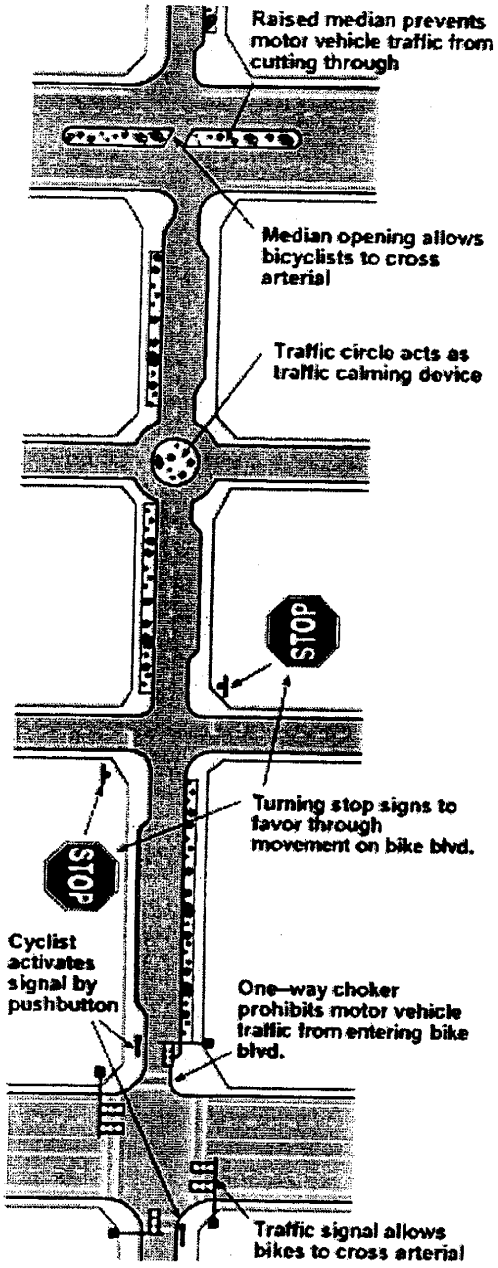

Figure 3-17. Aerial view of a bicycle boulevard (Source: Oregon Department of Transportation)

situations, and to alert motorists of the presence of bicyclists

- Providing protection where the boulevard crosses high-volume arterials with:

- Signals, where a traffic study has shown that a signal will be safe and effective; to ensure that bicyclists can activate the signal, signal loops should be installed where bicyclists ride, supplemented with a push button that won't require dismounting; or
- * Median refuges, with gaps wide enough to allow bicyclists to pass through (min. 2.4 m [8 ft]); the median should be wide enough to provide a refuge (min. 3 m [10 ft]). The design should allow bicyclists to see the travel lanes they should cross.

Raised Bike Lanes

Normally, bike lanes are an integral portion of the roadway surface and are delineated from motor vehicle lanes with painted stripes. Though most bicyclists ride on these facilities with comfort, others prefer more positive separation, but separated paths are not practical in most urban settings. Raised bike lanes incorporate the convenience of riding on the street with the psychological separation of a barrier, with these advantages:

- A mountable curb allows cyclists to enter or leave the lane as needed for turning or overtaking;

- Motorists know they are straying from the travel lanes when they feel the slight bump created by the mountable curb; and

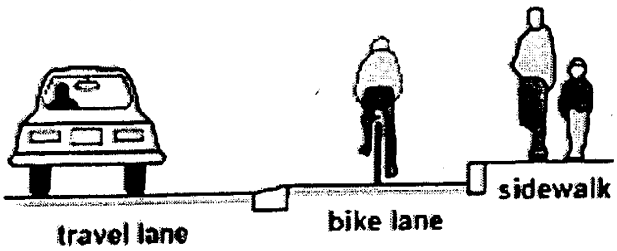

Figure 3-18. Cross-section of a raised bike lane (Source: Oregon Department of Transportation)

- Novice bicyclists are more likely to ride in the bike lane, leaving the sidewalk for pedestrians.

An effective design provides a gentle slope, with no lip, so a bicycle tire is not caught during crossing maneuvers. Using concrete curbs in an asphalt roadway increases the visibility of the bike lane stripe. The raised bike lane is dropped prior to intersections, where the roadway surfacing is uniform.

The disadvantage of raised bike lanes is the greater costs of construction: the travel lanes and bike lanes should be paved separately and a narrow paving machine is required for paving the bike lane.

The additional costs are mitigated by reduced long-term maintenance costs:

- The bike lane portion receives less wear and tear than the travel lanes;

- The bike lane accumulates less debris, requiring less frequent sweeping; and

- The bike lane stripe doesn't need frequent repainting.

- Note: on roads with parking, the bike lane should

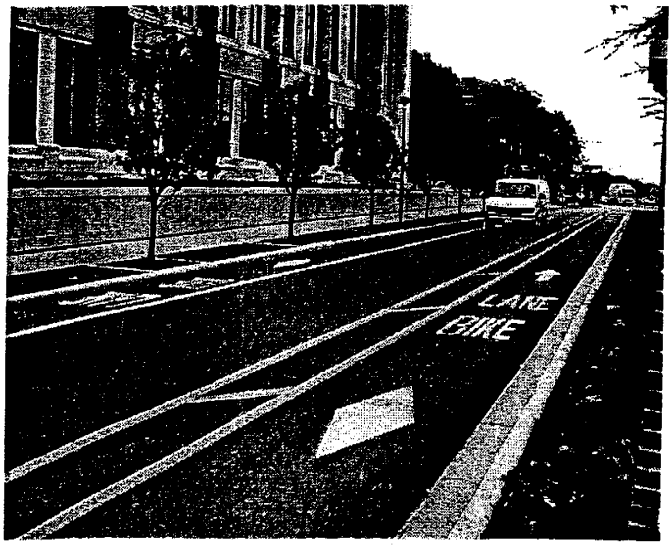

Figure 3-19. Contra-flow bike lane (Source: www.pedbikeimages.org/Dan Burden)

be placed between the travel lanes and parked cars, elevating the parking lane.

Contra-Flow Bike Lanes

Contra-flow bike lanes on a one-way street are not usually recommended. They may encourage cyclists to ride against traffic, which is contrary to the rules of the road and a leading cause of bicycle/motor vehicle crashes. There are, however, special circumstances when this design may be advantageous:

- A contra-flow bike lane provides a substantial savings in out-of-direction travel;
- The contra-flow bike lane provides direct access to high-use destinations;
- Improved safety because of reduced conflicts on the longer route;
- There are few intersecting driveways, alleys or streets on the side of the contra-flow lane;
- Bicyclists can safely and conveniently reenter the traffic stream at either end of the section;
- A substantial number of cyclists are already using the street; and
- There is sufficient street width to accommodate a bike lane.

A contra-flow bike lane may also be appropriate on low volume, low speed, one-way residential streets recently converted from two-way (especially where this change was made to calm traffic). For a contra-flow bike lane to function well, these special features should be incorporated into the design:

- The contra-flow bike lane should be placed on the right side of the street (to motorists' left) and should be separated from on-coming traffic by a double yellow line. This indicates that the bicyclists are riding on the street legally, in a dedicated travel lane.
- Any intersecting alleys, major driveways and streets should have signs indicating to motorists that they should expect two-way bicycle traffic.
- Existing traffic signals should be fitted with special signals for bicyclists; this can be achieved with either loop detectors or push-buttons (these should be easily reached by bicyclists without having to dismount).

NOTE: Under no circumstances should a contra-flow bike lane be installed on a two-way street, even where the travel lanes are separated with a raised median.

Diagonal Parking

Diagonal parking causes conflicts with bicycle travel: drivers backing out have poor visibility of oncoming cyclists and parked vehicles obscure other vehicles backing out. These factors require cyclists to ride close to the center of a travel lane, which is intimidating to inexperienced riders.

Where possible on one-way streets, diagonal parking should be limited to the left side, even if the street has no bike lane; on one-way streets with bike lanes, the bike

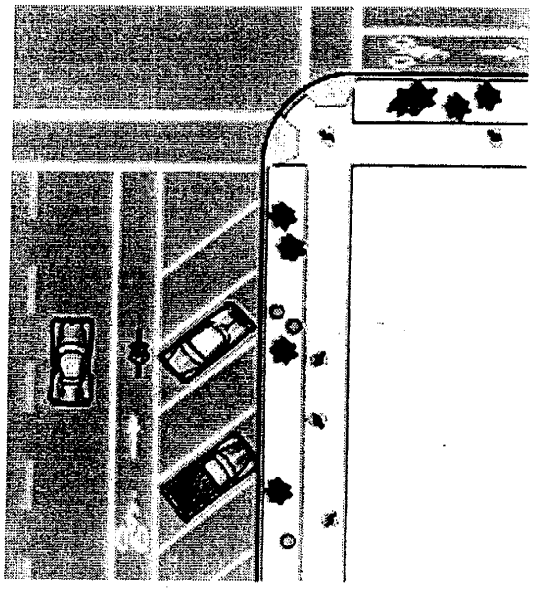

Figure 3-20. Aerial view of a bike lane and diagonal parking. (Source: Oregon Department of Transportation)

lane should placed adjacent to parallel parking (preferably on the right).

Bike lanes are not usually placed next to diagonal parking. However, should diagonal parking be required on a street planned for bike lanes, the following recommendations can help decrease potential conflicts:

- The parking bays should be long enough to accommodate most vehicles;
- A 200 mm (8") stripe should separate the parking area from the bike lane; and
- Enforcement may be needed to cite or remove vehicles encroaching on the bike lane.

Bike Lanes & Bus Lanes

In most instances, bicycles and buses can share the available road space. On routes heavily traveled by both bicyclists and buses, separation can reduce conflicts (stopped buses hinder bicycle movement and slower moving bicycles hinder moving buses).

Separate bus lanes and bike lanes should be considered, with the bus lane at the curb side, to reduces conflicts between passengers and bicyclists. Buses will be passing bicyclists on the right, but the fewer merging and turning movements reduce overall conflicts.

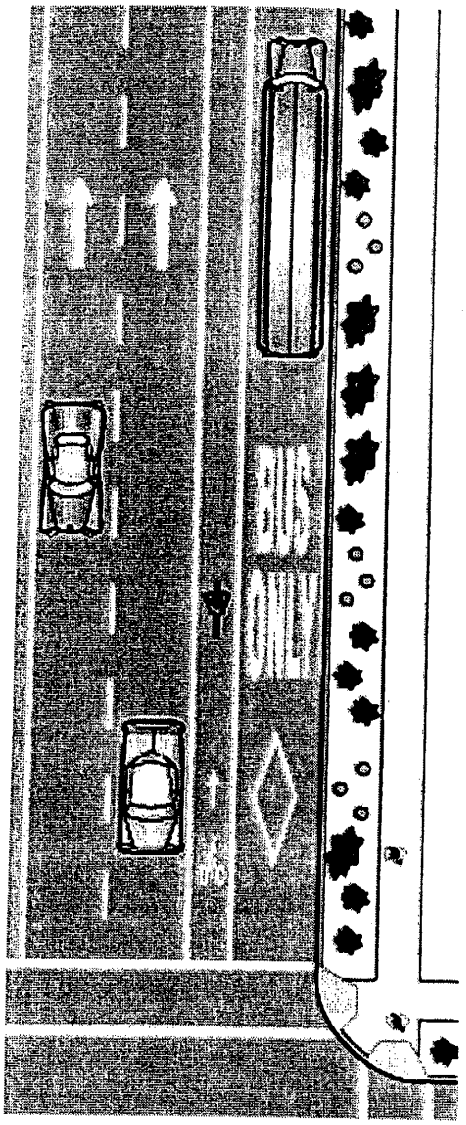

Figure 3-21. Aerial view of a bike lane and bus lane (Source: Oregon Department of Transportation)