PORTLAND'S BIKEWAY NETWORK

INTRODUCTION

In June 1996 Portland's City Council adopted the Portland Bicycle Master Plan. Among its ambitious goals was the development of 630 miles of bikeways within Portland's city limits. At the time of adoption, Portland had 144 miles of bikeways divided among bicycle lanes, shared off-street paths, and bicycle boulevards. Figure 7.1 shows the bikeway network as it existed in 1996. At that time, there were approximately 4,500 daily bicycle trips made across the four Central City bridges commonly used by cyclists[1].

Over the past 11 years Portland has added 122 miles of developed bikeways to its network and has seen bicycle traffic—across what are now four truly bicycle-friendly Central City bridges—increase from 4,500 daily trips in 1996 to over 12,000 daily trips in 2006. This correlation is not coincidental; it is the result of focused improvements on City Bikeways that prioritized connections, the filling in of important gaps, with a focus on projects that could generally be readily and realistically achieved

The development of Portland's bikeway network has been the primary ingredient in Portland's success at increasing bicycle use in the past ten years. It is the facilities for bicycling on Portland's streets and public lands—the bikeway network—that largely shape the experience of each cyclist and largely determine whether their cycling experience will be pleasant, or merely acceptable, or worse. It is not just the quantity of facilities, but also whether they are connected and continuous. It is not whether Portland's bikeways meet current standards but whether their quality meets the desire for Portlanders to feel comfortable and safe. For those reasons will this chapter describe not just the quantity of bikeways, but also focus on the quality of experience they provide.

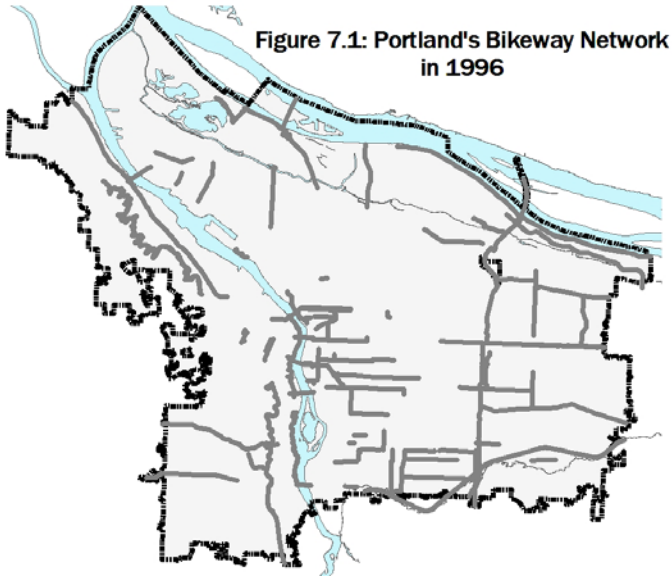


Figure 7.1: Portland's Bikeway Network in 1996

Criteria for Selecting Bikeways and Projects

Portland focused its bikeway development along roadways and in areas of the city that were likely to benefit the most people. Focused capital projects conducted in the mid- to late-1990s included "Central City Bikeways", "Southeast Bikeways", "Northwest Bikeways", the "Tillamook Bikeway," the "Forties Bikeway," and the "Clinton-Woodward Bikeway." Figure 7.2 shows the location of these projects. What they generally had in common was a focus on providing connected bicycle access to regional and town centers, most notably, the Central City and Downtown.

[1] At the time, only the Hawthorne, Burnside, and Broadway had facilities that could be described as "bicycle-friendly." The Steel Bridge had only very

Special attention was focused on providing complete, comfortable, and safe routes to the Central City and the Willamette River bridges, recognizing that the Central City is the primary employment destination in Portland.

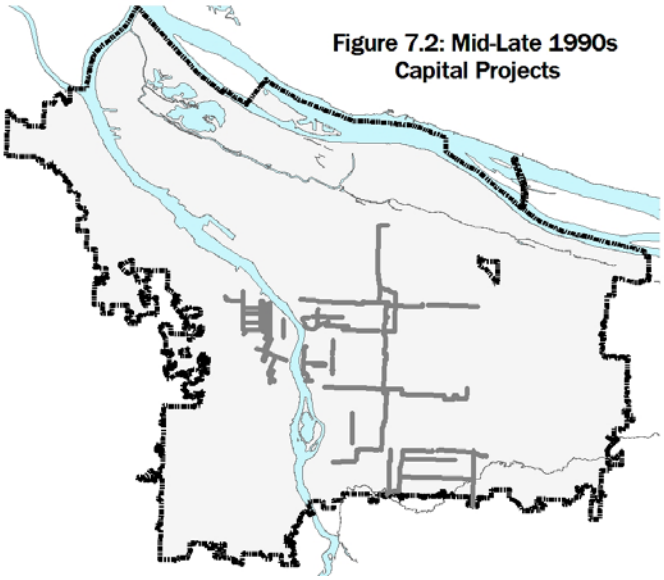


Figure 7.2: Mid-Late 1990s Capital Projects

Many of these projects, particularly those with bicycle lane elements, were selected because they offered relatively few impediments to bicycle improvements. They were on roadways with oversized travel lanes that could be easily narrowed to allow bicycle lanes. Or, they were roadways with four travel lanes that could undergo a "road diet" and be reconfigured to a 3-lane roadway with bicycle lanes. Or, the roadways included lightly-used on-street parking that could be eliminated from one side of the street to allow bicycle lanes. While these types of projects always involved discussion, public process, and some controversy, such projects were generally considered to be "low-hanging fruit," as they were readily achieved without much difficulty or cost.

Other projects were undertaken as opportunity arose. Portland's regular repaving of arterial roadways always presents opportunities to inexpensively restripe these roadways to include bicycle lanes. Such was the case on SE Sandy (to SE 7th) and NE Glisan Street, among others. This strategy remains as one of the most cost-effective ways to provide bicycle lanes. It avoids the relatively high cost of grinding out existing striping, and does not create the "ghost lines" in the roadway that remain from the physical grinding of skip-striped lines. Such line remnants can be confusing to motorists, especially at night and during wet weather when the gouges carved by grinding reflect pooled water. Light reflected from this pooled water creates a visual impression of striping and makes the roadway look like it has two sets of striping.

Portland's Office of Transportation initiated a two-year process in 1994 to develop a classified bikeway network as part of the Bicycle Master Plan. The creation of that network considered bikeway corridor plans that had been previously proposed[2]. Prior to the Bicycle Master Plan, Portland had identified specific popular bicycling corridors that would offer benefit to more cyclists through implementation of formal bikeway designs. However, to create a comprehensive bikeway network, Portland needed more than the existing corridor plans.

To develop an interconnected bikeway network the Master Plan selected bikeways based on several criteria, including:

narrow shared sidewalks.

2 There were numerous previous plans that recommended bikeway improvements. These included: "Bicycle Facilities for Portland" (1973), "Improvement of the SW Sunset Blvd-SW Dosch Rd Bikeway" (1977), "Reed-Hawthorne Bicycle Route Study" (1985), "Analysis of the Reed-Hawthorne Bicycle Route" (1987 and 1988), "Upper Southeast Corridor Bicycle Route Study" (1986), "Outer Central Corridor Bicycle Route Study" (1987), "Lower Southeast Corridor Bicycle Route Study" (1987), "NE Fremont Street Bikeway Project" (1989), "Lower Northeast Corridor Bicycle Route Study" (1989), "Albina Corridor Bicycle Route Study" (1989), "Northeast Bikeway Signing and Improvement Plan" (1991), "SW Terwilliger Boulevard Bikeway Project" (1991), "North Portland Bikeway Improvement Plan" (1993), "Central City Transportation Management Plan Bicycle Study" (1993), and the final adopted "Central City Transportation Management Plan" (1995).

- Connection to land uses
- Ease of implementation
- Need for safety improvements
- Lack of parallel facilities
- Need for continuity, and
- Providing a bikeway every half-mile both north-south and east-west.

These criteria, combined with extensive fieldwork, resulted in the initial classification of 630 miles of City Bikeways and Off-Street Paths. Additional roadways were developed as City Bikeways when the Office of Transportation determined, in the context of undertaking a capital project, that certain roadways could not be designed as bikeways as called for in the Bicycle Master Plan. This typically occurred on Major or Minor City Traffic streets where bicycle lanes could not be provided for one or more reasons.[3] For example, the Northwest Bikeways Project, in 1998-1999, determined that Glisan and Everett streets, though classified as City Bikeways, could not be striped with needed bicycle lanes. Instead, the project developed parallel bicycle boulevards on NW Johnson and NW Flanders Streets. Similarly, the 40's Bikeway Project developed NE 37th Avenue as a bicycle boulevard rather than striping bicycle lanes on NE 42nd Avenue. The Office of Transportation incorporated these modifications—classifying these roadways as City Bikeways—into the City's Transportation System Plan (TSP)[4] after the fact.

The City's Transportation System Plan identifies only two bicycle classifications: "City Bikeway," for bikeways within the public right-of-way, and "Off-Street Paths," for shared, multi-use paths that are not open to motorized vehicles and are generally, though not exclusively, outside the boundaries of the public right-of-way. However, the City's Bicycle Master Plan identifies four separate types of facilities for Portland's City Bikeways: Bicycle Lanes, Bicycle Boulevards, Signed Connections, and Off-Street Paths. These facilities reflect different criteria for their development, different treatments to develop them, different locations in the private and public realm, and different functions.

Bicycle lanes are the most ubiquitous bikeway facility, both in the existing Bicycle Master Plan, as well as developed on Portland roadways. Bicycle lanes are developed as striped lanes for the exclusive use of bicycles on roadways where the average daily traffic is 3,000 cars per day or greater. Roadways classified as City Bikeways with bicycle lanes as the recommended treatment are also generally classified for higher volumes of motor vehicle traffic, transit, and/or freight, as well. They are generally Neighborhood or District Collector streets that are intended to work well for everybody.

Bicycle Boulevards are developed along City Bikeways that carry fewer than 3,000 daily motor vehicle trips. There is no special striping on boulevards, though other treatments are used to create conditions conducive to bicycling in a shared roadway environment.

[3] Bicycle lanes generally could not be provided on Major or Minor City Traffic Streets when parking could not be removed, the configuration of travel lanes could not be altered, and/or travel lanes could not be sufficiently narrowed to allow striping of bicycle lanes.
[4] The Transportation System Plan is the City's guiding policy document for transportation.

Though signed connections are identified as City Bikeways in the City's Transportation System Plan, the Bicycle Master Plan does not recommend any treatment for these roadways other than the placement of signs. These bikeways are generally connector routes that link other City Bikeways, or that lead to a point of interest.

Off-Street paths are in areas of the right-of-way, or outside the right-of-way, that are intended for non-automotive use only. In Portland, these paths are often along rivers, freeway right-of-way, rail right-of-way, and on bridges.

Growth in Network

By Facility Type and District Portland's bikeway network has grown steadily since the Bicycle Master Plan was adopted in 1996. Since 1990 Portland's bikeways grew from 78 miles of roadway to more than 265 miles today. Much of this growth occurred in the years between 1994 and 2002. During this period the city built 166 miles of bikeways, representing 60% of today's existing network. These 166 miles included 20.5 miles of bicycle boulevards (68% of today's total of 30 miles), 111 miles of bike lanes (66% of today's total of 167 miles), and 34 miles of off-street paths (49% of today's total of 69 miles). Figure 7.3 shows the annual development of bikeways by type.

Figure 7.3:

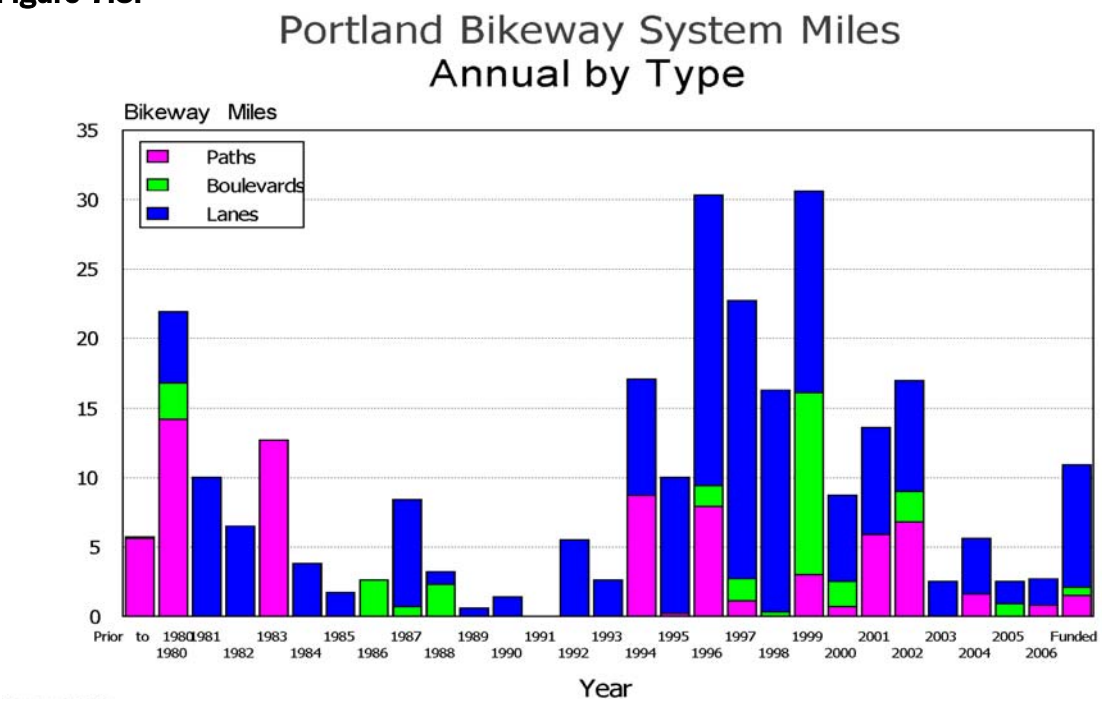


Table 7.1:

Bicycle Facilities by City District (miles)

02/07

		Existing	Funded	Recommended	Total	% of Existing/Funded to Total	District Area (sq. miles)	Miles of Existing Facilities per Square Mile
North	Bicycle Lanes	26.0	3.3	24.2	53.5	54.7%		
	Bicycle Boulevard	1.2	0.0	4.4	5.6	21.0%		
	Off-Street Paths	15.4	0.1	5.5	21.1	73.8%		
	Signed Connections	0.0	0.0	6.0	6.0	0.0%		
	Subtotal North:	42.6	3.5	40.1	86.2	53.4%	20.2	2.1
Inner Northeast	Bicycle Lanes	23.6	0.6	51.0	75.2	32.1%		
	Bicycle Boulevard	9.2	0.6	19.0	28.7	33.9%		
	Off-Street Paths	6.6	0.4	12.7	19.7	35.4%		
	Signed Connections	0.0	0.0	3.6	3.6	0.0%		
	Subtotal Northeast:	39.3	1.5	86.3	127.2	32.1%	29.5	1.3
Southeast	Bicycle Lanes	20.6	0.7	29.3	50.6	42.1%		
	Bicycle Boulevard	13.4	0.0	19.8	33.2	40.4%		
	Off-Street Paths	12.8	0.0	1.0	13.8	92.6%		
	Signed Connections	0.0	0.0	3.2	3.2	0.0%		
	Subtotal Southeast:	46.8	0.7	53.3	100.8	47.2%	22.4	2.1
Outer East	Bicycle Lanes	44.3	1.5	43.9	89.8	51.0%		
	Bicycle Boulevard	0.0	0.0	5.5	5.5	0.0%		
	Off-Street Paths	14.7	0.0	7.3	22.0	66.8%		
	Signed Connections	0.0	0.0	0.4	0.4	na		
	Subtotal Outer East:	59.0	1.5	57.2	117.7	51.4%	27.4	2.2
Northwest	Bicycle Lanes	10.1	0.2	25.4	35.8	28.9%		
	Bicycle Boulevard	3.7	0.0	0.7	4.5	83.5%		
	Off-Street Paths	9.3	0.0	1.3	10.6	88.1%		
	Signed Connections	0.0	0.0	2.5	2.5	0.0%		
	Subtotal Northwest:	23.2	0.2	29.9	53.4	43.9%	20.2	1.1
Southwest	Bicycle Lanes	24.2	0.7	63.9	88.9	28.1%		
	Bicycle Boulevard	0.0	0.0	1.9	1.9	0.0%		
	Off-Street Paths	4.6	0.0	1.7	6.2	73.4%		
	Signed Connections	0.0	0.0	9.4	9.4	0.0%		
	Subtotal Southwest:	28.8	0.7	76.9	106.4	27.8%	18.2	1.6
Central	Bicycle Lanes	21.8	1.7	18.0	41.5	56.6%		
	Bicycle Boulevard	2.2	0.0	2.8	5.0	44.3%		
	Off-Street Paths	5.7	1.1	1.3	8.1	83.9%		
	Signed Connections	0.0	0.0	1.9	1.9	0.0%		
	Subtotal Central:	29.7	2.8	24.0	56.6	57.5%	4.6	6.5
Citywide (summed from above)	Bicycle Lanes	170.6	8.8	255.9	435.3	41.2%		
	Bicycle Boulevard	29.7	0.6	54.1	84.4	35.9%		
	Off-Street Paths	69.2	1.6	30.8	101.6	69.7%		
	Signed Connections	0.0	0.0	26.9	26.9	0.0%		
	Total Citywide**:	269.5	11.0	367.7	648.2	43.3%	142.6	1.9

Portland's Bikeway Network is approximately 45% complete. Under the existing plan, when complete it will comprise 431 miles of bicycle lanes, 84 miles of bicycle boulevards, 101 miles of off-street paths, and 27 miles of signed connections. Not including signed connections, those facilities are 41%, 36%, and 70% complete, respectively. Table 7.1 shows the relative completeness of bikeways by area of the city.

There are notable differences between different areas of the city both in terms of what has been developed and what is slated for development. As shown in Table 7.2, city-wide, 45% of the network is complete. There is significant variation in percent completeness in the seven recognized transportation districts in Portland. Percent completeness of the network ranges from a low of 28% in Southwest Portland, to a high of 53% and 58% in North Portland and the Central City, respectively.

Table 7.2: Bikeway Completion by District

District	Total Miles	Existing & Funded Miles	Percent Complete	Percent of Existing Facilities That Are		
				Boulevards	Lanes	Paths
North	86	46	53%	3%	64%	34%
Inner Northeast	127	41	32%	24%	59%	17%
Inner Southeast	101	48	47%	28%	45%	27%
Outer East	118	61	51%	0%	76%	24%
Northwest	53	23	44%	16%	44%	40%
Southwest	106	30	28%	0%	84%	16%
Central	57	33	58%	7%	72%	21%

Of the 280 miles that have been developed (includes 9 miles of funded, but not yet constructed projects), 64% have been developed as bicycle lanes, 26% have been developed as off-street paths, and 11% have been developed as bicycle boulevards. As bicycle boulevards are the most "family-friendly" of bikeways in the public right-of-way it is worthwhile to consider how these facilities have been developed in the different sectors of Portland. Inner Northeast and Inner Southeast Portland have the highest percentage of their existing network comprised of boulevards. Boulevards are 24% and 28% of the existing bikeways in these parts of the city, respectively. Northwest Portland is next highest, with 16% of their developed bikeways consisting of boulevards.

Contrast this to Outer East and Southwest Portland, where there are no boulevards. North Portland and the Central City also contain relatively few miles of boulevards, with only 3% and 7%, respectively.

By Project

Portland's Bikeways have been developed by a number of agencies and projects over the past 15 years. While the Portland Office of Transportation has been the primary architect of the city's bikeway network and its principal developer, others have contributed notably. Table 7.3 displays the number of bikeway miles developed by different agencies and projects.

Table 7.3:

Bikeway Development By Project
(miles)

Development Before 1993	82.1	*82.1*
Bicycle-Specific Capital Projects		*130.5*
40's Bikeway	7.7	
Burnside Corridor Project	2.2	
Central City Bikeways	9.0	
Clinton-Woodward Bikeway	4.6	
Lovejoy Ramp	0.4	
Missing Links	41.4	
North Portland Bikeways	6.8	
Northwest Bikeways	8.0	
Other	23.4	
Southeast Bikeways	14.6	
Greeley Bikeway	1.5	
Tillamook Bikeway	4.5	
Vancouver-Williams Bikeway	6.3	
Other Projects		*13.9*
Arena Project	1.3	
Broadway-Weidler Project	2.5	
Capitol Highway Project	1.1	
Interstate MAX	3.4	
LID Improvements	0.3	
Streetcar	0.2	
Traffic Calming Projects	0.4	
Unassigned	4.7	
Other Agencies		*39.9*
BES	4.0	
Parks	18.3	
ODOT Bikeways	12.3	
PDC	0.3	
Port of Portland	5.0	
Total		*266.3*

Of particular note is the miles developed by PDOT's "Missing Links" program. This program, funded at a modest $50,000 per year, has allowed the Office of Transportation to opportunistically and efficiently develop City Bikeways in conjunction with other projects, notably regularly-scheduled pavement overlays of roadways. Without the Missing Links funding, those 41 miles of city bikeways—typically developed as bicycle lanes—would not have been striped, or would have cost much more if undertaken as a project requiring grinding of existing lines and then re-striping with bicycle lanes.

Network Growth and Ridership

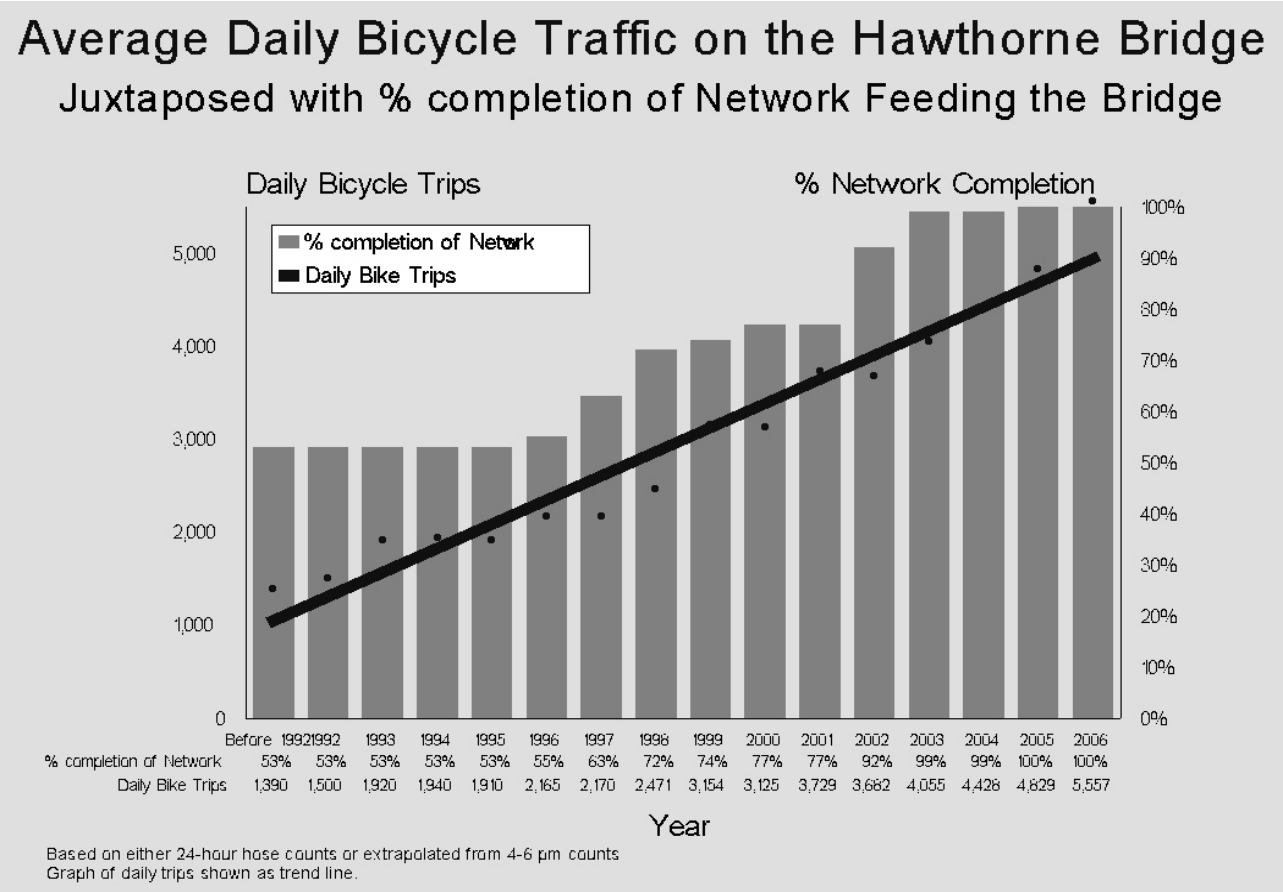
There is a strong correlation between the growth of Portland's bikeway network and growth in ridership. Figure XX shows this correlation between overall network growth and increases in ridership across the four bicycle-friendly Willamette River bridges.

This correlation is particularly evident when looking individually at these four bridges and the relative merits of the local bikeways feeding and serving each bridge. As the figures show, the positive correlation is strong. As the networks serving the Hawthorne, Broadway, and Steel bridges have developed over time, the ridership on those bridges has grown. Similarly, as the facilities serving the Burnside Bridge have not grown, neither have the number of bicycle trips across that bridge.

It is also worthwhile considering the quality of the facilities both serving the bridges and on the bridges themselves. The Hawthorne Bridge has the longest established facilities; they were in place by 2003. In addition, XX% of those facilities are bicycle boulevards and off-street paths—the two types of bikeways that offer the least interaction with motor vehicles. In addition, the bikeway on the bridge itself is an off-street path that was

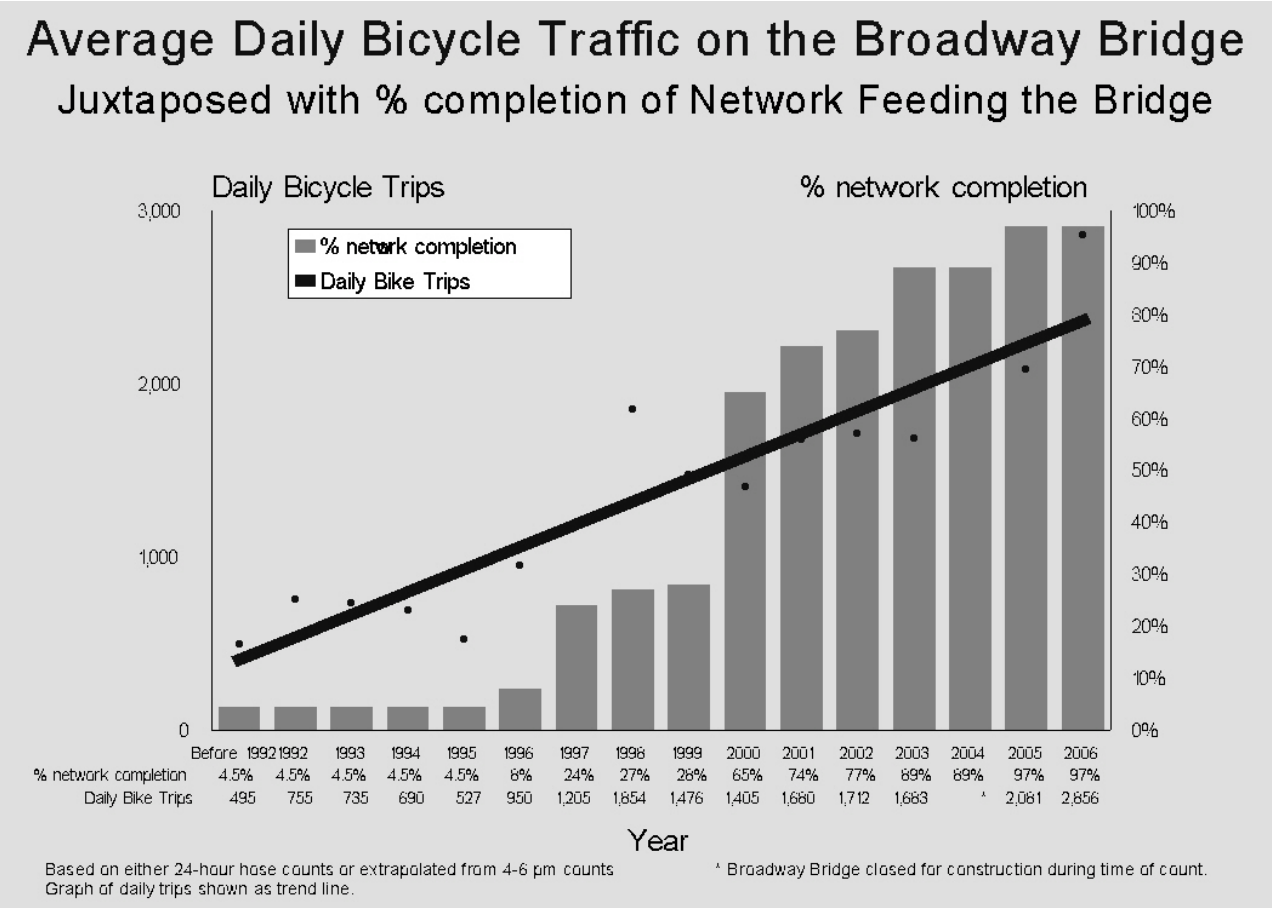
significantly improved in 1999 when it was widened from two six-foot sidewalks to two ten-foot sidewalks. Also improved at that same time were interactions between cyclists and motorist with the closing of one ramp from what was then Front Avenue, the stop sign control on another, and the striping of two blue bicycle lanes.

Figure 7.4:



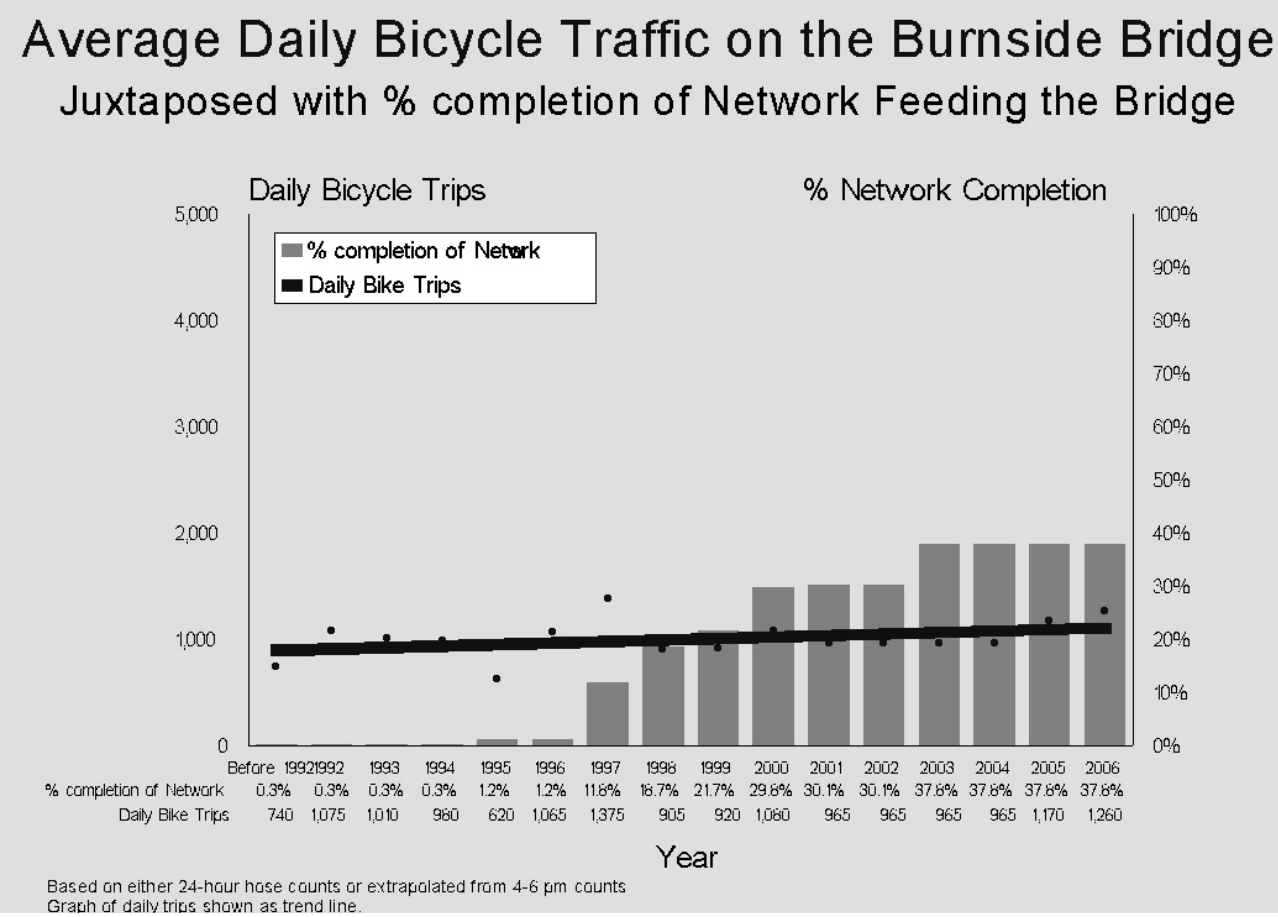
With the Broadway Bridge the network developed piecemeal over time. However, as with both the Steel and Hawthorne bridges, the facility on the Broadway Bridge is an off-street path. While it principally bicycle lanes on arterial streets feeding the Broadway Bridge, these lanes are on relatively low volume and low speed arterials (Broadway-Weidler and Vancouver-Williams). The same arterials, as well as Lloyd Boulevard and Multnomah Avenue, both of which carry even lower volumes than the two couplets feeding the Broadway, similarly serve the Steel Bridge. In addition, the Steel Bridge is notably served by two of the principal off-street paths in the region: Waterfront Park and the Eastbank Esplanade.

Figure 7.5:



The Burnside Bridge is unique among the four bridges, for a number of reasons. Primary among those is the incomplete nature of the network feeding it. While Ankeny Street is a bicycle boulevard that well serves inner SE Portland, final access to the bridge requires cyclists to ride on Grand Avenue and then along Burnside, neither of which has bicycle facilities. None of the other recommended facilities that would serve the bridge on either the east or west sides of the river have been developed. The bridge itself is striped with a five-foot bicycle lane, rather than having an off-street path as do the other three bridges. In addition, the bicycle lanes on the bridge drop at both the east and west ends before connecting to other bikeway facilities. Overall, access to the Burnside Bridge suffers from not only a lack in quantity of facilities, but also in the quality of facilities provided. It is therefore not surprising that bicycle trips across this bridge has remained relatively flat over the past 16 years.

Figure 7.6:



Recent Additions to the Bikeway Network

Some more recent additions and changes to the city's bikeway network, while adding significantly to ease of operation and connectivity, have not added many bikeway miles. Nonetheless, these additions represent sizeable investments in terms of funds expended, planning resources tapped, and engineering resources devoted. These recent additions include:

- The scramble signal in the Rose Quarter at the intersection of Oregon Street and Interstate Avenue
- The HAWK signal at the intersection of 41st and E Burnside
- The "Three Bridges" project in Sellwood along the Springwater Corridor
- The Eastbank Esplanade and Riverwalk projects along the Central Eastside and hanging from the Steel Bridge, respectively
- The Bikeway Network Signing Project, and
- The Port's path to the Airport

This listing does not include the handful and growing number of curb extensions and median refuges that have been added to facilitate cyclist's crossing of busy arterial streets. While not significant to the total miles of bikeways, these more focused point projects have nonetheless addressed significant gaps in the city's bikeway system.

Bikeway Facilities

Ownership

Portland's Office of Transportation is the "road authority" for the City of Portland. While this means that PDOT owns and manages (and constructed) the majority of roads, and thus bikeways in the city, it is by no means the only agency involved in developing and managing the city's bikeways. The Oregon Department of Transportation owns a number of roadways in Portland, and is thus directly responsible for the existing and future bikeways on their roads. Multnomah County also owns and operates significant bikeways in the city—most significant among their holdings are a number of the bridges across the Willamette River. Portland Parks and Recreation also plays an important role in the city's bikeway system as they are the principal owner and manager of several significant off-street paths. Other jurisdictions and agencies with ownership and management responsibility for city bikeways include Metro, the Port of Portland, and the Multnomah County Drainage District.

Primary Facilities: Lanes

Bicycle lanes are the most frequently used bikeway treatment on Portland's streets. Portland currently has 167 miles of roadway striped with bicycle lanes. PDOT has followed three primary strategies for striping bicycle lanes on city streets:

- Narrow existing travel lanes in order to stripe bicycle lanes
- Reconfigure a roadway to remove travel lanes to provide the needed width, and
- Remove on-street parking to provide for bicycle lanes.

Portland's roadways are typically striped with bicycle lanes only when the average daily traffic on the street (ADT) exceeds 3,000 vehicles per day (vpd). In limited circumstances Portland has striped bicycle lanes on roadways carrying lower volumes for a number of reasons. The most significant of these other reasons are speed and stopping patterns. For example, the 40's Bikeway Project striped bicycle lanes on SE 42nd even though traffic volumes were lower than 3,000.vpd Because of traffic volumes that approached 3,000 vpd, in combination with relatively high speeds and traffic operations that allowed long stretches of free flowing traffic, PDOT judged that bicycle lanes offered the most benefit to people riding bicycles on that street.

PDOT's general practice is to stripe two bicycle lanes on a two-way roadway. Occasionally, because of serious width or operational constraints, there is room for only one bicycle lane. In those instances the city has striped bicycle lanes in the uphill direction, if there is one. PDOT will also stripe these climbing lanes on roadways with lower traffic volumes in recognition that it is not a pleasant experience for cyclists to slowly climb a hill leading a "slow-moving parade" of motorists eager to pass.

Most of Portland's bicycle lanes are the traditional "right-running" bicycle lane. They run either against the right curb or adjacent to parking on the right side of the roadway. There are few examples of bicycle lanes that run along the left side of a roadway. One example is on SW 14th Avenue between SW Jefferson and SW Stark, which is a one-way street section. Because of significant conflicts with I-405 traffic entering the right side of 14th, PDOT staff decided to stripe the bicycle lane to the left. This creates difficulties "down the road" when the bicycle lane

necessarily must return to the right hand edge of the roadway in order to integrate into the standard roadway configuration.

There are other circumstances when a bicycle lane moves away from the right edge of the roadway. This notably occurs when the right hand lane becomes a right-turn only lane. In this case the desire is to have through cyclists—and thus the bicycle lane—to the left of the right-turn lane. This "right-turn drop lane[5]" generally presents cyclists with a difficult situation. Those cyclists continuing straight on the roadway must merge across what are typically heavy volumes of right-turning traffic in the absence of a bicycle lane or clear guidance. With a right-turn drop lane the bicycle lane ends, disappears for some distance determined by the speeds of motor vehicles on the roadway, and then reappears to the left of the right-turn lane. This design is considered so incompatible to pleasant bicycling that the city attempts to provide options to this type of maneuver whenever possible. An example of this is on NE Killingsworth just west of I-205 where the recently-designed "East End Connector"[6] includes a right-turn drop lane on a high-volume, high-speed roadway. Initially, every effort was made to create a right-turn add lane, for reasons that will be described below. When that proved undoable, cyclists were given an option. Just before the curb-tight bicycle lane drops and migrates left, cyclists are provided a curb cut allowing them easy access to a sidewalk widened for their use. From the sidewalk, cyclists are then able to cross the right-turning traffic at the intersection and with a signalized crossing. While slower and less efficient than riding on the roadway, the sidewalk path provides cyclists with a much less harrowing option than merging across 1,000 motorists per hour traveling at 45 mph. Cyclists may choose to stay in the travel lane if they wish, and use the bicycle lane, but at least they are offered a second option.

A right-turn add lane is much more comfortable for cyclists as the bicycle lane continues uninterrupted. The add lane design is one in which the roadway widens to add an additional travel lane that is designated for right turns only. Right turning motorists must merge across the bicycle lane and yield to any cyclists. The bicycle lane is continuous, though it may be dashed—and colored blue—in the area where motorists are expected to pass through it.

There are occasions where a right turn lane is added but without sufficient roadway width to continue the bicycle lane. A similar situation occurs when a bicycle lane and unused on-street parking—with a combined width of 12-13 feet—serve as a de facto right-turn lane. This latter situation presents potential road hazards, particularly for motorists. Motorists traveling in the travel lane who wish to turn right from the travel lane can be surprised by right turning motorists to their right who are using the width offered by the combined bicycle lane and parking strip. This also presents difficulties should two motorists try to turn right at the same time as in these situations there may be only one lane to receive them. In situations like this PDOT's practice has been to drop the bicycle lane, create a true right-turn only add lane and sign it "Right Turn Only Except Bikes." This allows cyclists to proceed in a straight-line path. The advantage of this is that cyclists aren't required to merge left into a through travel lane. The disadvantage is that cyclists lost the positive guidance and designated and identified place in the roadway.

Another design for addressing this type of limitation—i.e., the need for a bicycle lane and turn lane but

[5] So called because the lane drops—i.e., does not continue—beyond the intersection.
[6] Connecting Killingsworth conveniently and directly with Columbia Boulevard—an important freight connection.

insufficient width for both—is found in the Oregon Department of Transportation's Bicycle and Pedestrian Plan, and at one location in Oregon. Along St. Helens Road (Hwy 30), which is owned and managed by ODOT, the state created a "shared turn lane." This design continues the bicycle lane through the middle of the turn lane. When a cyclist is present the motorist must yield and/or wait. With smaller motor vehicles there can be enough room for the cyclist and motorist to operate side-by-side at very slow speeds.

Bicycle Lane Widths

Five feet is the standard width for bicycle lanes in Portland. However, there are bicycle lanes of width ranging from as narrow as 3-feet—used only in exceptionally unusual circumstances, to four-feet, the more typical 4.5 feet, 5.5 feet, 6.0 feet, and 6.5 feet. It is worth describing in detail some of the decisions made to create bicycle lanes of these widths in order to better inform future decisions about bicycle lanes.

Three-foot bicycle lanes are found, for very short stretches, in at least two locations. One is on Capitol Highway, just south of Multnomah Village. A capital improvement project could not afford to widen the roadway enough to stripe bicycle lanes in both directions so climbing lanes were provided. Nearing the crest of the hill, from both directions, and due to topographic and roadway constraints, the bicycle lanes, which are full-width beginning at the bottom of the hills, narrow to approximately 3 feet before they drop at the crest. PDOT decided to maintain this minimal width because to end the bicycle lanes at a wider width would have dropped them well shy of the crest and the benefit of having a separating stripe in the uphill direction seemed to outweigh the potential harm of a narrow bicycle lane. Planners took into account the speed of the traffic on the roadway (it is posted at 25 mph), the grade (steep—making it difficult for cyclists to comfortably share the lane), the absence of a curb line, and the value of maintaining some level of separation between motorists and cyclists as these vehicles approached the crest of the hill.

A second location is inbound on SW 6th Avenue at the overcrossing of I-405 at the south end of the Central Business District. Existing travel lanes on the overcrossing did not allow for a full-width bicycle lane to begin at the intersection with SW Broadway. Instead PDOT began striping a bicycle lane at the point where they could achieve a three-foot width. This width immediately begins tapering to a full-width bicycle lane within fewer than 200-feet. Several advantages to beginning the bicycle lane informed this decision. Beginning the bicycle lane as soon as possible would have the effect of encouraging motorists to begin moving to the left as soon as possible, conferring an advantage to cyclists even before the bicycle lane begins. Because of other challenging conditions in SW Portland, many cyclists using this route are assumed to be more skilled than the average cyclist and would feel comfortable in a 3-foot bicycle lane.

Four-foot bicycle lanes are rarely used, despite being the minimum acceptable standard width according to the American Association of State Highway and Transportation Officials (AASHTO).[7] One instance in Portland is on NE Tillamook Street between NE 37th and 43rd avenues. There, the roadway is 42 feet from curb-to-curb with parking on both sides of the street. This cross-section allowed for two ten-foot travel lanes, two seven-foot parking lanes, and two four-foot bicycle lanes. This configuration does not meet PDOT's own design guidelines

[7] The AASHTO manual is the primary guide and standards document for roadway design. The AASHTO *Guide for Development of Bicycle Facilities*. published in 1999, provides guidelines and standards for bikeway designs.

for bicycle lanes, which states that "a four-foot bicycle lane should not be used in combination with a 7 foot parking lane and/or a 10 foot travel lane[8]." PDOT decided to stripe the bicycle lane based an analysis of the unique conditions on this stretch of Tillamook, including:

- Traffic volumes are relatively low, but still high enough to call for bicycle lanes
- It is a relatively short, 6-block segment
- Parking turnover is not uniformly high across the segment, and, most importantly,
- It is not a typical arterial segment in that traffic is stopped every other block.

It was this last element that was most significant as it helps to keep traffic speeds very slow.

Portland has many bicycle lanes measuring 4.5-feet as this width is recommended on bicycle lane retrofits of 36-foot wide roadways, which Portland has in abundance. On such roadways, the recommended configuration with bicycle lanes is for one seven-foot parking lane, two ten-foot travel lanes, and two 4.5-foot bicycle lanes. Similarly, as five feet has been the standard for bicycle lanes in Portland, all streets, where width exists, are generally striped as such. There are many examples of five-foot bicycle lanes in Portland.

Five-and-a-half-foot bicycle lanes are typically used on streets with gutter pans. The standard width for a concrete gutter pan is 18 inches and Portland bicycle lane design guidelines call for leaving four feet clear of a longitudinal joint in a bicycle lane. Such longitudinal joints are formed at the 1.5-foot width between the concrete and the asphalt of the roadway. Hence, the 5.5-foot bicycle lane.

Six foot bicycle lanes are used on higher volume roadways, or on roadways where sufficient width exists. Examples of six-foot bicycle lanes can be found on portions of SW Barbur Boulevard, NE Lombard Street, NW 18th and NW 19th avenues, N Vancouver and Williams avenues, to list a few.

There is one bicycle lane of 6.5 feet in Portland. It is on N Vancouver Avenue between Fremont Street and Broadway. This width is the equivalent of the European standard bicycle facility width of 2 meters. When asked why this width, Dutch transportation planners universally responded that it is at 2 meters that two cyclists could comfortably ride side by side. This recognition of the social component of travel is intended to make the cycling experience more pleasing and enjoyable. In addition to this "sociability factor," bicycle lanes of this width also offer the advantage of providing a wider margin for cyclists relative to both passing traffic and on-street parking.

Other Design Conditions

Occasionally bicycle lanes are provided on only one-side of a two-way roadway. As mentioned previously, this occurs only when insufficient width exists to stripe both directions. A good example of this is on SW Palantine Hill Road, adjacent to Lewis and Clark Law School. A recent development allowed the roadway to be widened to 28-feet of total width. This width could have allowed for two ten-foot travel lanes and two four-foot bicycle lanes. However, this is a hilly area. Both uphill and downhill grades generally require wider than normal bicycle lane widths. In the uphill direction, cyclists go slowly and tend to wobble a bit, requiring more than standard width.

[8] According to PDOT's design guide, a four foot minimum bicycle lane *may* be acceptable when either physical constraints exist, for a segment of less than 1 mile that links to existing bikeways on both ends, or, is implemented in conjunction with traffic calming devices, or is adjacent to parking with [very] low use and turnover, or is adjacent to an uncurbed street shoulder.

Cyclists going downhill travel at a higher than normal speed and require extra width in order to have more maneuvering room to avoid potential obstacles in the bicycle lane. For these reasons, PDOT decided to stripe a six-foot uphill bicycle lane adjacent to an 11-foot travel lane, and provide an 11-foot downhill travel lane for shared travel. Similar conditions exist on NW Wardway Street between Nicolai and Vaughn streets.

Bicycle lanes approach intersections in a number of different ways that can be divided into two general categories: the bicycle lanes either carry all the way through to the crosswalk, or they drop prior to the crosswalk. The desirable and most common condition is for the lanes to run continuously to the crosswalk. However, there are numerous examples where bicycle lanes drop prior to an intersection. This has been commonly described by cyclists as a distressing deficiency in the network. Such a condition is distressing to many cyclists in part, because one condition under which the bicycle lane drops is when travel lanes are added to accommodate high volumes and high demand at a signalized intersection. Thus, the bicycle lanes are often dropped just when cyclists need them the most: on a high volume roadway where people are switching lanes to turn left or right, or continue straight through an intersection.

The most common situations in which bicycle lanes are dropped are with the development of a right-turn lane or an additional through travel lane at an intersection. Such lanes are added in a number of ways:

- by dropping the bicycle lane(s) and/or parking lane(s) and/or narrowing the existing lanes on the roadway
- by combining the width of unused on-street parking with the width of the bicycle lane, and
- by widening the roadway, but not enough to provide for bicycle lanes.

There are also situations where bicycle lanes continue through an intersection. Mostly notably, this occurs with blue bicycle lanes, which are discussed later. Striping through an intersection also occurs when bicycle lanes are "skip-striped" through an intersection. The Office of Transportation does this in areas where the intersection is either very large, skewed so that movement through the intersection is not clear or requires some diversion from a straight path, or otherwise in need of positive guidance. Skip striping is one means of addressing some Portlander's stated preference for increased guidance about where to be in the public right-of-way.

Primary Facilities: Bicycle Boulevards

Bicycle boulevards are those City Bikeways with fewer than 3,000 vehicles per day (vpd). These are generally Local Service Streets, but can also be Neighborhood Collector Streets. Portland currently has approximately 30 miles of developed bicycle boulevards.

These are streets that generally work well for bicycling because they are low volumes. However, there are things that PDOT does to make them perform better. The sum of PDOT's efforts in creating a bicycle boulevard is to create a supremely family-friendly bikeway on which bicyclists are given priority both by design and operation. This is accomplished by addressing four principal issues:

- Motor vehicle volumes
- Motor vehicle speeds
- Free-flow for cyclists
- Ease of crossing arterial intersections, and

- Way-finding.

Primary among these treatments is reducing volumes of motor vehicle traffic.

As already noted, Portland's best-functioning bicycle boulevards—those on Ankeny, Lincoln and Harrison, Clinton, Williams (north of Killingsworth), and Tillamook streets—owe much of their good performance to prior improvements that dramatically reduced motor vehicle volumes. These diversion devices, of which there are a handful of types and examples in Portland, are the most cost-effective and efficient manner in which to permanently reduce motor vehicle volumes on a roadway. Their type, application, and policies for use are discussed elsewhere in this document.

Reduction in volumes has also occurred on roadways following traffic calming. Traffic calming is used on bicycle boulevards—and elsewhere—to reduce motor vehicle speeds. In addition to keeping motor vehicle volumes low, keeping motor vehicle speeds low is also crucial to the comfortable operation of a bicycle boulevard. PDOT's experience with traffic calming has been that not only are speeds reduced, but volumes of motor vehicles generally drop, as well. For example, after speed bumps were placed on SE Clinton between 12th and 39th avenues, as part of the Clinton-Woodward Bikeway Project, motor vehicle volumes on stretches of the roadway dropped by 25 percent. This was particularly significant because prior to the drop volumes exceeded 3,000 vpd on that stretch. Normally, this would have triggered the striping of bicycle lanes. Because of a narrow roadway, heavy demand for parking, and traffic circles already on Clinton Street, striping bicycle lanes was not a feasible option. While unable to directly address the higher than desirable volumes, we could address speed, which we did by building speed bumps. A beneficial side-effect of addressing speed was to cause a drop in volume below the 3,000 vpd threshold.

Cyclists generally do not like to stop their forward movement; as objects in motion they tend to like to stay in motion. This is true for any mode of transportation. However, the cost of stopping, in terms of personal physical effort required to start again, is greatest for cyclists. Thus, it is generally more desirable for cyclists to stop as infrequently as possible. To accomplish this on boulevard streets PDOT will typically move stop signs as often as possible, to allow free-flow conditions on the boulevard, and instead stop traffic entering the boulevard street. The potential downside to this is that such free-flowing conditions can be attractive to motorists who may decide to use the boulevard street rather than a potentially congested parallel arterial street. This is a condition that the PDOT carefully considers and closely monitors.

One of the conditions on a bicycle boulevard street that helps to keep motor vehicle volumes low, is the difficulty motorists have crossing arterial streets crossed by the boulevard. While moving stop signs can attract motorists, the difficulty of crossing high volume streets tends to deter them. Of course, this crossing difficulty applies to people on bicycles, as well. Therefore, another principal improvement on a bicycle boulevard route is to provide cyclists with good crossings, without simultaneously creating good crossing opportunities for motorists. PDOT's guideline for sufficiency in crossings is an average of one crossing opportunity ("gap") per minute over the peak traffic hour ("rush hour"—generally 5:00-6:00 pm). PDOT has addressed crossings in one of three ways:

- Curb extensions

- Median refuges, and
- Specialized traffic signals.

Curb extensions serve to make cyclists more visible to motorists, and give cyclists a better view of oncoming traffic. Their primary design purpose is to decrease the distance cyclists must cross, and thus decrease the time required to cross. Advance analysis of the intersection identifies whether this approach will be successful in creating more crossing opportunities. Curb extensions work best on two-lane roadways with just one travel lane in each direction of travel.

Median refuges can be used on either two or more lane roadways. They allow cyclists to focus on just one direction of traffic at a time. Rather than requiring a cyclist to wait for gaps in both directions of travel, they can cross one side of the roadway, take refuge, and then consider the second side. Median refuges are generally a raised concrete island of one form or another. Examples can be found at SE Sandy and Ankeny, N Williams at Portland, and NE Davis at South 39th. A painted version of a median refuge is found at SE 41st and Stark. This is more of a bicycle "center turn lane," though it operates as a median refuge, facilitating north-south travel along the 40's Bikeway and the crossing of Stark Street.

Specialized traffic signals—typically either a "pedestrian half signal" or a HAWK[9] signal—are a very effective means to facilitate bicycle crossings because they completely stop the crossing traffic. Portland has not installed new pedestrian half-signals since the late 1980s because the Federal Highway Administration (FHWA) disallowed their use. Portland still has 48 in place, and have incorporated them into several successful bicycle boulevards[10]. Examples can be found at 41st and Hawthorne, 41st and Glisan, Taylor and 39th, and 16th and Hawthorne. In 2006 Portland installed its first HAWK signal at 41st and E Burnside. Its operation has been successful to date and will likely become the standard for additional signalized crossings A significant impediment to their installation is cost. A signalized intersection can cost 2 to 4 times more than either a median refuge or curb extensions.

While Bicycle Boulevards are appealing facilities for riding, until recently they suffered from relative anonymity. Unlike streets striped with bicycle lanes, where the striped lanes themselves advertised those roadways as suitable for bicycling, there was nothing to distinguish a boulevard street from any other street. The improvements that make them work well—crossing treatments, speed bumps, diversion, few stop signs—are either subtle, widely-spaced, or both. As such, there was no obvious visual cue that bicycle boulevards were designed for bicycling. That changed beginning in 2005 with the installation of Bicycle Boulevard Pavement Markings. These one-foot diameter "bike dots" make the bicycle boulevard streets as visible to cyclists as do the bicycle lanes on higher volume roadways. In addition, the boulevard pavement markings also serve a way-finding function as they incorporate arrows to direct cyclists around the inevitable jogs taken by a boulevard route over the miles it runs.

"Bike Dot"

[9] High Intensity Actuated WalK signal is essentially a modified pedestrian half signal.
[10] The existing half-signals were grandfathered in following the FHWA ban. These are called half signals, in part, because they retain stop signs on the local streets entering the roadway and only offer a traffic signal to the arterial traffic on the collector street.

Primary Facilities: Shared Use Paths

Shared use paths are restricted to bicycles, pedestrians, and other non-motorized users. They are among our most popular places in the city to bicycle, and range from paths across the Willamette River on the Hawthorne, Steel and Broadway bridges, to the Springwater Corridor Trail, the I-205 Bike Path, the Eastbank Esplanade, and the extensive trail system in North Portland, including the Marine Drive Trail. Portland has 70 miles of shared, off-street paths.

Design standards for trails have changed significantly since Portland began building trails in the 1970s. Standards formerly called for an eight-foot wide path to be shared by two-way bicycle and pedestrian traffic. Such conditions exist on the Greenway Trail along the Willamette River in SW Portland. Some trail planners also designed blind curves into paths as a means of managing bicycle speeds, believing that if cyclists were unable to see what was approaching around a corner then they would slow down. Portland's experience has demonstrated that wider paths are better for high volumes of mixed users and that ample sight distance is preferable to not being able to see around corners.

Pathways in Portland include some with widths that are significantly substandard by any measurement, including four- to five-foot sidewalks on the St. Johns Bridge, Ross Island Bridge, Sellwood Bridge, and the upper deck of the Steel Bridge. The widths of other paths on bridges also include approximately 8.5-feet of clear space on the Broadway Bridge, eight-feet along the lift span of the Riverwalk on the Steel Bridge, and ten feet on the approaches to the Steel Bridge and on the Hawthorne Bridge sidewalks. Because the bicycle traffic on the Broadway and Hawthorne bridges is essentially one-way on each sidewalk, those facilities operate more like 17-foot and 20-foot pathways—with really wide medians down the center.[11]

The I-205 pathway is generally 10-feet wide, as are the Peninsula Crossing Trail, Marine Drive Bike Path, and Columbia Slough Trail in North and Northeast Portland. The width of the Eastbank Esplanade ranges from 12-14 feet. The predominant width of the Springwater Trail along the Willamette is 14 feet, though it narrows at pinch points. The original section of the Springwater Trail east of Sellwood, is 12-feet wide. Two trails that are currently funded but not yet built are those for the south side of the Morrison Bridge, which will be 15-feet wide (with approximately 13.5 feet of clear space) and the Greenway Trail through South Waterfront. The latter facility will include separate paths for pedestrians and bicyclists. The total width of the Greenway Trail is planned to be 25-30 feet, with 12 feet for the bicycle path, ten feet for the pedestrian path and a landscaped median of varying width between them. Except for this last planned path, pedestrians and cyclists share all other multi-use paths in Portland.

The design of many of Portland's paths, and the operating conditions resulting from those designs has been a source of much friction in recent years. The friction has been between cyclists and pedestrians and among cyclists themselves. The high volumes of cyclists and pedestrians, combined with the great difference in their operating speeds and expectations along our pathways, has resulted in many complaints about their operating conditions. The chief complaints arise from pedestrians uncomfortable with the manner in which cyclists pass them in close

[11] In 2005 Multnomah County, which owns and manages the Hawthorne Bridge, formally signed the sidewalks as one-way for bicyclists. This followed a multi-year consideration of how to best address the many complaints received from pedestrians (and some cyclists) about conflicts and uncomfortable conditions resulting from crowded two-way bicycle traffic.

proximity and speeds that make them feel uncomfortable and unsafe. This complaint is beginning to be made more frequently by cyclists, similarly complaining about being passed in silence, and in close proximity by faster cyclists.

The narrower pathway width of eight or ten feet called for in design guidelines developed in previous decades was sufficient when the numbers of cyclists were much lower than today. With bicycling becoming more popular, and with higher densities of bicyclists and pedestrians on paths, and with expectations of higher volumes to come, current designs seem inadequate to the task of creating a welcoming and comfortable environment for all users.

Primary Facilities: Signed Connections

Portland's Bicycle Master Plan calls for approximately 26 miles of signed connections. In the Transportation System Plan these streets are simply identified as City Bikeways, the same as every other on-street bikeway. Signed connections are intended to be on local, low-traffic streets where bicycle lanes or boulevard treatments are not needed. They are intended to connect two developed bikeways or to provide a connection to major attractions. Examples of Signed Connections are the roadways leading to Mt.Tabor and Rocky Butte, as well as roadways leading to Council Crest and Forest Park. Shorter examples include the segment of SE Clay Street between 12th and Water, and SE 7th between Ankeny and Sandy. Some of these segments could clearly benefit from a more advanced bikeway treatment, notably NW Thurman Street leading to Forest Park. There, traffic volumes are relatively high and speeds can be fast. Other Signed Connections are vestiges of the bikeway system that was in place ten years ago. Such a street is N Concord Avenue, which connected to an overcrossing of N Going Street and served as a continuation of the Denver Avenue bicycle lanes. The striping of bicycle lanes on N Interstate greatly relieved pressure on that route.

Since the only recommended treatment for Signed Connections is signing, these facilities were considered incomplete until the city began to comprehensively sign the city's bikeway network in 2005. Now, most of the designed signed connections have bikeway signing directing people to the appropriate destinations.

Secondary Facilities

There are a number of bikeway network design treatments that help create, augment, or in some cases, substitute for the Primary Bikeway Facilities, described above. These include:

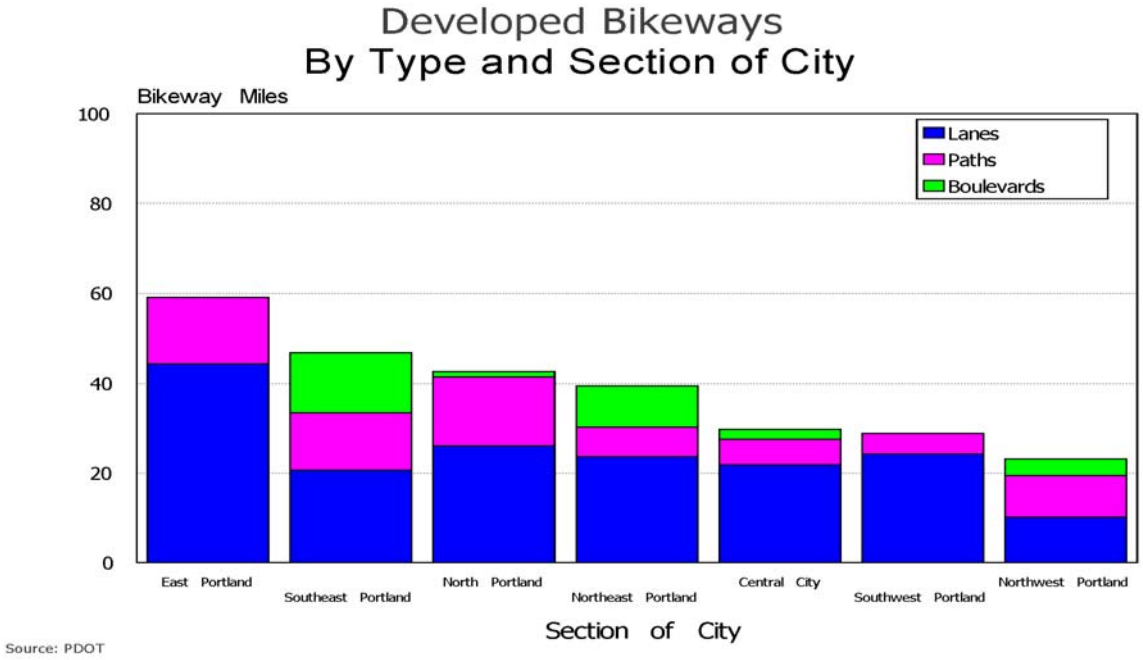
- Shared lane pavement markings
- Arterial crossing treatments
- Traffic calming treatments
- Traffic diversion
- Signing and marking
- Blue bicycle lanes, and
- Bicycle-specific signalization.

These are all described in depth in Chapter 9, Design, Construction and Maintenance Practices.

Cycling Zones

Planning and policy guidance for transportation in Portland often falls along the lines of Portland's seven established transportation districts. These districts are geographic constructs and generally follow the well-established manner in which the city is divided: N, Inner NE, Inner SE, Outer East, SW, NW, and the Central City[12]. Figure 7.7 displays the established bikeways in each of these seven districts.

Figure 7.7



However, this division does not necessarily correlate to cycling conditions. While these seven districts define political divisions within Portland, an accurate map of varying cycling conditions might be more akin to a watershed map, or a map of different biozomes. The conditions that define the cycling environment include:

- Type, quantity and quality of the established bikeways
- Type and quality of local service bikeways
- Barriers and the frequency and ease of crossings
- Access to common destinations, such as retail, employment, entertainment, etc.

Understanding how different areas of Portland operate for bicycles and differ in these aspects will inform recommendations for improving these different areas. Figure XX displays initial thinking about the various cycling zones in Portland.

Defining Cycling Zones

These zones were defined primarily by identifying as boundaries geographic and roadway barriers to leaving the zone. The assumption behind this approach is that people are generally reluctant to cross difficult conditions, such as are presented by these barriers. The zones were also formed with consideration of the relative ease or difficulty

[12] W and E Burnside, the Willamette River, I-205, and N Williams Avenue form the boundaries of these districts. The Central City is comprised of the Downtown, River District, Lower Albina, the Lloyd District, the Central Eastside, South Waterfront, and Goose Hollow.

of crossing these barriers. For example, I-205 is a significant barrier. The zones in East Portland are defined in part by the major roadways to be crossed both north to south and east to west, such as Stark, Division, Powell, Glisan, 102nd, 122nd, etc. In addition, these zones also reflect the relative ease of crossing I-205. The crossings in the north and south tend to be difficult, while those toward the middle are more manageable.

Once the boundaries are defined the zones must be analyzed in a manner that allows for both clear and meaningful qualitative and quantitative comparison. This analysis will incorporate:

- The density of developed bikeways in the zone, both north-south and east-west
- An algorithm that considers motor vehicle speed and volume data on existing City Bikeways, including bicycle lane streets and bicycle boulevards
- Consideration of the quality of other local service bikeways
- Topography of the zone
- Ability of residents to access common retail and entertainment destinations within the zone (i.e., without crossing significant barriers)
- A normalization of the number and difficulty of crossing the barriers into and out of the zone, and
- Average commute trip time (from the US Census) as a proxy for distance people in the district travel on average to get to work.

Deficiencies

Deficiencies are both subjective and objective

- Objective deficiencies can be identified with recognized criteria that are generally agreed upon.
- Other deficiencies will be subjective, with some conditions seeming deficient to some while to others they barely rise to the level of awareness. Indeed, what are deficiencies to some cyclists may be advantages to others.
  - i.e., lanes dropping prior to an intersection may give skilled cyclists the needed opportunity to switch to a desired turn lane.
- At this point, it is the intent of the city to design a system for the average citizen who does not self-identify as a "cyclist" and who is among the majority in terms of expressing concern about operating with motor vehicles. For that reason, this report identifies as deficiencies what many, perhaps even a plurality of current cyclists might not identify as a deficient condition.

Lanes

- Narrow
- Dropped
- Transitions
- High speeds

Boulevards

- Difficult crossings
- Volumes too high
- Speeds too high

Paths

- Too narrow
- Difficult connections
- No separation

Signed Connections

Cycling Zones

Description

- Qualitative
- Quantitative
  - Reasons for selected metrics

Map