Final REPORT

Regional Active Transportation Plan Benefits of Active Transportation and Considerations for Implementation

Prepared for

Metro

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Acronyms and Abbreviations

2035 State RTP	*2035 Regional Transportation Plan* (Federal and state required regional transportation plan) (Metro, 2010)
BMT	bicycle miles traveled
CAZ	Cycle Analysis Zone
CH_4	methane
CO_2	carbon dioxide
EPA	U.S. Environmental Protection Agency
GHG	greenhouse gas
GIS	geographic information system
HEAT	Health Economic Assessment Tools
I-5	Interstate 5
I-205	Interstate 205
I-405	Interstate 405
mph	miles per hour
N_2O	nitrous oxide
ODOT	Oregon Department of Transportation
PMT	person miles traveled
SOV	single occupant vehicle
TOD	transit-oriented development
UGB	Urban Growth Boundary
US 30	U.S. Highway 30
VMT	vehicle miles traveled
Volpe	Volpe National Transportation Systems Center
WHO	World Health Organization

Regional Active Transportation Plan (ATP) Benefits of Active Transportation and Considerations for Implementation

This report articulates the benefits associated with active transportation, considerations that need to be addressed as the regional pedestrian and bicycle networks are developed, and potential costs of development.

Benefits of active transportation described in this report, such as improved health and increased safety, are based on results of Metro's evaluation of potential improvements to the regional pedestrian and bicycle networks and the extensive body of research documenting benefits.

Considerations include implications to policies and other transportation modes that should be taken into account as the network is developed. Costs are generalized, assessed by network and facility type and assume high quality facility design.

The purpose of this report is to provide information for guiding investments and priorities.

Methodology

This report uses data from the Regional Bicycle Network Evaluation and Pedestrian Flow Analysis reports (Metro, 2013) and other regional data sources to draw conclusions about benefits related to active transportation and the bicycle and pedestrian networks. Literature citations and locally produced studies are tied to and support the benefit findings.

Generally, quantitative findings and conclusions are drawn from peer-reviewed academic articles and studies and are referenced more heavily than qualitative or advocacy-oriented literature.

Studies conducted in the Portland region were also prioritized.

Benefits Related to Active Transportation Networks

This section identifies potential benefits to the region associated with improvements made to the existing regional pedestrian and bicycle networks.

Benefits are indentified using results of evaluations of the improved pedestrian and bicycle networks (ATP Regional Bicycle Network Analysis, 2013 and ATP Regional Pedestrian Network Analysis, 2013). Improvements to the pedestrian network included completing sidewalk gaps on regional pedestrian corridors and barrier streets, completing gaps in the regional trail network, and adding pedestrian crossings approximately every 500 feet. Improvements to the bicycle network included a complete network of "bicycle parkways" – the highways of bicycle travel, completing gaps in bicycle lanes and regional trails, and new crossings of barriers. Three different "bicycle parkway" networks were evaluated – a low build (the Mobility Corridor network), a medium build (the Grid network), and the high build (the Spiderweb network). The analysis of results from the regional pedestrian and bicycle network evaluations are supported by and tied to literature citations of research, locally produced studies, and supporting data from surveys.

Benefits of active transportation are organized under four broad criteria.

- Improved **access** to destinations.
- Improved **safety** for all users, regardless of age and ability.
- Increase access for low-income, minority, non-white, non-English-speaking, youth (under 18), disabled, and elderly (over 65) populations **(Equity)**.
- Increase the number of trips made by walking and bicycling **(Increased Activity)**.

Access

An increase in and improved access to destinations via the pedestrian and bicycle networks provide the following benefits:

1. Increased access to destinations by biking and walking
2. Increased travel choices
3. Time savings for shorter trips
4. Makes transit function better
5. Economic – tourism
6. Economic – increased support of local businesses
7. Economic – business retention and recruitment
8. Economic – increased development potential of properties

1. Increased Access to Destinations by Biking and Walking

Evaluated improvements to the regional bicycle network substantially increase access to destinations by walking and bicycling. Each of the proposed "bicycle parkway" networks contains approximately 60 percent greater total bicycle network mileage than the 2010 bicycle network of 866 miles. The substantial increase in total mileage will serve a much larger share of local and regional destinations and provide residents with greater access to jobs, goods, and services without the use of an automobile. Each of the bicycle parkway networks provide more separated, protected, and traffic-calmed facilities, which improve safety.

Improvements to the regional pedestrian network would substantially increase access to regional destinations by constructing a fully built sidewalk and trail system. The evaluated concept assumes that a completed pedestrian network would result in 1,502 miles of sidewalk and 156 miles of trail gaps filled compared to the existing 2010 regional pedestrian network. In addition, the regional pedestrian network includes new pedestrian crossings approximately every 500 feet, to enhance pedestrian connectivity. These new connections would increase the number of people that are within a 1-mile walk of important destinations (including transit, parks, food, civic, health, and retail locations) for proposed pedestrian districts, pedestrian corridors, and regional trails. The change in access to destinations compares the existing pedestrian network to the proposed completed Regional Pedestrian Network.

Biking and walking serve the following primary destination types – access to transit; differentiating high capacity or high frequency transit; and access to jobs, basic services, hospitals, school, civic institutions, town centers, retail, and grocery stores (healthier food). Transportation is a derived demand, meaning people travel to get to places, so access is a direct benefit.

Accessibility is the ultimate goal of most transportation. The demand for travel is directly derived from the demand for economic-related activities such as labor, goods, and services. Improving walking and bicycling conditions helps improve the convenience, comfort, and affordability of access to destinations by increasing the diversity of transportation options. These bicycle and pedestrian networks would also increase access to healthier food options, especially in "food deserts" where few full-service grocery stores are in close proximity. Bicycle and pedestrian access to transit stations can help facilitate longer trips, especially when the origin or destination of the trip is not within walking distance of transit.

The ability to walk or bike to destinations increases the incidence of active transportation. Humpel et al. (2004) found that positive changes in perceived convenience of accessing walkable streets and paths led to twice the amount of physical activity over a 10-week timeframe. Owen et al. (2004) found in a literature review that perceived accessibility of destinations such as stores or parks was found to be positively associated with walking for transportation purposes. Similarly, Hoehner et al. (2005) discovered that physical activity for transportation was positively associated with the perceived and objectively measured number of destinations, including grocery stores and restaurants, within a 5-minute walk in a neighborhood. Buehler and Pucher (2011) found that cities with greater supplies of bike paths and lanes have significantly higher bicycling mode share; both facility types have a similar positive association with bicycling commute levels in American cities. Infrastructure that allows convenient biking and walking to transit can also increase access to destinations. Transit-oriented developments

(TODs) feature high sidewalk connectivity. Cervero (2006) reported that, for commutes of 30 minutes or less, survey respondents who moved to TODs from non-TODs enhanced accessibility to jobs by 6.5 percent compared to driving because of the availability of transit within short walking distances.

The increase in density and connectivity of sidewalks and bikeways facilitates access. This would likely increase the likelihood of individuals walking or bicycling to destinations. Density is measured by the linear feet of bike routes in an area, while connectivity is measured by the number of intersections (of three connections or greater) per area.

Bikeway connectivity without proportionate density may not result in a high quality bike network. In the 2035 State RTP network, the area with the highest density of bikeways is Downtown, Northwest Portland, and Goose Hollow, while the area with the highest connectivity of bikeways is in East Portland between Sandy Boulevard and Division Street. In the 2035 State RTP network, all areas will experience either an improvement in density and connectivity or no significant changes in the local network between the 2035 State RTP network and the bicycle and pedestrian network concepts evaluated.

Table 1 indicates that each of the bicycle network concepts significantly increases access to destinations compared with the existing 2010 network. Of the three bicycle network concepts, the Spiderweb Concept provides the greatest density and connectivity of bike routes. This concept supplies the most comprehensive access to regional destinations.

TABLE 1
Bicycle Network Miles of Facilities by Type, Portland Region within the Urban Growth Boundary

	Bicycle Network				
BICYCLE FACILITY	**2010**	**2035 State RTP**	**Spiderweb Concept**	**Mobility Corridor Concept**	**Grid Concept**
New Bicycle Boulevard	–	–	5	1	10
Improved Bicycle Boulevard	–	–	16	1	16
Total Bicycle Boulevard	65	165	170	166	175
New Trail	–	–	35	21	30
Improved Trail	–	–	98	58	81
Total Trail	109	248	283	268	278
New Cycle Track	–	–	11	8	8
Improved Bicycle Lane to Cycle Track	–	–	150	68	120
Total Cycle Track	0	2	161	76	129
Total Bicycle Lane	691	921	771	853	800
Total Advisory Bike Lane	0	24	24	24	24
Total Bicycle Network	866	1,359	1,409	1,387	1,406
Total Miles of Bicycle Parkway	–	–	314	157	266
Total New Bicycle Facilities	–	–	51	30	49
Increase in Facilities over 2035 State RTP Network			3.7%	2.1%	3.5%

2. Increased Travel Choices

Making improvements to the regional bicycle and pedestrian networks increase the transportation options for more Metro area residents, making bicycling and walking more viable for daily travel. With these increased options, residents are able to reduce the amount they drive. Additional facilities are likely to attract more residents to walking and bicycling by meeting unmet latent demand. The bicycle and pedestrian network evaluation indicated that increasing the miles of pedestrian and bicycle facilities available to people increased access and use.

Increasing infrastructure that provides protection from traffic, especially separated paths, will encourage more people to walk and ride bicycles. Research by Dill and Gliebe (2008), conducted within the Portland region, indicates that bicyclists will travel out of their way to use a separated path, even if a shorter route is available on high traffic streets. Those who live in areas with a connected street grid are more likely to bicycle and bicyclists will avoid streets with high vehicle traffic.

According to Metro's Opt In Poll (2012), most respondents (75 percent or more) indicated that more dedicated bike lanes would encourage bike riding for transportation on a more frequent basis. More than 60 percent of those who responded to Metro's Opt In poll were interested in riding a bicycle as a mode of transportation more often.

Table 1 shows the increase in all types of facilities in the bicycle networks evaluated. The bicycle networks that provide more separated facilities increase the attractiveness of bicycling and the number of residents who would use bicycling as a mode of transportation. Therefore, the network with the most miles of separated facilities (Spiderweb network) is more likely to attract riders and would provide more options for those who prefer separated facilities (283 miles).

A Volpe National Transportation Systems Center (Volpe) study showed that when cities invest in on- and off-street non-auto infrastructure, the amount of miles traveled by walking or bicycling increases between 22 and 49 percent. In communities where these investments occur, the bicycling and walking mode share increases above the national average. The driving mode share also decreased in communities with improved non-motorized facilities (Volpe, 2012).

Evaluation of the networks shows that as separated bicycle facilities are added, bicycle miles traveled (BMT) on separated facilities (trails and cycle tracks) would increase substantially from the existing 2010 network. BMT on separated facilities increases by 45 percent with the Spiderweb network, 38 percent with the Mobility Corridor network, and 43 percent with the Grid. The increase in travel correlates directly with the amount of separated facilities built (shown in Table 1).

In addition, the model data support the research findings—bicycle trips increase when there are more separated facilities. For each of the concepts, there is around a 1 percent increase in bicycle trips compared to the 2035 State RTP system (Metro, 2013).

Pedestrian analysis did not provide a forecast of future potential use in the same way as evaluation of the bicycle networks did; however, the Pedestrian Flow Analysis demonstrates that pedestrians within the Metro region have increased access to essential destinations with the 2035 pedestrian network relative to existing conditions (Pedestrian Network Analysis, 2013).

Expanded access for pedestrians and bicyclists results in expanded travel choices for Metro residents. Moreover, with a more robust and intertwined network, the viability of bicycling and walking for every-day travel increases, and they become legitimate choices compared to auto travel.

3. Making trips by bicycle can provide Time Savings benefit

Short trips made by car could take more time than the same trips using a bicycle, especially if the time for parking is included. If short trips, those less than 3 miles, are increasingly made by bicycle, the result would be less auto congestion for all users of system.

The average trip length of bicycle trips within the UGB is less than 3 miles (Metro, 2013), and nearly 45% of trips made by car are under 3 miles in length and 15% are under one mile in length (Metro, 2013). For trips under three miles, the bicycle is competitive in terms of travel time with the automobile. Jennifer Dill, transportation planning professor at Portland State University, conducted a study within the Portland region, and found that for half of shorter trips (3 miles or less), the difference between bicycle and automobile travel time was less than 5 minutes (Dill, 2008). Add to that the time that it takes to park a car, and, for short trips, bicycling is competitive with driving a car in terms of total travel time, and bicycling has the potential to provide travel time savings.

4. Linking Transit, Biking, and Walking Supports Transit

Establishing pedestrian and particularly bicycle connections to bus and train stations helps extend the reach of the transit network, making transit commute trips feasible for a broader segment of the population. Providing pedestrian and bicycle connections to transit can help replace trips that were previously taken by automobile (Bachand-Marleau et al., 2011). Increasing access to transit for non-motorized transportation can help with the first mile/last mile problem of commuting when households or places of employment are beyond a realistic distance for walking from a transit station. Taylor and Mahmassani (1996) found that commuters located within 1.5 miles of a transit station are best suited for accessing transit by bike, although distances of 2 to 3 miles are also plausible. The “first/last mile” is used to describe the difficulty people face when trying to get from their origin or destination to a transit hub or station, especially in lower density areas. To and from a transit station, pedestrian or bicycle access may be difficult because of a discontinuous, long, or unsafe network, termed, “the first/last mile” problem.

Improving sidewalk and trail connectivity and adding crossings increases pedestrian access to transit. In the pedestrian network evaluation areas with the highest transit access “score,” or the greatest increase in the number of people with access to transit, are concentrated in Washington County, particularly along the TriMet Westside MAX lines. This is because the existing sidewalk network is discontinuous and the lack of regular pedestrian crossings is common in suburban locations. Other areas with high increases in transit access are the Gateway Transit Center in Northeast Portland and the Park Avenue MAX station in Clackamas County. It is important to note that access scores favor larger areas with more people, because regional pedestrian areas are not uniform in size.

To facilitate bicycle/transit trips, it is important to fully integrate bicycles with the transit system, by either providing enough covered, secured parking at the stations or allowing bicycles aboard transit vehicles. These improvements, if combined with suburban bicycling infrastructure enhancements, can be effective in expanding the catchment area of transit stations. The existence of bicycle lanes at a minimum along the route provides a significant incentive, especially for inexperienced cyclists, to access transit by bike rather than automobile (Taylor and Mahmassani, 1996).

The provision of sidewalks at the origin and destination stations and the presence of a walkable street grid with high connectivity within station areas significantly influences whether someone accesses the station by foot or bike, or use transit at all (Cervero 2001 and 2006).

Pucher et al. (2010) discovered through a literature review that provision of adequate bicycle parking at public transit stations increased both transit and bicycle use. Lockers are found to be strongly preferred to short-term bicycle racks because of perceived security advantages, assuming both offer equal amounts of weather protection (Taylor and Mahmassani, 1996). Bicycle racks on rail and bus vehicles are purported to have positive effects, as well, although the finite capacity on vehicles is judged insufficient to handle demand during peak hours. This may be an issue, because 60 percent of respondents in a survey preferred the option to bring their bicycle on board transit. However, the option of parking bicycles at one end of the trip may be used more often (Bachand-Marleau et al., 2011). Bikeshare stations placed at key transit locations may help reduce the incidence of individuals bringing their bicycles aboard transit vehicles.

A denser bicycle network that is well connected will provide better access to transit. The Oregon Household Activity Survey estimates that bicycles were used to access transit for 3 percent of all transit trips. The average bike trip distance for this commute is 2.5 miles, with the total bike and transit trip averaging 10 miles. Access to destinations and directness of route are two explanations why more bicycle miles are traveled per mile of cycle track than bicycle boulevards, even though both facility types received the same level of attractiveness in Metro's bicycle model (Metro, 2013).

5. Economic – Tourism

A denser, more connected, bicycling and walking facilities create destinations for tourism walking and bicycling.

The increase in density and interconnected pedestrian and bicycle network will support tourism-related economic development as more and more tourists are visiting areas with attractive bicycle infrastructure. According to Darren Flusche's research on bicycling and economic development, nationwide, the bicycling industry contributes an estimated $133 billion a year to the U.S. economy, supporting nearly 1.1 billion jobs and generating $17.7 billion in federal, state, and local taxes. In 2008, bicycle-related activity in Portland generated around $90 million, with 60 percent of that amount from bicycle retail sales, rental, and repair. Tourists who are likely to use a bicycle while on vacation generally are in higher income brackets and spend more per day than traditional car-oriented tourists (Flusche, 2009).

An Oregon Bicycle Tourism Study for Travel Oregon concluded that travel-generated expenditures made for both day and overnight trips in Oregon with bicycle activity amounted to over $325 million in 2012. Of the 17.4 million people who visited Oregon in 2012, 4.5 million rode a bicycle while in the state. The amount of expenditures in Portland is less than the statewide figures, though some of the tourists that come to Oregon are likely to visit the Portland metropolitan area.

The bicycle network concepts are likely to continue to support bicycle tourism within Portland by increasing the off-street and separated bicycle facilities, especially the trails. According to Canada's "Bike on Tours" website (2013), elements that attract bicycle tourists include the following:

- Bicycle-friendly streets and paths that are wide enough for bicyclists and other users
- Access to scenic roads, natural areas, and waterfront, cultural, and historic attractions
- Route maps and effective advertising

Interconnected bikeways also foster tourism by providing an easy-to-use and connected system within the city.

6. Economic – Increased Support of Local Businesses

People who walk and bike to local businesses spend as much as customers who drive, and actually spend more at all types of businesses except super markets.

Kelly Clifton, transportation planning professor at Portland State University, conducted an empirical study of travel choices and consumer spending across 89 businesses within the Portland metropolitan area, and found that bicyclists, pedestrians, and transit riders are competitive consumers (Clifton, 2013). When demographics and socioeconomics are controlled for, transportation mode choice does not have a statistically significant effect on consumer spending at convenience stores, drinking establishments, and restaurants. When trip frequency is accounted for, the average monthly expenditures by customer modes of travel reveal that bicyclists, pedestrians, and transit riders are competitive consumers and, for all businesses except supermarkets, spend more than those who drive.

All three bicycle networks and the Regional Pedestrian Network provide added connections to commercial corridors and urban centers, which are destinations with local businesses.

Economic – Business Retention and Recruitment

Many businesses locate where their employees will have transportation options. Employees consider transportation when looking for work and biking and walking facilities have the potential to attract the 'creative class.'

Increasing transportation options to commercial and employment centers widens the potential pool of employees for companies and widens employment opportunities for those populations who may be limited in their ability to drive. Providing facilities for walking or bicycling increases the comfort and opportunities of residents to walk or bike to employment opportunities or to more readily access transit to increase employment options.

Cities that foster a culture of walking and bicycling, including supporting it with infrastructure, are better at attracting the ‘creative class,’ knowledge based workers, such as engineers, attorneys, and healthcare providers. The ‘creative class’ is a term developed by Richard Florida (2002), professor of economics at Carnegie Mellon University. In his discussion of creative class theory, he explains that places are valued for their authenticity and uniqueness by the ‘creative class.’ He argues that an authentic place offers unique and original experiences—a place made up of chain stores and restaurants is not authentic because chain establishments can be experienced anywhere. In an examination of Asheville, North Carolina, Scherer (2007) found that cities, such as Asheville have been successful in attracting the creative class, in part because of their bicycling and walking infrastructure. Asheville has received accolades from magazines for being a great walking town and a great biking destination.

The project team analyzed pedestrian facility improvements to determine the population within a half-mile buffer from the improvements, what proportion of residents already had access to destinations, and the percentage increase in access for populations with the pedestrian facility improvements along the corridors, districts, and regional trails. The results show that investments in areas currently lacking facilities for pedestrian access greatly improved the percentage of the population with increased access. With the improved Regional Pedestrian Network, the biggest gains are generally outside of the Central City. Outer east Portland and the southwest and southeast areas of the metropolitan area realize larger percentages of the population with increased access. The Central City and inner east side, while housing a large portion of the population, already provide fairly complete access to destinations for pedestrians. Therefore, in those areas, small pedestrian facility improvements do not notably increase access for adjacent populations.

The findings from the same analysis for districts are similar to the study corridor findings. Investments in areas outside of the downtown and Central City provide access for a larger portion of the adjacent population than improvements in areas with existing good connectivity. The Regional Pedestrian Network increases access for up to 50 percent of the population, depending on the district. Again, the study districts outside the Central City core area had the largest gains in population with access to destinations; in the Park Avenue Park and Ride, Hayden Island, and 148th Avenue Districts, access increased for over 40 percent of the population (ATP Pedestrian Network Analysis, 2013).

8. Economic – Increased Development Potential of Properties

Adding bicycle and pedestrian facilities increase property values. Planned improvements to the regional bicycle and pedestrian network have the potential to increase the real value and development potential of property in the region.

Relatively recently, studies have investigated property value effects from nearby bicycle and pedestrian facilities. A few researchers have found that, in Indianapolis, Indiana, houses closer to multi-use trails sell for an average of 11 percent more than similar houses in other locations. A multi-use path has a positive, statistically significant effect on home values (Flusche, 2009).

The National Association of Realtors & National Association of Home Builders (2000) found in their “Consumer’s Survey on Smart Choices for Home Buyers,” publication that 36% of 2,000 home buyers designated multi-use trails as either an “important” or “very important” community amenity. Trail availability outranked 16 other options, including security, parks, and access to shopping or business centers.

As shown in Table 1, the three bicycle concepts increase off-street bicycle facilities by between 344 and 444 miles, potentially increasing property values along those routes. Higher real estate prices translate to higher property taxes and property redevelopment adjacent to these separated bicycle facilities.

A study by Metro and Fregonese and Associates found that investments in public amenities (including non-automobile transportation options, commercial services, and parks and open space) will have a major effect on development feasibility. The non-automobile transportation options include pedestrian facility improvements (streetscape designs around desirable destinations), bike infrastructure (wayfinding to bike lanes and street improvements on low traffic streets and/or bicycle boulevards), and streetcars for dense, urban settings. These transportation and other amenities, which would allow land developers to realize a higher return on investment, help spur property redevelopment. Consequently, the City Portland region within the UGB could realize the density specified in the applicable zoning code (Fregonese and Associates, 2010).

Gary Pivo studied how walkable areas affect property values. He found that greater walkability increases commercial real estate property values and their developers' return on investment. The study found that a 10-percent increase in walkability increased property values by 1 to 9 percent, depending on the type of property (Pivo, 2013). The bicycle concepts and the Regional Pedestrian Network increase walkability by making regional connections and closing gaps in the bicycle and pedestrian networks. These improvements are likely to increase values for commercial, residential, rental, and retail properties within the City.

Safety

Walking and biking provide users, regardless of age and ability, with the following safety benefits:

1. Increased actual and perceived safety
2. Reduced instance and cost of crashes
3. Personal security because of "eyes on the street"
4. Increased safety for other modes of travel

1. Increased Actual and Perceived Safety

Adding facilities separated from traffic, overcoming barriers, and providing improved crossings enhances actual and perceived safety of people walking and riding bicycles. To increase region-wide pedestrian and bicycling mode share, new dedicated infrastructure such as sidewalks and multi-use paths are needed to increase safety and encourage more people to walk and bike for daily trips.

Disconnected sidewalk networks, the lack of safe crossings, and fast, wide roadways with large crossing distances discourage individuals from walking, especially in auto-oriented environments. Moreover, the lack of bicycle infrastructure, either dedicated space on streets or separated from automobile traffic, discourages those who are "interested but concerned." This subset of the population is curious about bicycling, and may ride sometimes for recreational purposes, but perceives that utilitarian bicycling is unsafe because of the possibility of riding alongside motorists or in shared traffic lanes (Geller, 2006). This group would like to see more quiet streets with fewer cars, as well as more paths without any cars at all.

For pedestrians, the presence of a sidewalk is fundamental to their sense of safety and comfort in the road environment (Landis et al., 2001). Greater lateral separation between vehicles and pedestrians and the presence of buffers such as trees or parked cars further increase the perceived comfort or safety of pedestrians, while higher vehicle speeds and volumes decrease their sense of comfort and safety. An increase in perceived safety may lead to greater rates of bicycling and walking. This would likely lead to increases in actual safety, which is a benefit in and of itself.

Perceived safety is closely related to actual safety. Cho et al. (2009) reviewed the relationship between perceived and actual crash risks for pedestrians and found that higher actual crash risks increased the perception of crash risk, while higher perceived crash risk is negatively associated with actual crash rates. The authors found that an increased perception of risk and an unfriendly environment reduced actual crash rates for both pedestrians and bicyclists because of behavioral changes (Cho et al., 2009). Perceived safety may increase as the number of cyclists and pedestrians increase after developing more specialized infrastructure. Jacobsen (2003) and Robinson (2005) determined that collision rates between pedestrians or bicyclists and motorists decline as the number of people walking or bicycling increases. This suggests that motorists exhibit greater awareness of vulnerable road users when they see more of them. Therefore, they drive more cautiously to avoid collisions.

Pedestrian collision risk decreases in areas with higher pedestrian volumes, and increases with higher motor vehicle volumes (Geyer et al., 2006). Severe single-bicycle crashes are also reduced in areas with high bicycle mode share (Schepers, 2012). Schneider et al. (2003) determined that both pedestrians and drivers perceived a lower pedestrian crash-risk environment when more complete sidewalks were provided and more danger when segments or intersections had incomplete sidewalks.

Dill (2009) and Tilahun et al. (2007) determined that bicyclists are willing to go out of their way to ride along on-street bicycle lanes, bicycle boulevards, and completely separated paths. This finding supports the need for well-connected neighborhood streets and a denser network of bicycle-specific infrastructure to entice more adults to bicycle for transportation. Hunt and Abraham (2007) found that time spent bicycling in mixed traffic conditions is more onerous for riders than time spent bicycling on bike lanes or bike paths. This has been replicated in stated preference surveys dedicated to women (Garrard et al., 2007), young children (Mehan et al., 2009), and senior bicyclists (Hayes et al., 2003). These populations indicate a preference for using off-street separated paths because of perceived safety benefits. Those perceptions may lie close to reality. Cyclists riding on streets are at increased risk of conflicts with motor vehicles, and those injured in crashes involving a motor vehicle sustain more severe injuries (Haileyesus et al., 2007).

The Bicycle Network Evaluation (Metro, 2013) found that safer, higher quality facilities attract a higher number of bikes per mile of bicycle facility because opportunities for safe bicycle travel increase. Bike model data show that people prefer regional bicycle parkways and other separated facilities for travel because they completely separate the bicycles from vehicle traffic. Therefore, adding such facilities offers the potential to increase the number of bicycle trips. The number of BMT on bicycle lanes decreases up to 44 percent from the 2035 State RTP network to the network concepts, while the amount of BMT on roadways with no bicycle facilities decreases up to 11 percent. Much of that traffic is shifted to separated facilities, such as trails and cycle tracks, where there is a substantial increase in the number of BMT. Based on geographic information system (GIS) analysis, the improvements in the Spiderweb Concept would intersect with the highest number of pedestrian and bicycle crash locations between 2007 and 2011 (619 crashes) compared to 408 crash locations in the Grid Concept and 247 crashes in the Mobility Corridor Concept.

The Regional Pedestrian Network concept identifies new sidewalks and pedestrian crossings added to roads within the Regional Pedestrian Network that Metro identified as having barriers to pedestrians (that is, those with high volumes, speeds, and auto lanes). Improvements to the sidewalk network would help improve both perceived safety and actual safety in the region.

- **High-risk barrier streets.** The area with the greatest number of sidewalks added to high-risk barrier streets was Damascus in Clackamas County. The areas where the highest number of new crossings were added were in Milwaukie in Clackamas County; the Hayden Island MAX station and St. Johns in North Portland; and the Flavel Street MAX station in Southeast Portland.
- **Pedestrian corridors.** For pedestrian corridors, the greatest number of new sidewalks per mile of barrier streets was located on SW Stafford Road and SE 242nd Avenue in Clackamas County, while the greatest number of new crossings was on SW Dosch Road in Southwest Portland and on Johnson Creek Boulevard in Clackamas County.
- **Trails.** The trails that had the most sidewalks added nearby were Sullivan's Gulch Trail in Northeast Portland and North Clackamas Greenway in Clackamas County. In addition, a very high number of new crossings were added in the vicinity of several trails across the region.

2. Reduced Instance and Cost of Crashes

Improving regional bicycle and pedestrian networks, especially on arterial roadways would help reduce crash risks for people walking and bicycling.

Society bears a heavy economic and emotional toll from the loss of life and incapacitating injuries resulting from automobile crashes. In the Portland metropolitan area in 2009*,* serious pedestrian crashes resulted in 11 fatalities and 39 incapacitating injuries (Metro, 2012). In addition, 4 bicyclists died and 36 bicyclists suffered incapacitating (Type A) injuries. The National Safety Council estimates the economic cost (in 2010 dollars), such as lost wages and productivity, medical expenses, and administrative expenses, of each fatality to be $1,420,000, and for each Type A injury to be $69,200. The total comprehensive cost (in 2011 dollars) of each traffic fatality is estimated at $4,360,000and for each incapacitating injury at $220,300 (National Safety Council, 2012). This includes economic costs as well as the measure of the value of lost quality of life. In 2009, the total comprehensive cost from serious crashes in the Portland metropolitan area was almost $82 million in 2011 dollars. Table 2 shows the total region-wide Portland metropolitan area economic and comprehensive losses from serious crashes in 2009.

TABLE 2
Annual Cost of Fatalities and Incapacitating Injuries in the Portland Metropolitan Area (in 2011 dollars)

	Number of Fatalities in 2009	Number of Incapacitating Injuries in 2009	Economic Cost per Person		Comprehensive Cost per Person		Total Economic Cost	Total Comprehensive Cost
			Fatalities	Type A Injury	Fatalities	Type A Injury		
Pedestrians	11	39	$1,410,000	$69,200	$4,360,000	$220,300	$18,208,800	$56,551,700
Bicyclists	4	36	$1,410,000	$69,200	$4,360,000	$220,300	$8,131,200	$25,370,800
TOTAL							**$26,340,000**	**$81,922,500**

Source: Metro, Year 2012; National Safety Council, 2012.

The annual number of serious pedestrian-motor vehicle crashes leading to fatal or incapacitating injuries fell from 122 in 2007 to 90 in 2009 (According to the *Metro State of Safety Report* (Metro, 2012). In the region, most serious pedestrian motor vehicle crashes occur on arterials (67 percent) and on roads with 4 to 5 lanes (50 percent). The regional pedestrian network would provide complete sidewalks on arterials when implemented. Pedestrian motor vehicle crashes are the second most common fatal crash type in the region, constituting 29 percent of fatal crashes and 11 percent of serious crashes, compared to 2 percent of all crashes in the region. The "most contributing factor" to these pedestrian crashes is that the motorist failed to yield right-of-way (30 percent), followed by the motorist's alcohol or drug consumption (23 percent). Most serious bicycle crashes occur on arterials (52 percent) and on roads with 2 to 3 lanes. The "most contributing" factors to serious bicycle crashes is that the motorist failed to yield right-of-way (48 percent), followed by the motorist's alcohol or drug consumption (11 percent).

Retting et al. (2003) reviewed literature evaluating the efficacy of traffic engineering countermeasures to improve safety by reducing the incidence of pedestrian-motor vehicle crashes. The studies they reviewed showed the following results:

- Traffic-calming measures designed to manage vehicle speeds could decrease pedestrian-motor vehicle crashes by 25 percent.
- Other measures to reduce crashes include better crosswalk treatments, such as the following:
  - Refuge islands in the middle of roadways decreased the risk of conflicts by 50 to 67 percent compared to intersections without refuge islands.
  - Crosswalk markings were associated with either no difference in pedestrian crash rates or higher crash rates, although the difference in crash risk was associated with the inherently more unsafe conditions at uncontrolled intersections.

- – Pedestrian overpasses decreased the number of crashes by up to 91 percent near the intersection.

- Installing in-pavement flashing lights to warn drivers when pedestrians are present reduced vehicle speeds, increased driver compliance at crosswalks, and reduced the number of incidents.

Knoblauch et al. (1987) discovered that, in residential and mixed residential areas, pedestrian crashes were more than twice as likely to occur at locations without sidewalks than otherwise would occur on the basis of pedestrian exposure to accidents when crossing roadways. Residential areas that had no sidewalks had 23 percent of all reported crashes in the study area compared to just 3 percent of exposure.

Reynolds et al. (2009) reviewed literature related to the effect of transportation infrastructure on bicycling injuries and crash rates. They determined that, although the studies sometimes had conflicting results, generally bike lanes and paths have lower crash-rate and injury risks than roadways without bike facilities. In one study, roads with marked bicycle lanes were found to reduce collision frequency by 53 percent. However, in another study, total crash rates increased on roads with bicycle lanes, especially roads with left-hand bicycle lanes, compared to roads without such lanes. Bicycle crash rates on streets without bike facilities were found to be greater than rates for on-road bicycle routes or lanes; the rates for serious crashes involving hospitalization showed a similar trend. The relative risk for bicycling injuries based on infrastructure type was highest for major thoroughfares, less so for neighborhood streets and sidewalks, and lowest for bike paths and unpaved streets. The risk of being a cyclist who had a collision or fall in the past year was 40 percent lower on bicycle paths and lanes than on roadways.

Based on crash history data on Montreal facilities, Lusk et al. (2011) found that cycle tracks had 2.5 times the number of riders as comparable reference streets. The risk of injury on cycle tracks was over 25 percent less than on streets without dedicated bicycle infrastructure. Bicycle lanes on roads may also improve safety and the collision risk for all users by reducing vehicle speeds. Converting excess vehicle capacity to on-street bicycle lanes in the form of a road diet[1] was shown to reduce crash frequencies by 6 percent after the road diet was implemented (Huang, 2003). However, the road diet did not affect crash rates or severity. However, Pawlovich et al. (2006) showed that road diets in Iowa reduce crash frequency per mile by 25 percent and crash rates by 19 percent.

Improvements in the bicycle concept and pedestrian networks (such as providing a greater number of separated-facility, low-traffic bicycle boulevards; constructing improved crossing locations; and addressing gaps in the existing network) would either reduce or eliminate conflicts with vehicles (depending on the facility type), and lead to fewer crashes or reduced crash severity. This would reduce the cost of crashes related to pedestrian and bicyclist casualties.

Bicycle boulevard facilities with traffic-calming features (such as chicanes, speed bumps, and diverters) will reduce the number of vehicles on the roadway and reduce the speed differential so that shared traffic operation becomes more comfortable for cautious or inexperienced bicyclists. Pitt et al. (1990) found that children were injured much more severely when struck by vehicles exceeding 30 miles per hour (mph) compared to those who were hit by more slowly moving vehicles. Haileyesus et al. (2007) discovered that cyclists riding on streets are at an increased risk of colliding with a motor vehicle and will sustain more serious injuries than those riding on separated facilities. However, improved facilities on high-speed, high-volume traffic arterials would be most effective in reducing serious bicycle crashes and lowering the cost of crashes within the region. The *Metro State of Safety Report* (Metro, 2012) noted that 53 percent of all fatal and serious bike crashes occurred on arterial roadways.

The bicycle and pedestrian networks would provide the greatest number of improvements to areas with the greatest number of pedestrian and bicycle crash locations. Based on GIS analysis, the improvements in the Spiderweb Concept would intersect with the highest number of pedestrian and bicycle crash locations

[1] A road diet reduces the number of lanes from an even number, such as four or six , with two, three, or more lanes traveling in each direction, to a an odd number of lanes, such as three or five, with a center turn lane. Road diets have shown to reduce the number of rear-end collisions and usually allocate removed travel lane width to bicycle and pedestrian facilities.

between 2007 and 2011 (619 crashes). Compare this to 408 crashes in the Grid Concept and 247 crashes in the Mobility Corridor Concept. The Spiderweb Concept has the densest bicycle network, especially in the Central City (which had the highest number of pedestrian and bicycle crashes between 2007 and 2011. The Spiderweb Concept (and Grid Concept, to a smaller extent) includes improvements along high-crash corridors such as the 120th, 122nd, Barbur, Division, Powell, Williams-Vancouver, Sandy, and Foster corridors in Portland. Other high-crash areas that are not addressed include the MLK, Cesar Chavez, Powell, 181st, and Broadway corridors in Portland, as well as Gresham, Beaverton, Hillsboro, Raleigh Hills, and Tualatin areas. For the Regional Pedestrian Network, many of the high-crash corridors are located on barrier streets, where the majority of sidewalk and crosswalk improvements are planned. Therefore, the Regional Pedestrian Network will likely help reduce the number of pedestrian crashes significantly.

The Spiderweb Concept would have the most miles of separated facilities of the three concepts (444 miles of trails and cycle tracks) (Table 1). All three bicycle network concepts would have lower average daily BMT on roadways with no bicycle facilities (22 to 23 percent) compared to the 2010 network (39 percent) and the 2035 State RTP network (26 percent) (Table 2). The Spiderweb Concept bicycle network would also have the highest average daily BMT on separated facilities (45 percent) compared to the Grid Concept (42 percent) and the Mobility Corridor Concept (38 percent). All three bicycle networks perform better in this regard than the 2010 network (11 percent) and the 2035 State RTP network (25 percent). These results imply that a greater share of total bicycle travel on separated facilities and a reduced share of travel on roadways with no facilities would reduce bicyclist conflicts with vehicles, bicycle-motor vehicle crash severity, and costs associated with bicycle-motor vehicle crashes. The Regional Pedestrian Network would have similar outcomes, because improved connections would increase the walking mode share and corresponding driver awareness of pedestrians, which would reduce pedestrian-motor vehicle crash risk.

3. "Eyes on the Street" improves personal security

Implementing the Regional Pedestrian Network would increase walk scores in areas with network additions. Based on the correlation that Anderson et al. (2013) found, implementation of the Regional Pedestrian Network could decrease the occurrence of crime because of added "eyes on the street."

The concept of "eyes on the street" asserts that the greater the number of people walking on a street, the greater the number of eyes and, therefore, greater personal security. The number of witnesses on the street would deter people from committing crimes.

Planners and those in the criminal law field have studied the effects of the built environment on crime. In the Los Angeles, California, area, researchers found that, when controlling for zoning, blocks with higher walk scores (meaning blocks that are more walkable from an urban design standpoint) have slightly lower expected crime counts compared to adjacent areas (Anderson et. al, 2013). The study itself measured a correlation between higher walk scores and lower crime rates. The implication of this finding is that better walking facilities lead to higher walk scores. Presuming that people use the better facilities, they would create a greater presence on the street, which would deter criminal acts.

4. Increased Safety for Other Modes of Travel

Separated bicycle and pedestrian facilities can reduce potential conflict points and make it safer to operate vehicles and freight trucks. Roadway diets can benefit certain vehicle crash types, such as rear-end crashes.

Safety and the perception of safety are important for any mode of travel. The three bicycle concepts and the improved Regional Pedestrian Network would increase the number of separated facilities in the Portland metropolitan area, reducing conflict points. The Regional Pedestrian Network would add 156 miles of trails (including barrier-street crossings), while the three bicycle concepts would add between 21 and 35 miles of new trails, and between 58 and 98 miles of improved trails (Table 1). The three bicycle concepts would add or improve between 156 and 298 miles of traffic-separated bicycle facilities (either trails or cycle tracks), adding improved on-street facilities and facilities in areas not currently designed for active transportation modes.

Providing facilities to allow residents to increase their usage of active transportation modes and reduce reliance on the automobile would reduce exposure to automobile crashes. A study by Frumkin et al. (2004) found a correlation between high levels of vehicle miles traveled (VMT) per capita and higher accident and injury rates. More time in vehicles increases exposure to vehicle crashes. When travelers move to active transportation modes, especially on separated facilities, the exposure to crashes in vehicles would decrease (Frumkin et al., 2004). All three bicycle concepts and the Regional Pedestrian Network would allow more residents to reduce their personal VMT, potentially reducing their exposure to vehicle crashes and injuries.

In addition, a study conducted by Lusk et al. (2011) concluded that the injury and crash rate for bicyclists on cycle tracks was less than the rates on in-street bicycle lanes. Cycle tracks in Montreal had 28 percent lower injury rates when compared to bicycle lanes on similar streets. In addition, 2.5 times as many cyclists used the cycle tracks compared to the streets with bicycle lanes (Lusk et al., 2011). Bicycle modeling findings support this result. They indicate that the bicycle concept network facilities would have about 2.5 times more bike traffic than the average bike facility. The bicycle concept modeling also show that the number of BMT on roadways with no bicycle facilities decreases in the three bicycle network concepts, from 39 percent (in the 2010 network) to 22 percent in the Spiderweb and Grid Concepts (Table 2).

The *Metro State of Safety Report* (Metro, 2012) found that nearly 53 percent of all fatal and serious bicycle crashes occurred on arterial roadways. The bicycle network concepts reduce the amount of travel on these roadways without protected facilities, potentially reducing fatal and serious bicycle-motor vehicle crashes in the Portland region.

Vehicle crashes occur more often in congested and highly traveled areas (Kononov, 2008). All three of the bicycle concepts and the Regional Pedestrian Network shift trips from vehicles to active transportation modes. Potentially, this would reduce congestion on highly traveled areas and, therefore, increase safety.

Speed reductions or road diets, where lanes of traffic are converted to accommodate all road users (including pedestrians and bicyclists), can greatly reduce crashes for all transportation modes.

Equity

Does the network increase access for low-income, minority, non-white, non-English-speaking, youth (under 18), disabled, and elderly (over 65) populations? Increasing access (see Access criterion discussion) serves these populations by providing the following equity benefits:

1. Improved access to destinations for the transportation disadvantaged
2. Better air quality in low-income areas (Environmental Justice neighborhoods)

1. Improved Access to Destinations for the Transportation Disadvantaged.

Implementation of the Regional Pedestrian Network concept provides greater access to transportation-disadvantage groups and represents a benefit in terms of access to jobs, services, and food. The analysis finds that the 10 pedestrian districts with the highest percentage of underserved populations also score highly in the access and cost measures. This means that, with implementation of the Regional Pedestrian Network concept, the 10 districts would have greater walking access, with relatively low cost per person with this increased access.

The transportation disadvantaged are considered to be households with no access to a vehicle, youth under 18, and elderly populations (over 65). These populations can benefit the most from increased access to walking and bicycling, which would reduce their household transportation costs relative to driving.

Those who are transportation disadvantaged are those who have no access to a private vehicle, are low-income with less access to private vehicles, youth under 18, or are elderly (over 65) and have mobility issues. Transportation-disadvantaged populations could benefit from additional access to walking and biking opportunities, especially for utilitarian purposes (such as commuting to work, shopping, and other daily travel needs).

The Center for Housing Policy conducted a study evaluating the combined housing and transportation burdens of working families, defined as those households earning between $20,000 and $50,000 annually (Center for Housing Policy, 2006). They evaluated combined housing and transportation-cost burdens for working families in 28 metropolitan areas at the neighborhood level. Within the Portland region, working households spent 28 percent of their income on housing and 31 percent on transportation – that is, 60 percent on both. The study found that increasingly jobs are suburbanizing, and commuting for work among working families occurs region-wide. A regional bicycle and walking system would provide more non-driving options for working families. According to the study, in Portland, 84 percent of the working families> commute by private vehicle, 7 percent by public transit, and 4 percent by walking and biking. On average, such households working families spend $10,383 on transportation. Driving includes the cost of owning a personal vehicle, gas, insurance, parking, and maintenance. Driving is more costly than bicycling or walking. Expanding regional bicycling and walking options expands affordable transportation options for working families.

In a study of diverse geographic locations (Mississippi, North Carolina, Maryland, and Minnesota), residents in low-income communities were found to be less likely to own a car and three times less likely to have a grocery store within their neighborhoods. Therefore, these residents rely more heavily on mass transit to complete their shopping. They are more likely to shop at smaller, local, convenience stores with less healthy food at higher prices (Morland et al., 2002). Regional bicycling and walking options in low-income and transportation-disadvantaged neighborhoods can expand residents' access to grocery stores and healthier foods that may be outside of their neighborhoods.

Todd Litman explored mobility options for residents who are unable to drive or residents who choose alternate transportation modes to reduce household expenditures. He found that those who do not drive struggle to access jobs, housing, education, social services, and other activities. These difficulties mainly stem from land-use patterns that separate affordable housing from employment centers, but the lack of both facilities for active transportation modes and transit access contribute to the problems (Litman, 2013).

Many studies have looked at the cost of transportation and housing for lower-income residents. These studies have showed that proportionately, lower-income residents spend more on transportation and housing than middle- and upper-income earners. These residents often live in areas with few active transportation opportunities and less access to transit, and they spend more time commuting than their counterparts. This lack of facilities or access to daily needs reduces transportation options to the comparatively more expensive vehicle mode. When employment hubs invest in bus access and active transportation modes, significant positive employment effects are realized (Sanchez, 1999).

For the Regional Pedestrian Network, the Pedestrian Flow Analysis (2013), examined network implications for the transportation-disadvantaged, historically underserved sub-groups – low income populations (less than 80 percent of poverty level), non-white populations (Asian, Hispanic, Pacific Islander, American Indian/Alaskan Native), low English-proficiency populations, young populations (under 18), and elderly populations (over 65). Because it is not possible to forecast the future distribution of the transportation-disadvantaged, the analysis assumes a distribution of transportation-disadvantaged similar to the distribution in 2010.

2. Better Air Quality in Low-income Areas (Environmental Justice Neighborhoods)

Greater access to bicycling and walking would result in better air quality in low-income areas. The Regional Bicycle Network Evaluation (Metro, 2013) analyzed the presence of underserved populations (that is, concentrations of non-white, low income, old, young, and low-proficiency-English populations) related to each bicycle network concept. **All the bicycle network concepts increase bicycle facility access to underserved populations compared to the 2035 State RTP network (Regional Bicycle Network Evaluation, 2013).**

Implementation of the Regional Pedestrian Network (districts, corridors, and trails) increases opportunities for biking and walking in areas of higher than average transportation-disadvantaged populations

(Pedestrian Flow Analysis, 2013). Use of these facilities would lead to better localized air quality for the transportation-disadvantaged and Environmental Justice communities.

Miranda et al. (2011) assessed whether air quality (as established by the American Lung Association) disproportionately affected disadvantaged communities. The study focused on the race, age, and poverty demographics of communities. Consistent with the concept of Environmental Justice, Miranda et al. (2011) found that non-Hispanic blacks are consistently overrepresented in communities with the poorest air quality. The air-quality results for older- and younger-age-group neighborhoods, as well as poverty level neighborhoods, vary by the pollutant under consideration. The study concludes that low-income and minority communities tend to experience higher ambient air pollution levels.

The U.S. Environmental Protection Agency (EPA) states that asthma is a serious problem. In 1990, it killed about 4,000 people a year and cost about $4.2 billion in medical care and lost time from school and work . Asthma is the leading chronic illness among children in the United States, and the leading cause of school absenteeism. Asthma can be triggered by pollutants such as vehicle exhaust. The EPA advocates using public transportation, carpooling, and other activities that reduce driving (such as active transportation) as a way to combat asthma (retrieved, 2013). Asthma sufferers are particularly sensitive to localized air quality effects.

The "Increased Activity" item "2) Reduced congestion/vehicle miles traveled, improved air quality, and reduced greenhouse gas emissions" section concludes that implementation of the bicycle network would decrease driving VMT region-wide. This decrease in driving would result in better ambient air quality.

Increased Activity

Does the network increase the number of trips made by walking and bicycling? Increased bicycling and walking activity provides the following benefits:

1. Reduced mortality and morbidity rates
2. Reduced congestion/vehicle miles traveled, improved air quality, and reduced greenhouse gas emissions
3. Economic – fosters active-transportation-related industries and jobs
4. Improved personal sense of well-being and social cohesion
5. Reaching a tipping point in bicycling and walking, and moving towards a cultural shift

1. Reduced Mortality and Morbidity Rates

Improvements to the regional bicycle and pedestrian networks increases access and will lead to more active lifestyles. The bicycle network increase the number of bicycle trips, the BMT, and miles of new bike facilities over the 2035 State RTP network. The three bicycle network concepts add between 2,525 and 4,383 new bike trips per day over the 2035 State RTP levels (Metro, 2013). This translates to between a 2 and a 4 percent increase in BMT over the 2035 State RTP network, with 38 to 45 percent of the BMT on separated bicycle facilities. Pedestrian mode share is also expected to increase in 2035, from 8.81 percent (with the 2035 State RTP) to around 9.68 percent(with the Regional Pedestrian Network), which represents around 200,000 more trips than with the 2010 system.

Increasing facilities and opportunities for active transportation will result in more residents choosing active transportation modes for their everyday needs. These choices are reflected in the increase in BMT and travel on off-street paths. These improvements potentially reduce mortality and morbidity rates related to inactivity because more residents are likely to choose active transportation modes.

In 2035, the three bicycle-network-concept-model results show a reduction in all metrics except total person trips and the percent of person trips using non-single occupant vehicle (SOVs) (for example, shared ride, walk, bike, and transit). With the three bicycle network concepts, auto person trips, SOV trips, person miles traveled, VMT, VMT per capita, VMT per employee, and SOV percent of person trips are reduced when compared to the 2035 State RTP system.

As discussed in the "Access" section "Economic –Business Retention and Recruitment" item, the Regional Pedestrian Network increases access to a variety of destinations, including health care, transit, parks, food stores, and retail areas. The increased access for populations is found for investments outside of the Central City core, mainly in the western suburbs and outer southeast. These locations currently have limited pedestrian connectivity, and improvements would benefit a large segment of the adjacent populations.

A number of studies indicate that a lack of physical activity contributes to increased mortality rates through a variety of causes that include heart disease, diabetes, and other obesity-related illnesses. Inactivity also contributes to morbidity and a reduced quality of life. Implementation of the bicycle and pedestrian networks increase opportunities for physical activity; therefore, potentially reducing mortality rates.

A study in New Zealand cited by the World Health Organization estimated that an increase in active modes for transportation would result in a reduction of mortality by 17.5 percent in all population groups. An Austrian study for the same organization estimates that a 5-percent bicycle mode share saves 412 lives every year because of regular physical activity (World Health Organization [WHO], 2011).

In a study by Danaei et al., overweight/obesity, and physical inactivity were each responsible for nearly 1 in 10 deaths nationwide. Inactivity contributes in various magnitudes to heart disease, stroke, breast cancer, colon cancer, and diabetes (Danaei et al., 2009). The bicycle network concepts and improvements to the pedestrian network will help residents increase their physical activity, which would help reduce the risk of life-threatening health conditions in the Portland metropolitan area.

Besser and Dannenberg (2005) determined that increased access to public transit may help promote and maintain active lifestyles, with 29 percent of respondents achieving 30 minutes or greater of physical activity a day solely by walking to and from transit. Access to transit accounted for 16 percent of all walking trips, and those trips tended to be longer than other walking trips (Weinstein and Schimek, 2005).

According to the WHO's Economic Assessment of Transport Infrastructure and Policies (WHO, 2011), an increase in physical activity has beneficial effects on coronary heart disease, stroke, diabetes, some types of cancer, musculoskeletal health, energy balance, and aspects of mental health. The three bicycle network concepts increase the number of trips by bicycle and BMT. These concepts will reduce the need to drive for some residents, providing easier access to food and retail options, parks, and open space. This increased access will help reduce morbidity rates, the occurrence of diseases, and health care costs. In the San Francisco Bay area, increasing daily walking and bicycling from 4 to 22 minutes reduced the burden of cardiovascular disease and diabetes by 14 percent, premature deaths by 4.8 percent, and years living with a disability by 2.9 percent (Maizlish et al., 2013).

These reduced health care costs can save a lot of money. In Wisconsin, Grabow et al. (2010) quantified the health benefits from reducing short car trips and increasing bicycle trips as around $410 million per year. Another study using a model of the 11 largest Midwestern metropolitan areas calculated the annual health care costs as around $3.8 billion by replacing half of short car trips with bicycling (Grabow et al., 2012).

In an Atlanta, Georgia, study, car-friendly communities had almost double the rate of obesity compared to pedestrian-friendly communities (22 percent versus 12 percent) (Frank et al., 2007). Each additional hour spent in a car per day was linked to a 6 percent increase in the likelihood of obesity, while each additional kilometer walked per day was associated with a 4.8 percent reduction in the likelihood of obesity (Frank et al., 2004).

2. Reduced Congestion/Vehicle Miles Traveled, Improved Air Quality, and Reduced Greenhouse Gas Emissions

Increasing the percentage of all trips made by bicycling and walking may benefit society at large by removing vehicles from the road, reducing the number of overall VMT, and creating more free-flowing roadways.

To alleviate congestion and reduce VMT in the region, the proposed concepts must be attractive enough to shift existing automobile trips to walking and bicycling, perhaps in combination with transit for longer trips.

Research has not been in agreement about the effects of increased bicycle mode share on congestion and which transportation mode group is more likely to switch to bicycling.

Some scholars have posited that any excess roadway capacity from transportation mode shifts would be negated by "induced demand," because motorists will take new trips or shift existing ones to take advantage of the reduced congestion. Some researchers have shown that while bike trips may replace car commutes, oftentimes they are used for completely new trips or for recreational purposes (Krizek, 2007). Others have accounted for reduced congestion cost in their analysis to determine societal benefits derived from investing in cycle track networks (Sælensminde, 2004).

Researchers have attempted to monetize the benefits of avoiding congestion per individual who switches from driving to bicycling. Assuming a congestion cost of $1.67 per mile and commuting 6 miles each day for 50 weeks, Rabl and de Nazelle (2005) assume that society enjoys a benefit of $2,595/year from reduced congestion for each driver who shifts to bicycling. Ogilvie et al. (2004) found that targeted behavior change programs in Scotland and Australia caused a significant transportation mode shift among motivated participants (5 percent) from driving to walking and bicycling. This also may have reduced congestion and VMT. Survey respondents who moved from non-TODs to TODs where they could walk or bike to transit reported a 42 percent decrease in average VMT (Cervero, 2006).

The fundamental link between emissions and VMT is well-understood (Frank et al., 2000). A single commuter shifting from driving to active transportation directly benefits the environment. The network distance of each trip is directly proportional to air pollution related to greenhouse gas (GHG) emissions such as methane (CH_4) and nitrous oxide (N_2O). These emissions directly contribute to global climate change, which may increase the incidence of health problems caused by a warming planet (Knowlton et al., 2007). These problems include heat-related illness and death; health effects related to extreme weather events; health effects related to air pollution; water-borne and food-borne diseases; and vector-borne and rodent-borne diseases. Rabl and de Nazelle (2012) estimate that the societal cost of carbon dioxide (CO_2) emissions is $33 per metric ton. Automobiles also produce fine particulate matter, which reduces visibility and harms plant and human health. Exposure to fine particulate matter pollution has been linked to premature death in people with heart or lung disease, nonfatal heart attacks, irregular heartbeats, aggravated asthma, decreased lung function, and increased respiratory symptoms (Davidson et al., 2005; Ostro and Chestnut, 1998).

A case study was conducted in four American communities to document a federally funded pilot program to increase the use of non-motorized transportation. The study estimated that between 2007 and 2010, the community members walked or bicycled 32 million miles that otherwise they would have driven. In counts, an average increase of 49 percent for bicyclists and 22 percent increase for pedestrians were observed in that time span. During the 2007 to 2010 time span, bicycling mode share increased 36 percent, walking mode share increased 14 percent, and driving mode share decreased 3 percent. The communities were estimated to have reduced their production of CO_2 by 22 pounds per person in 2010 (a total of 7,701 tons). Assuming a one-to-one trade-off between vehicle trips and non-motorized trips, they avoided production of 30.8 million pounds of carbon dioxide emissions as a result of the pilot program, in addition to savings in other criteria air pollutants that contribute to health problems.

Metro's transportation model predicts that implementing the bicycle network concepts would reduce overall VMT in the UGB compared to the 2035 State RTP network by less than 1 percent (Table 7). This decrease in average weekday VMT ranged from 11,377 miles for the Grid Concept to 72,947 miles for the Mobility Corridor Concept to 101,783 miles for the Spiderweb Concept. Total weekday vehicle trips would also decrease from between 1,545 (for the Grid Concept) and 3,400 (for the Spiderweb Concept). However, overall person trips would increase from between 99 (for the Spiderweb Concept) and 167 (for the Mobility Corridor Concept). These predictions suggest that travelers would experience a very modest mode shift from automobiles to other forms of transportation. On the whole, SOV travel as a percent of overall person trips for the bicycle network concepts would decrease by 2 to 3 percent from those with the 2035 State RTP network. However, it is important to note that the three bicycle network concept scenarios did not address policy changes (such as additional parking costs, cost of transportation, tolling) or social changes (increased cultural cache of bicycling) that would potentially have a large impact on the number of trips made by bicycle in the future and on the reduction of VMT. The cost of parking alone can have a significant impact on mode choice.

The amount of CO_2 emitted depends more on fuel consumption than strictly VMT. The average fuel economy of all gasoline-powered vehicles in 2011 based on Federal Highway Administration was 21.4 miles per gallon.[2] Based on EPA calculations related to the amount of CO_2 emitted per gallon of gasoline (that is, 8,887 grams of CO_2 per gallon), the amount of CO_2 emitted from driving 1 mile is 415 grams (EPA, 2011). The Metro transportation model (2013) estimates 101,783 fewer VMT for the Spiderweb Concept compared to the 2035 State RTP network. Therefore, about 42 metric tons of CO_2 would not be released because investments in the bicycle network concept would encourage a mode shift from driving to bicycling and walking. The Mobility Corridor Concept would release 30 metric tons of CO_2 less than the 2035 State RTP network, and the Grid Concept would release 5 metric tons of CO_2 less than the 2035 State RTP system. Carbon dioxide accounts for 95 percent of GHG emissions from passenger vehicles. Other GHGs, such as CH_4 and N_2O, are related more to VMT than to fuel consumption. The Spiderweb Concept would release just over 1 metric ton less of non-CO_2 GHG emissions than the 2035 State RTP, while the other bicycle network concepts would reduce the emission amounts released by slightly less.

According to the 2011 Oregon Household Activity Survey, people use automobiles to make nearly 45 percent of all trips less than 3 miles in Multnomah, Washington, Clackamas, and Clark Counties. This provides the best opportunity for bicycling trips to replace driving trips. For trips less than 3 miles within Metro's urban growth boundary, bicycle trips account for 5.6 percent of the transportation mode share in the 2035 State RTP, and pedestrian trips account for 20 percent of the transportation mode share in the 2035 State RTP, compared to 5.1 percent and 19 percent, respectively, in 2010. Within 12 miles, 4 percent of trips are taken by bike and 10.6 percent by 2035 by walking in the 2035 State RTP compared to 3.5 percent by bike and 9.8 percent by walking in 2010. Between 2010 and the 2035 State RTP, the number of new originating bicycle trips is expected to increase by 63 percent. The average length of bicycle trips is expected to increase from 2.42 miles in 2010, to 2.58 miles in the 2035 State RTP, and to 2.62 to 2.64 miles in the bicycle network concepts. These predictions indicate that improving the networks will facilitate bicycling for longer trips that people otherwise might have driven.

The number of biking and walking trips and their percentage of transportation mode share are forecast to increase over the next 25 years. The bicycle model predicts that regional bicycle mode share for all trips within the UGB will expand from 3.1 percent in 2010 to 3.6 percent in the 2035 State RTP, with a slight increase in mode share from the 2035 State RTP in each of the three network concepts. The following factors can explain the relatively minor increase in mode share and VMT between the 2035 State RTP and each of the three bicycle network concepts:

- The number of new facilities is much greater between 2010 and the 2035 State RTP than between the 2035 State RTP and the three bicycle network concepts.
- Population and employment levels, the cost of parking, and land-use assumptions change between the 2010 and the 2035 State RTP networks, but are held constant between the 2035 State RTP and the three bicycle network concepts.
- Bicycle parkways are expected to be designed at a higher level than regular trails or bicycle boulevards, but the model does not incorporate a difference in the level of attractiveness (for those facilities that are classified as trails or bicycle boulevards in 2010 and the 2035 State RTP).
- Policy changes (such as tolling and transportation costs) and social changes (such as an increased cultural cachet of bicycling) are not figured into the model, although they would have a large effect on the number of bicycle trips made in the future.

[2] Number of miles driven by all light-duty vehicles (passenger cars, light trucks, vans, and sport utility vehicles) divided by total fuel consumption (Office of Highway Policy Information, 2013).

Several routes receive heavy usage in the 2035 State RTP scenario and may be able to divert auto trips away from parallel routes. These include the Sullivan's Gulch Trail, area-wide diagonal routes (Foster Road, Sandy Boulevard, Barbur Boulevard, and the Gresham MAX Path), the Beaverton Creek Trail, the Bronson Creek Greenway, the Surf to Turf Trail, the Westside Trail, the Clinton Street bike boulevard, the Sunrise Corridor Trail, the Powerline Trail, the Trolley Trail, Lake Road, the McLoughlin Trail, and various north-south and east-west routes in Portland. In addition, several routes that have been added in the bicycle network concept scenarios show an increase in volume in the model. These include the Interstate 405 (I-405) Trail, the US 26 Trail, Powell Boulevard, the Fanno Creek Trail south section, the Westside Trail south section, a fully completed Interstate 205 (I-205) Trail, and a route serving downtown Hillsboro.

3. Economic – Fosters Active-Transportation-Related Industries and Jobs

Industries related to active transportation include bicycle manufacturing companies, equipment, clothing, repair, and tourism. Other industries related to active transportation include those that rely on their location in a sustainable region. **The bicycle and pedestrian networks increase the mode share for active transportation modes and will continue to support these industries. With improvements in all three bicycle network concepts, more people will bike to work and other activities, creating demand for bicycles, gear, and bicycle repair.**

A study on the economic effects of the bicycle industry in Wisconsin showed that bicycle recreation and tourism generates $924 million annually. As discussed in the "Access" section "Economic – Tourism" item, in 2008, sales from bicycle-related retail and service enterprises in Portland generated around $54 million. Recreational cyclists are a high yield, high spending market and provide economic and social opportunities for regions (Beeton, 2009).

Ontario, Canada's report on active transportation, *The Business Case for Active Transportation* calculates the annual economic benefits of bicycling and walking in Canada at around $3.5 billion. This amount includes reduced costs to construct and maintain roads, reduced costs associated with GHG emissions, reduced health care costs, reduced fuel and upkeep costs for users, reduced parking subsidies, and increased property values along greenways and trails, among other items. The study suggests that if the rest of Canada increases its active transportation share similar to Victoria, British Columbia's current transportation mode share, the benefits could double to $7 billion per year.

The National Recreation and Park Association (undated) estimates that the $6.7-million public funding investment in bicycle paths/facilities for North Carolina's Outer Banks produces economic benefits of around $60 million annually. The 680,000 tourists that visit the area come partly to cycle. In addition, home sales near regional trails were more likely to be sold close to the asking price, while, on average, houses farther from the trails sold for less.

4. Improved Personal Sense of Well-being and Social Cohesion

Bicycling and walking, for either recreational or utilitarian purposes, can reduce symptoms of depression. Implementation of the bicycle and pedestrian networks would increase opportunities for bicycling and walking, and in the case of bicycling, modeling data show that bicycling would increase.

Dunn et al., (2001) observed that greater amounts of occupational and leisure time physical activity are generally associated with reduced symptoms of depression. They also found that light, moderate, and vigorous-intensity exercise can reduce symptoms of depression. Both resistance training and aerobic exercise (such as bicycling and walking) can reduce symptoms of depression. Dose-response effects would need further study.

Hessmen et al. (2000) conducted a cross-sectional study of over 3,000 individuals between the ages of 24 and 64 to determine the psychological effects of exercise. They found that those who exercised at least two to three times a week experienced significantly less depression, anger, cynical distrust, and stress than those exercising less frequently or not at all. Furthermore, regular exercisers perceived their health and fitness to be better than less frequent exercisers did. Finally, those who exercised at least twice a week reported higher levels of a sense of coherence and a stronger feeling of social integration than their less frequently exercising counterparts.

Leyden used a household survey to measure the social capital of citizens living in neighborhoods that ranged from traditional, mixed-use, pedestrian-oriented designs to modern, car-dependent suburban subdivisions in Ireland. Leyden found that persons living in walkable, mixed-use neighborhoods have higher levels of social capital compared to those living in car-oriented suburbs. Respondents living in walkable neighborhoods were more likely to know their neighbors, participate politically, trust others, and be socially engaged.

Implementing a regional bicycle network and/or walking network would provide more opportunities for aerobic exercise. Based on the Bicycle Network Evaluations Report (Metro, 2013), all bicycle network concepts would increase the number of bicycle trips compared to 2010 and the 2035 State RTP network. The Spiderweb Concept would increase bicycle trips the most, by 1.5 percent over the 2035 State RTP network, followed by the Grid and the Mobility Corridor Concepts. Implementation of the Regional Pedestrian Network would provide more opportunities for walking and running for utilitarian and recreational reasons.

5. Reaching a Tipping Point in Bicycling and Walking, and Moving Towards a Cultural Shift

More children biking and walking leads to changed behavior (everyone is doing it). Increased perceived safety attracts the interested but concerned. Reaching a tipping point in bicycling and walking, and moving towards a cultural shift, addresses the latent demand for bicycling and walking.

To reach a cultural shift in active transportation rates, walking and bicycling must be validated as acceptable forms of transportation for all people. One way to attain this cultural shift is if others perceive a “critical mass” of pedestrians and bicyclists, which would signal that these are safe, enjoyable, and even fashionable activities for transportation (Gatersleben and Appleton, 2007). Research has shown that building more separated facilities is necessary to attract the “interested but concerned” demographic that skews toward women (Garrard et al., 2008), children (Mehan et al., 2009), and the elderly (Hayes et al., 2003) who value perceived safety. Building new separated infrastructure increases the active transportation mode share and awareness of walking and bicycling within the community. This awareness helps reduce collision rates between pedestrians or bicyclists and motorists (Jacobsen, 2003; Robinson, 2005) and establishes the beginning of a cultural shift where active transportation is an accepted or even celebrated part of one’s lifestyle. Handy and Xing (2011) found that social environment factors, such as whether a supervisor disapproves of bicycling, can affect the likelihood of a person commuting to work by bicycle. Participants with relatives who bicycle or provide social support by accompanying them while riding were more likely to bicycle for transport (de Geus et al., 2008).

A study on bicycling culture in Australia (Bonham and Koth, 2009) found that the low bicycling mode share (2 percent) contributed to the lack of a vibrant bicycling culture the campus community felt was necessary to embrace bicycling. Suggestions from existing cyclists included conducting social activities to exchange information and bond over common interests; implementing a bicycling context on campus (such as wayfinding and convenient, secure bike racks) that is functional but also advertises the bike-friendliness of the campus; and supporting transit-demand-management initiatives (such as limiting the amount of free and low-cost campus parking) to encourage alternate modes of transport (Bonham and Koth, 2009).

Pucher et al. (2010) reviewed programs and policies that were found to increase the likelihood of bicycling and overall bicycling culture in cities. This included the availability of parking (particularly secure and sheltered) and locker facilities with showers at workplaces, as well as recreational ciclovias such as Portland’s Sunday Parkways. Positive associations have been found between recreational riding on ciclovias and utilitarian bicycling rates. Bike-to-work days are popular events for first-time riders and evidence shows that they increase bicycling beyond the event. Other elements in Portland further increase awareness. These include on-street bicycle corrals that remove parking spaces, bicycle-specific infrastructure (such as bike boxes and bike signals), and events (such as Pedalpalooza, a month-long celebration of bicycle culture where many group rides are organized).

Considerations

This section provides an overview of considerations when implementing the regional bicycle network, including trails. Considerations include consistency with other applicable policies, such as state and local policies. Considerations include potential impacts to other transportation modes, such as auto traffic, freight, or transit. In some cases, the bicycle network could have potential effects to the local environment. This section discusses implications of implementation. Fewer implications are anticipated with the implementation of the pedestrian network; therefore, this section focuses on implementation of the bicycle network, including trails. A primary consideration with trails is with crossings of roadways.

Consistency with Existing Policies

The implementation of regional bicycle parkways, the proposed highest functional classification for bikeways in the region, can make use of various types of facilities (e.g. off-street trails, low traffic side streets, major urban arterials), but the facilities must provide direct routes, prioritize bicycle travel, and provide separation from auto traffic on roadways with higher levels of traffic and speeds. Implementation of regional bicycle parkways may have implications for other policies and other transportation modes, depending on where they are located. When implementing the networks, an agency must consider consistency with all applicable functional classifications.

To illustrate the types of policy questions that may arise as the regional bicycle network is implemented and expanded, two major streets in the region are used as examples. This discussion focuses on Barbur Boulevard and Powell Boulevard in Portland as hypothetical cases for discussion purposes. This report uses these streets because they are both considered regional streets, carry high volumes of auto traffic, are frequent transit routes (and therefore experience a high level of pedestrian activity), are identified as high demand bicycling routes and are anticipated to be the focus of future planning efforts for bicycle, pedestrian, and transit improvements.

Both Barbur Boulevard and Powel Boulevard are identified as part of the regional active transportation network and are designated Regional Streets in the 2035 Regional Transportation Plan. The regional classification states that regional streets consist of four or more vehicle travel lanes, balanced multi-modal function, broad right of way, limited on-street parking, wider travel lanes than boulevards, corridor land uses set back from the street, sidewalks with pedestrian buffering from street, and a raised landscaped median with turn pockets at intersections. The right-of-way ranges between 80 and 100 feet or greater.

The Oregon Highway Plan (OHP) designates Barbur Boulevard and Powell Boulevard as district highways, which are, “facilities of county-wide significance and function largely as county and city arterials or collectors. They provide connections and links between small urbanized areas, rural centers, and urban hubs, and also serve local access and traffic. The management objective is to provide for safe and efficient, moderate to high-speed continuous-flow operation in rural areas reflecting the surrounding environment and moderate to low-speed operation in urban and urbanizing areas for traffic flow and for pedestrian and bicycle movements.” The OHP policy emphasizes traffic flow, whereas, the regional designations of a bicycle parkway calls for separation from traffic and bicycle priority. A regional street calls for bike lanes and emphasizes multi-modal balance, including provisions for transit.

Barbur Boulevard and Powell Boulevard are also designated by the OHP as freight routes. Policy 1C: State Highway Freight System, states, that “It is the policy of the State of Oregon to balance the need for movement of goods with other users of the highway system, and to recognize the importance of maintaining efficient through movement on major truck freight routes.” This policy balances the need for traffic through movement, including trucks, with other policies pertaining to other transportation modes. The upgrade of a bicycle lane or addition of a bicycle parkway could potentially slow through movement if lane widths are reduced or additional safety features are added; however, cyclists already use these routes and better protected facilities have potential safety benefits. In certain locations however, such as multi-modal areas or town centers, these may be desirable outcomes that also increase pedestrian safety. Each applicable functional classification for freight, bicycling, and walking emphasizes a different modal priority leading to implications with project development. Project implications could include with the allocation of roadway width to traffic lanes versus bicycle lanes or sidewalks; the frequency of access drives; signal timing and phases; and lane markings and signage. Balancing modes and different uses of the public right of way often occurs as projects are developed. Overlapping plans and sometimes conflicting policies are sorted through and with public involvement the best use of space is developed. Potential Impacts to Other Transportation Modes

Multi-modal roadways, such as Barbur Boulevard or Powell Boulevard, balance transportation modes through the allocation of roadway space and design treatments. The implementation of a bicycle parkway on a roadway, such as Barbur Boulevard or Powell Boulevard could have impacts to other modes, just as current designs and allocation of roadway space have impacts on pedestrians and bicyclists today.

Road Diets

"Road Diets" are a way to reconfigure roadway space in a way that allows for the inclusion of wider sidewalks and separated bicycle facilities such as buffered bicycle lanes. A classic road diet involves converting a four lane roadway (two travel lanes in each direction) into three lanes, made up of two through lanes and a center two-way left turn lane. The reduction of lanes allows the roadway to be reallocated for other uses such as bike lanes, pedestrian crossing islands, and/or parking. Road diets can have multiple safety and operational benefits for vehicles, as well as pedestrians and cyclists (FHWA, retrieved 2013). Benefits include:

- Decreasing vehicle travel lanes for pedestrians to cross, therefore reducing the multiple-threat crash (when one vehicle stops for a pedestrian in a travel lane on a multi-lane road, but the motorist in the next lane does not, resulting in a crash), for pedestrians,
- Providing room for a pedestrian crossing island,
- Improving safety for bicyclists when bicycle lanes are added (such lanes also create a buffer space between pedestrians and vehicles),
- Providing the opportunity for on-street parking (also a buffer between pedestrians and vehicles)
- Reducing rear-end and side-swipe crashes, and
- Improving speed limit compliance and decreasing crash severity when crashes do occur.

These represent multi-modal safety benefits.

Considerations for Freight, Transit, and Emergency Service Routes

Design considerations need to be given for pedestrian and bicycle facilities on designated freight, transit, and emergency service routes because large vehicles have unique operating and design needs that can conflict with the needs for bicyclists and pedestrians. The presence of many large vehicles can decrease safety and level of comfort for bicyclists, requiring use of more protected/separated facilities or alternate, parallel routes. Traffic calming measures to reduce vehicle speeds and increase comfort for cyclists are typically not appropriate on large vehicle routes because of the large corner radii needed for turns and disturbances caused by speed bumps.

Both Barbur Boulevard and Powell Boulevard are being considered for high capacity transit improvements. If bus rapid transit, for example, was implemented on either roadway, it would likely be in the median, which suggests symmetry of the roadway. Driveways would be limited to right-in, right-out only, and turn movements would be restricted to intersections. Bicycle and pedestrian access to median transit platforms would need to be considered carefully.

Similarly, on transit routes where buses may merge over bicycle facilities to serve stops, left-side bike lanes, buffered bike lanes, or other design treatments should be considered to reduce "leapfrogging" and conflicts between bicycles and boarding/alighting passengers.

Consideration of Oregon's "Hole-in-the-Air" Policy

Oregon's statewide "Hole-in-the-Air" policy (ORS 366.215) strives to maintain a roadway's carrying capacity by maintaining width and height physical restrictions according to applicable standards. This policy adds complexity when designing to include bicycle and pedestrian amenities, such as, bike parking, cyclist oriented signals, cross-walk treatments, and wayfinding signs.

Environmental Considerations for Trails

Trails for active transportation have the potential for greater bicycle and pedestrian use. In some cases, trails may pass through sensitive wildlife habitat. The needs for active transportation and consequences to wildlife must be carefully balanced. Potential consequences to wildlife include increased human activity in the form of additional presence and noise, which can be disrupting to wildlife. The trail itself can act as a barrier and divide habitat, particularly for smaller animals. Trails also increase impervious surface and have the potential to increase storm water runoff. Trails can introduce culverts in areas, which can funnel prey into narrow areas for predators. If the trail has lighting, the light pollution could have implications for wildlife.

These potential consequences can be mitigated with design treatments. For example, pervious pavement can be used to reduce water runoff. Wildlife crossing treatments can be considered at key animal routes or at culverts.

Costs

Costs were developed to compare benefits and trade-offs. Planning-level cost estimates are based on unit costs per mile for facility types, by network. These cost estimates do not include right-of-way acquisition costs, only unit costs for design and construction. Appendix A contains information about costs per mile by facility type and what is included in the cost per mile calculation (such as stormwater management, signalization, and other infrastructure requirements).

Tables 3 through 6 include the planning level costs for each concept, (Grid, Spiderweb, and Mobility Corridor Concepts), by facility type, and planning level cost estimates for the pedestrian network improvements evaluated.

TABLE 3
Bicycle Network: Grid Concept

Facility	Cost
New bicycle boulevard (no project in 2035 State RTP)	$2,477,000
Upgrade existing bicycle boulevard	$1,581,000
New separated 8-10’ in-roadway bikeway	$16,889,000
Upgrade existing in-roadway bikeway to separated	$240,552,000
New trail 12’ (no project in 2035 State RTP)	$90,723,000
Upgrade existing trail in 2035 State RTP network to 12-14’	$121,907,000

TABLE 4
Bicycle Network: Spiderweb Concept

Facility	Cost
New bicycle boulevard (no project in 2035 State RTP)	$1,209,000
Upgrade existing bicycle boulevard	$1,562,000
New separated 8-10’ in-roadway bikeway	$22,900,000
Upgrade existing in-roadway bikeway to separated	$299,400,000
New trail 12’ (no project in 2035 State RTP)	$105,645,000
Upgrade existing trail in 2035 State RTP network to 12-14’	$146,303,000

TABLE 5
Bicycle Network: Mobility Corridor Concept

Facility	Cost
New bicycle boulevard (no project in 2035 State RTP)	$345,000
Upgrade existing bicycle boulevard	$131,000
New separated 8-10’ in-roadway bikeway	$15,622,000
Upgrade existing in-roadway bikeway to separated	$136,250,000
New trail 12’ (no project in 2035 State RTP)	$61,692,000
Upgrade existing trail in 2035 State RTP network to 12-14’	$86,909,000

TABLE 6
Regional Pedestrian Network

Facility	Cost
New 17’ sidewalk and buffer	$684,000,000
New trail 12’ (no project in 2035 State RTP)	$456,000,000
Improved or new crossings	$124,080,000

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Appendix A
Unit Costs per Mile Assumptions

APPENDIX A

Unit Costs per Mile Assumptions

TABLE A-1
Construction Cost Assumptions

Bicycle or Pedestrian Facility Type	Cost Per Mile	Costs Include
New 17’ sidewalk and buffer	$2 million/side	Sidewalk, buffer, grading, a few sections with walls. Drainage/stormwater management system is assumed to already be in place.
Upgrade existing sidewalk to 17’ including buffer	$1 million/side	Sidewalk, buffer, grading, a few sections with walls. Drainage/stormwater management system already in place.
New trail 12’ (no project in 2035 State RTP)	$4 million	Costs are federalized and include acquisition of right-of-way, intersection crossings, signalization, crosswalks, mitigation, access points, bridge crossings, trailheads.
Upgrade existing trail in 2035 State RTP network to 12–14’	$1.5 million	Widen 4’ from 8’ to 12’ or 10’ to 14’, repave, lighting, signage, signalized crossings of barrier roadways, improved access to street network.
New bicycle boulevard (no project in 2035 State RTP)	$250,000	Signage, markings, speed humps, traffic diversion, crossing elements, and any other elements to develop a complete bicycle boulevard.
Upgrade existing bicycle boulevard	$100,000	Improve crossings, add signage, fix identified deficiencies, and so forth
New separated 8–10’ in-roadway bikeway	$1 million	Costs include signal timing, lane reconfigurations, striping, and raised curbs; no drainage needed.
Upgrade existing in-roadway bikeway to separated	$1 million	Costs include signal timing, lane reconfigurations, striping, and raised curbs; no drainage needed.
Improved or new crossings	$10,000 -$150,000/crossing	Lower costs are for 2–3 lane roadways with markings and rapid flash beacon. Medium costs are for a typical 4–5 lane arterial, includes treatments such as rapid flash beacons, curb ramps, median island, signage, and striping. Improvements will be identified on the pedestrian network. Highest cost is for a fully signalized intersection.