Appendix D. Predicting Walking and Bicycling Demand

Demand models are often used to quantify usage of existing pedestrian and bicycle facilities, and to estimate the potential usage of new facilities. As with all models, the results show a range of accuracy that vary based on a number of assumptions and available data. The models used for this study incorporated information from existing publications as well as data from the U.S. Census American Community Survey (ACS) 2006-2008 estimates for the Rapid City Metro Area. All data assumptions and sources are noted in the tables following each section of the analysis.

Existing Pedestrian and Bicycle Demand

The Rapid City Area pedestrian and bicycle demand models consist of several variables, including commuting patterns of working adults and predicted travel behaviors of area college students and school children. The year 2008 was used as the baseline for the demand analysis, as it is the most recent year for which data is available.

For this analysis, population data for the existing labor force (including the number of workers and percentage of pedestrian and bicycle commuters) were obtained from the 2006-2008 ACS estimate for the Rapid City Metropolitan Area. In addition to people commuting to the workplace via walking or by bicycle, the model also incorporates a portion of the labor force working from home. Specifically, it was assumed that about 25 percent of those working from home would make at least one walking trip, and another ten percent would make at least one bicycling trip during the workday.

The 2008 ACS was also used to estimate the number of children in the Rapid City Area. This figure was combined with data from National Safe Routes to School surveys, which found that approximately 11 percent of school children walk to and from school every day. College students constitute a third variable in the model due to the presence of the South Dakota School of Mines and Technology. Rapid City is also home to a National American University Campus, Western Dakota Technical Institute, and Oglala Lakota College's He Sapa College Center. However, the latter schools are not residential and are likely to have similar mode split to other local employment, rather than that of traditional college students. Data from the Federal Highway Administration regarding walking and bicycling mode share in university communities was used to estimate that 60 percent of students commuting to college walk to school. The 2001 National Household Transportation Survey found that commute trips (including work and school trips) comprise only approximately a third of total trips; trips for shopping, recreation and socializing are a significantly greater proportion of total trips. Table 33 shows results of the pedestrian demand model and identifies the variables and assumptions used in the model.

Many of the same assumptions from the pedestrian model were used to develop the bicycling model. The National Safe Routes to School surveys found that approximately two percent of school children bike to school. For college students, the Federal Highway Administration found that bicycling mode share in university communities is ten percent of students. Again, the large proportion of trips that are non-commute requires a multiplier to estimate the number of total bicycle trips in the Rapid City Area. Table 34 summarizes results and assumptions of the bicycle demand model and the estimated existing daily bicycle trips in the area.

Table 33. Existing Pedestrian Demand Model Results

Variable	Value	Source
Study area population	120,858	ACS 2006-2008 estimate for the Rapid City Metropolitan Area
Employed population	61,757	ACS Population of workers over 16
Walk-to-work mode share	2.0%	ACS Means of transportation to work for workers over 16
Number of walk-to-work commuters	1,239	(employed persons) * (walking mode share)
Work-at-home mode share	4.8%	ACS Means of transportation to work for workers over 16
Number of work-at-home walk commuters	739	Assumes 25% of population working at home makes at least one daily walking trip
Transit-to-work mode share	0.7%	ACS Means of transportation to work for workers over 16
Transit pedestrian commuters	392	Assumes 85% of transit riders access transit by foot
School children, ages 6-14	19,726	ACS 2006-2008 School enrollment by level of school
School children walking mode share	11.0%	National Safe Routes to School surveys, 2003
School children walk commuters	2,170	(school children pop.) * (walking mode share)
Number of college students	7,161	ACS 2007 School enrollment by level of school
Estimated college walking mode share	60.0%	*National Bicycling & Walking Study*, FHWA, Case Study 1, 1995
College walking commuters	4,297	(college student pop.) * (walking mode share)
Total number of walk commuters	8,837	(bike-to-work trips) + (school trips) + (college trips) + (utilitarian trips)
School and commute walking trips subtotal	17,673	Total walk commuters x 2 (for round trips)
Other utilitarian and discretionary trips:		
Ratio of "other" trips to commute trips	2.73	*National Household Transportation Survey*, 2001
Estimated non-commute trips	48,248	
Current Estimated Daily Pedestrian Trips:	**65,921**	

Table 34. Existing Bicycle Demand Model Results

Variable	Value	Source
Study area population	120,858	ACS 2006-2008 estimate for the Rapid City Metropolitan Area
Employed population	61,757	ACS Population of workers over 16
Bike-to-work mode share	0.1%	ACS Means of transportation to work for workers over 16
Number of bike-to-work commuters	62	(employed persons) * (bicycling mode share)
Work-at-home mode share	4.8%	ACS Means of transportation to work for workers over 16
Number of work-at-home bike commuters	296	Assumes 10% of population working at home makes at least one daily bicycle trip
Transit-to-work mode share	0.7%	ACS Means of transportation to work for workers over 16
Transit bicycle commuters	115	Assumes 25% of transit riders access transit by bicycle
School children, ages 6-14	19,726	ACS 2007 School enrollment by level of school
School children bicycling mode share	2.0%	National Safe Routes to School surveys, 2003
School children bike commuters	395	(school children pop.) * (bicycling mode share)
Number of college students	7,161	ACS 2007 School enrollment by level of school
Estimated college bicycling mode share	5.0%	National Bicycling & Walking Study, FHWA, 1995
College bicycling commuters	358	(college student pop.) * (bicycling mode share)
Total number of bike commuters	1,110	(bike-to-work trips) + (school trips) + (college trips) + (utilitarian trips)
School and commute bicycling trips subtotal	2,221	Total bicycle commuters x 2 (for round trips)
Other utilitarian and discretionary trips:		
Ratio of "other" trips to commute trips	2.73	National Household Transportation Survey, 2001
Estimated non-commute trips	6,062	
Current Estimated Bicycle Trips:	**6,062**	

The tables indicate that approximately 65,600 walking trips occur in the Rapid City Area each day, along with more than 6,000 bicycle trips. The largest group of pedestrians are school students (around 2,000), and the largest trip purpose is for non-commute trips (approximately 48,000). Most bicycle commuting trips are made by school students (almost 400). The model also shows that non-commuting trips comprise the vast majority of existing bicycle demand. These numbers are applicable to weekdays only, and are averaged over the course of the year.

Current Air Quality Benefits

The expected number of walking and biking trips in the Rapid City Area can be directly translated into reduced vehicle trips, as the current rates of walking and bicycling represent both residents and visitors using alternatives to driving. This number can be used to determine approximate reduction in vehicle miles traveled (VMT), which has the direct effect of reducing vehicular emissions.

The number of reduced vehicle trips, VMT and the ensuing vehicle emissions reduction was estimated from the results of the demand models described above. It was assumed that about 73 percent of pedestrian and bicycle trips would directly replace vehicle trips for adults and college students. For school children, the reduction was assumed to be 53 percent. The analysis estimated that the average pedestrian trip is roughly 1.2 miles in length for adults, whereas for children the distance is one-half mile. A bicycle roundtrip distance of eight miles was used for adults and college students, and one mile for school children. These distance assumptions have been used in various non-motorized benefits models throughout the United States. The vehicle emissions reduction estimates also incorporated calculations commonly used in other models.

From this estimate of the current levels of bicycling and walking in the Rapid City Area, it is possible to estimate that bicycling and walking currently remove approximately 6,000 vehicle trips per weekday, translating to a yearly reduction of about 1,600,000 vehicle trips. Table 35 through Table 38 illustrates the results of the vehicle trips, miles reduction and air quality benefits for pedestrian and bicycle trips, respectively.

Table 35. Vehicle Trips/VMT Reduction for Pedestrian Trips

Variable	Value	Source
Reduced Vehicle Trips per Weekday	6,017	Assumes 73% of walking trips replace vehicle trips for adults/college students and 53% for school children
Reduced Vehicle Trips per Year	1,570,363	Reduced number of weekday vehicle trips multiplied by 261 (weekdays in a year)
Reduced Vehicle Miles per Weekday	6,415	Assumes average round trip travel length of 1.2 miles for adults/college students and 0.5 mile for schoolchildren
Reduced Vehicle Miles per Year	1,674,326	Reduced number of weekday vehicle miles multiplied by 261 (weekdays in a year)

Table 36. Air Quality Benefits from Pedestrian Trips[*]

Variable	Value	Source
Reduced Particulate matter (PM10; tons/weekday)	118	Daily mileage reduction multiplied by 0.0184 tons
Reduced Nitrogen Oxide (NOX; tons/weekday)	3,200	Daily mileage reduction multiplied by 0.4988 tons
Reduced Reactive Organic Gas (ROG; tons/weekday)	466	Daily mileage reduction multiplied by 0.0726 tons
Reduced Carbon Dioxide (CO2; lb/weekday)	5,876	Daily mileage reduction multiplied by 0.916 lb
Reduced PM10 (tons/year)	30,808	Yearly mileage reduction multiplied by 0.0184 tons
Reduced NOX (tons/year)	835,154	Yearly mileage reduction multiplied by 0.4988 tons
Reduced ROG (tons/year)	121,556	Yearly mileage reduction multiplied by 0.0726 tons
Reduced CO2 (lb/year)	1,533,683	Daily mileage reduction multiplied by 0.916 lb

[*] *Source: NHTSA Corporate Average Fuel Economy for MY 2011 Passenger Cars and Light Trucks, Table VIII-5*

Table 37. Vehicle Trips/VMT Reduction for Bicycle Trips

Variable	Value	Source
Reduced Vehicle Trips per Weekday	816	Assumes 73% of bicycle trips replace vehicle trips for adults/college students and 53% for school children
Reduced Vehicle Trips per Year	212,904	Reduced number of weekday vehicle trips multiplied by 261 (weekdays in a year)
Reduced Vehicle Miles per Weekday	5,062	Assumes average round trip travel length of 8 miles for adults/college students and 1 mile for schoolchildren
Reduced Vehicle Miles per Year	1,321,217	Reduced number of weekday vehicle miles multiplied by 261 (weekdays in a year)

Table 38. Air Quality Benefits from Bicycle Trips[*]

Variable	Value	Source
Reduced Particulate matter (PM10; tons/weekday)	93	Daily mileage reduction multiplied by 0.0184 tons
Reduced Nitrogen Oxide (NOX; tons/weekday)	2,525	Daily mileage reduction multiplied by 0.4988 tons
Reduced Reactive Organic Gas (ROG; tons/weekday)	368	Daily mileage reduction multiplied by 0.0726 tons
Reduced Carbon Dioxide (CO2; lb/weekday)	4,637	Daily mileage reduction multiplied by 0.916 lb
Reduced PM10 (tons/year)	24,310	Yearly mileage reduction multiplied by 0.0184 tons
Reduced NOX (tons/year)	659,023	Yearly mileage reduction multiplied by 0.4988 tons
Reduced ROG (tons/year)	95,920	Yearly mileage reduction multiplied by 0.0726 tons
Reduced CO2 (lb/year)	1,210,262	Daily mileage reduction multiplied by 0.916 lb

[*] *Source: NHTSA Corporate Average Fuel Economy for MY 2011 Passenger Cars and Light Trucks, Table VIII-5*

Potential Future Walking and Bicycling Trips

Estimating future benefits requires additional assumptions regarding the Rapid City Area's future population and anticipated commuting patterns in 2035. The variables used as model inputs generally resemble the variables used in the demand model discussed earlier and represent a realistic, achievable goal of what the daily number of pedestrian and bicycle trips could be with a more complete pedestrian and bikeway system. Future population predictions determined by the Rapid City MPO were used in this model.

According to models developed for the *RapidTrip 2035* Long Range Transportation Plan, the area will be home to 58,371 households in 2035. The 2006-2008 ACS household distribution was used to estimate the total population in 2035.[13] *RapidTrip 2035* also predicts that employment will increase to 103,865 employed workers in the area. The distribution of the population who are school children or college students was assumed to

[13] The 2006-2008 ACS estimates found that approximately 27% of the households in the Rapid City Metropolitan Area are single-person households, 40% were two-person, 14% had three people, and 20% had four or more people. This distribution was applied to the 2035 household estimate to determine the population in 2035. For this analysis, it was approximated that households with four or more people have an average of five people.

remain the same. The estimated proportion of residents working from home was also not changed.

Regarding commuting patterns, walking and bicycling mode share was increased to address the higher use potentially generated by the addition of new facilities and enhancements to the existing system. Table 39 summarizes data on potential future pedestrian demand in the year 2035, while Table 40 illustrates the results of the demand model predicting 2035 demand for bicycle trips. Both of these analyses assume a more complete pedestrian and bicycle transportation network and concurrent program development to encourage use.

Table 39. Future Pedestrian Demand Model Results

Variable	Value	Source
Future study area population	143,861	*Rapid City Area 2035 Long Range Transportation Plan.*
Future employed population	103,865	*Rapid City Area 2035 Long Range Transportation Plan.*
Future walk-to-work mode share	4.8%	Based on increase from previous mode split due to improvements in the pedestrian network
Future number of walk-to-work commuters	4,973	(employed persons) * (walking mode share)
Future work-at-home mode share	4.8%	Same as 2006-2008 ACS mode split
Future number of work-at-home walk commuters	2,487	Assumes 50% of population working at home makes at least one daily walking trip.
Future transit-to-work mode share	1.0%	Based on increase from previous mode split due to improvements in the pedestrian network
Future transit pedestrian commuters	883	Assumes 85% of transit riders access transit by foot.
Future school children, ages 6-14 (grades K-8)	23,480	Same as 2006-2008 ACS mode split
Future school children walking mode share	29.0%	Portland Safer Routes to School Survey, 2007
Future school children walk commuters	6,809	(school children pop.)* (walking mode share)
Future number of college students in study area	8,524	Same as 2006-2008 ACS population proportion
Future estimated college walking mode share	60.0%	*National Bicycling & Walking Study*, FHWA, 1995.
Future college walking commuters	5,114	(college student pop.) * (walking mode share)
Future total number of walk commuters	20,266	(walk-to-work trips) + (school trips) + (college trips) + (utilitarian trips)
Future total daily walking trips	40,533	Total walk commuters x 2 (for round trips)
<u>Other utilitarian and discretionary trips:</u>		
Ratio of "other" trips to commute trips	2.73	*National Household Transportation Survey*, 2001
Estimated non-commute trips	110,654	
Future Daily Pedestrian Trips:	**151,187**	

Table 40. Future Bicycle Demand Model Results

Variable	Value	Source
Future study area population	143,861	*Rapid City Area 2035 Long Range Transportation Plan*
Future employed population	103,865	*Rapid City Area 2035 Long Range Transportation Plan*
Future bike-to-work mode share	2.0%	Based on increase from previous mode split due to improvements to the bicycle network
Future number of bike-to-work commuters	2,084	(employed persons) * (bicycling mode share)
Future work-at-home mode share	4.8%	Same as 2006-2008 ACS mode split
Future number of work-at-home bike commuters	2,487	Assumes 50% of population working at home makes at least one daily bicycling trip.
Future transit-to-work mode share	0.1%	Based on increase from previous mode split due to improvements in the pedestrian network
Future average daily bicycle on bus boardings	26	Assumes 25% of transit riders access transit by bicycle
Future school children, ages 6-14 (grades K-8)	23,480	Same as 2006-2008 ACS population proportion
Future school children bicycling mode share	3.0%	Portland Safer Routes to School Survey, Spring 2007
Future school children bike commuters	704	(school children pop.)* (bicycling mode share)
Future number of college students in study area	8,524	Same as 2006-2008 ACS population proportion
Future estimated college bicycling mode share	8.0%	*National Bicycling & Walking Study*, FHWA, 1995.
Future college bike commuters	682	(college student pop.) * (bicycling mode share)
Future total number of bicycle commuters	5,957	(bike-to-work trips) + (school trips) + (college trips) + (utilitarian trips)
Future total daily bicycling trips	11,913	Total bike commuters x 2 (for round trips)
Other utilitarian and discretionary trips:		
Ratio of "other" trips to commute trips	2.73	National Household Transportation Survey, 2001
Estimated non-commute trips	32,524	
Future Estimated Bicycle Trips:	**44,437**	

Potential Air Quality Improvements

Based on population growth and the expected increase in walking and bicycling, developing the Rapid City bicycle and pedestrian network will replace more than 17,000 weekday vehicle trips, eliminating more than 12 million vehicle miles traveled per year, shown in Table 41 through Table 44. Walking and bicycling throughout the region prevents significant quantities of vehicle emissions from entering the ambient air. Pedestrian and bikeway network enhancements are expected to generate more walking and bicycling trips in the future. This growth is expected to improve air quality by further reducing the number of vehicle trips, vehicle miles traveled, and associated vehicle emissions.

Table 41. Vehicle Trips/VMT Reduction for Pedestrian Trips

Variable	Value	Source
Reduced Vehicle Trips per Weekday	13,433	Assumes 73% of walking trips replace vehicle trips for adults/college students and 53% for school children
Reduced Vehicle Trips per Year	3,505,899	Reduced number of weekday vehicle trips multiplied by 261 (weekdays in a year)
Reduced Vehicle Miles per Weekday	16,540	Assumes average round trip travel length of 1.2 miles for adults/college students and 0.5 mile for schoolchildren
Reduced Vehicle Miles per Year	4,316,912	Reduced number of weekday vehicle miles multiplied by 261 (weekdays in a year)

Table 42. Air Quality Benefits from Pedestrian Trips[*]

Variable	Value	Source
Reduced Particulate matter (PM10; tons/weekday)	304	Daily mileage reduction multiplied by 0.0184 tons
Reduced Nitrogen Oxide (NOX); tons/weekday)	8,250	Daily mileage reduction multiplied by 0.4988 tons
Reduced Reactive Organic Gas (ROG; tons/weekday)	1,201	Daily mileage reduction multiplied by 0.0726 tons
Reduced Carbon Dioxide (CO2; lb/weekday)	3,211,476	Daily mileage reduction multiplied by 0.916 lb
Reduced PM10 (tons/year)	79,431	Yearly mileage reduction multiplied by 0.0184 tons
Reduced NOX (tons/year)	2,153,276	Yearly mileage reduction multiplied by 0.4988 tons
Reduced ROG (tons/year)	313,408	Yearly mileage reduction multiplied by 0.0726 tons
Reduced CO2 (lb/year)	3,954,381	Daily mileage reduction multiplied by 0.916 lb

[**] *Source: NHTSA Corporate Average Fuel Economy for MY 2011 Passenger Cars and Light Trucks, Table VIII-5*

Table 43. Vehicle Trips/VMT Reduction for Bicycle Trips

Variable	Value	Source
Reduced Vehicle Trips per Weekday	4,227	Assumes 73% of bicycle trips replace vehicle trips for adults/college students and 53% for school children
Reduced Vehicle Trips per Year	1,103,129	Reduced number of weekday vehicle trips multiplied by 261 (weekdays in a year)
Reduced Vehicle Miles per Weekday	31,199	Assumes average round trip travel length of 8 miles for adults/college students and 1 mile for schoolchildren
Reduced Vehicle Miles per Year	8,142,942	Reduced number of weekday vehicle miles multiplied by 261 (weekdays in a year)

Table 44. Air Quality Benefits from Bicycle Trips[*]

Variable	Value	Source
Reduced PM10 (tons/weekday)	574	Daily mileage reduction multiplied by 0.0184 tons
Reduced NOX (tons/weekday)	15,562	Daily mileage reduction multiplied by 0.4988 tons
Reduced ROG (tons/weekday)	2,265	Daily mileage reduction multiplied by 0.0726 tons
Reduced CO2 (lb/weekday)	28,579	Daily mileage reduction multiplied by 0.916 lb
Reduced PM10 (tons/year)	149,830	Yearly mileage reduction multiplied by 0.0184 tons
Reduced NOX (tons/year)	4,061,699	Yearly mileage reduction multiplied by 0.4988 tons
Reduced ROG (tons/year)	591,178	Yearly mileage reduction multiplied by 0.0726 tons
Reduced CO2 (lb/year)	7,459,103	Daily mileage reduction multiplied by 0.916 lb

[*] *Source: NHTSA Corporate Average Fuel Economy for MY 2011 Passenger Cars and Light Trucks, Table VIII-5*

Appendix E. Safety Needs Analysis

Local crash data is a valuable source of information for identifying difficult or dangerous areas for bicyclists. It can also highlight specific interactions between bicyclists and motorists that require increased awareness or engineering. This section provides an overview of bicycle crash typologies and common unsafe bicyclist behaviors, which can be addressed through engineering and education or awareness programs. The section also presents a summary of crash data involving bicycles and pedestrians provided by Rapid City for 2002-2008. This analysis builds on the *2002-2008 Pedestrian and Bicycle Crash Report* and identifies trends and specific locations to target improvements. The section ends with specific engineering and programmatic improvement recommendations to improve safety for bicyclists and pedestrians in the Rapid City Area.

Interpreting Crash Data

According to national and local surveys, concerns about safety are the most common reasons why people do not bicycle (or do not ride more often).[14] Many bicyclists feel that motorists do not see them or are openly hostile to them on roadways, particularly at intersections. Bicycle crash research supports concerns about bicycle/motorist interactions at intersections: the most commonly reported bicycle/vehicle crashes occur at busy arterial intersections. In addition, many bicyclists involved in crashes are younger people who have less experience riding on the road and/or cyclists who are riding the wrong way on the street or on the sidewalk. Both of these issues indicate the need for increased education for bicyclists and motorists alike.

Safety is also an important consideration for pedestrians. As the most vulnerable roadway users, pedestrians should feel safe walking along or crossing a street. Crash rates affect how safe people feel walking and bicycling in the city.

Certain caveats are necessary when interpreting crash data. First, pedestrian and bicycle crashes are generally considered to be significantly under-reported worldwide, particularly for crashes that do not result in serious injury. A street or intersection that did not experience a crash over the analysis period is not an indication that people are not bicycling or walking there, or that the area does not present hazards to walking or

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[14] A 2009 study in Oregon and southwest Washington found that people who feel that bicycling is very safe ride more than twice as often in an average week than those who feel that it is not safe. Source: http://bikeportland.org/wp-content/uploads/2009/10/btasurveyreportfull2.pdf

bicycling. Crash data also do not take into consideration "near misses" which characterize conditions at many high-risk locations without reported incidents. Second, in absence of bicycle, pedestrian and vehicle counts, there is no way to measure "exposure" to crashes. For example, consider two streets that experienced the same number of crashes but different levels of bicycling. The street with significant bicycle traffic is likely to be less dangerous than the street that saw the same number of crashes despite seeing little bicycle traffic (measured by crashes per bicyclist or crashes per miles traveled). Third, coding of crash data may be inaccurate, incomplete, or biased, which would limit the explanatory power of the data.

Crash Typologies

Identifying types of crashes involving bicyclists and pedestrians suggests several design and engineering solutions for reducing crashes. Some crash types can be reduced through good design at specific intersections, while other types indicate the need for greater overall education and visibility of bicyclists on the roadways or in paths. This section addresses crash typologies as defined by the Federal Highway Administration (FHWA). FHWA documented national bicycle and pedestrian injury and crash trends in a 1990 study that created standard typologies for crashes involving bicyclists.[15]

The *2002-2008 Pedestrian/Bicycle Crash Report* categorized crashes based on the Federal Highway Administration's *PEDSAFE: Pedestrian Safety Guide and Countermeasure Selection System* (2004) and the National Highway Traffic Safety Administration's (NHTSA) *Pedestrian and Bicycle Crash Analysis Tool* software. Pedestrian crashes were divided into the following typologies:

- Backing Vehicle - The pedestrian was struck by a backing vehicle on a street, in a driveway, on a sidewalk, in a parking lot, or at another location.
- Bus Related - The pedestrian was struck by a vehicle while: (1) crossing in front of a commercial bus stopped at a bus stop; (2) going to or from a school bus stop; or (3) going to or from, or waiting near a commercial bus stop.
- Dart/Dash - The pedestrian walked or ran into the roadway at an intersection or midblock location and was struck by a vehicle. The motorist's view of the pedestrian may have been blocked until an instant before the impact.

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[15] *Pedestrian and Bicycle Crash Types of the Early 1990's*, Publication No. FHWA-RD-95-163, W.H. Hunter, J.C. Stutts, W.E. Pein, and C.L. Cox, Federal Highway Administration, Washington, DC, June, 1996.

- Driverless Vehicle – The pedestrian was struck by a driverless vehicle that was left in gear or one that rolled forward or back.
- Multiple Threat/Trapped - The pedestrian entered the roadway in front of stopped or slowed traffic and was struck by a multiple threat vehicle in an adjacent lane after becoming trapped in the middle of the roadway.
- Non-Roadway - The pedestrian was standing or walking near the roadway edge, on the sidewalk, in a driveway or alley, or in a parking lot when struck by a vehicle.
- Other - Pedestrian struck after a vehicle/vehicle collision, pedestrian struck by falling cargo, emergency vehicle striking a pedestrian, pedestrian lying in the road, etc.
- Thru Vehicle No Traffic Control - The pedestrian was struck at an unsignalized intersection or mid-block location. Either the motorist or the pedestrian may have failed to yield.
- Thru Vehicle, Traffic Control - The pedestrian was struck at a signalized intersection or mid-block location by a vehicle that was traveling straight ahead.
- Turning Vehicle - The pedestrian was attempting to cross at an intersection, driveway or alley and was struck by a vehicle that was turning right or left.
- Unique Mid-block – The pedestrian was struck while crossing the road to/from a mailbox, newspaper box, or ice cream truck, or while getting into or out of a stopped vehicle.
- Unknown – The crash report did not provide adequate information to type the crash.
- Walking Along Roadway - The pedestrian was moving along the roadway and was struck from the front or from behind by a vehicle.
- Working/Playing in Road - A vehicle struck a pedestrian who was: (1) standing or walking near a disabled vehicle, (2) riding a play vehicle that was not a bicycle, (3) playing in the road or (4) working in the road.

This analysis will provide additional detail regarding crashes involving bicyclists, which may be less intuitive than crash typologies involving pedestrians.

Nationally, the most common crash types involving bicyclists are:

- Drive out - motorist failure to yield to a bicyclist in the roadway or failure to yield to a bicyclist who is crossing the roadway in a bike path or on a sidewalk.
- Ride out – bicyclist failure to yield to a motor vehicle (ran stop sign or red light, or failed to yield from uncontrolled driveway).

- Riding without required equipment – bicyclist failure to have required front light and rear reflector when riding after dark.

The following text describes these crash types, defines contributing factors, and outlines potential solutions.

Drive Out Crashes

Categories of drive out crashes identified in the 2008 crash report include:

- Turning vehicle - motorist made a right or left turn in front of a bicyclist.
- Thru vehicle, traffic control - bicyclist struck at a signalized intersection or mid-block location by a vehicle that was traveling straight ahead.
- Backing vehicle –bicyclist struck by a backing vehicle on a street, in a driveway, on a sidewalk, in a parking lot, or at another location
- Overtaking vehicle – bicyclist struck by a vehicle that was traveling in the same direction.
- Assault with vehicle –bicyclist intentionally struck by a driver
- Vehicle pull out - bicyclist struck at a location where the vehicle was facing a traffic control device or the vehicle exiting from an alley or driveway.

Drivers may not watch for bicyclists who are riding on the sidewalk or riding the wrong way in the street, and drive out crashes are often associated with these behaviors.

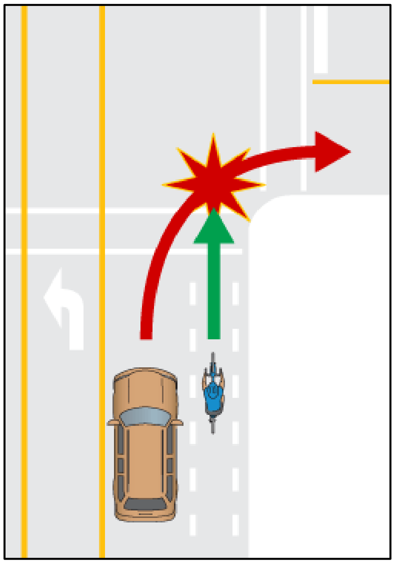


Figure 46. Right hook crash.
Source: Florida Bicycle Association

Right hook crashes are the most common type of drive out crash . They occur when a motorist turns right and hits a bicyclist who is continuing straight on the roadway. Right hooks often happen when bicyclists are crossing in a crosswalk, particularly at a side path or shared-use path crossing of a major roadway. Right hooks can occur when the turning motorist is turning right on a red light and the cyclist, who has a green light, is traveling perpendicular across the intersection.

Right hooks are the most frequent crash type for adult bicyclists, and can occur in bike lanes, making them a significant danger even for experienced cyclists in well-engineered locations.

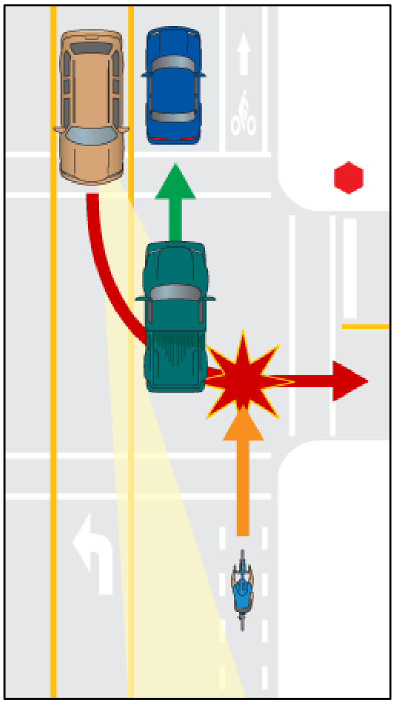


Figure 47. Left-turn multiple threat crash.
Source: Florida Bicycle Association

One particular dangerous drive-out type crash, a 'multiple threat' crash occurs when one vehicle stops for a bicyclist in a crosswalk or street crossing, blocking the view from another motorist, who continues through (Figure 47). This crash type only occurs on multilane roads, and tends to occur more frequently on high-speed roadways.

Mitigation

Drive out crashes indicate the need for additional education, both to increase motorists' awareness of the presence of bicyclists at intersections and in the roadway, and for cyclists to be aware of safe riding practices. Wrong-way riding and sidewalk riding should be discouraged.

Educational programs and marketing campaigns targeted at drivers can increase awareness about bicyclists. In addition, bicyclists should be taught about how to position themselves for maximum visibility and how to proceed safely. For example, if a motor vehicle passes a bicyclist shortly before the intersection and turns right in front of the bicyclist, the bicyclist should be prepared to make a sharp right turn to avoid colliding with the vehicle. Bicyclists can learn to anticipate this type of driver as well as practicing techniques for avoiding the crash.

An engineering solution to this problem is to mark a difficult crossing with pavement markings. Flashing lights and signage can also help increase visibility at the crossing. In significantly problematic locations, the vehicle right turn signal phase can be separated from the bicycle crossing phase at bike path crossings. Pedestrian refuge islands can help unsignalized intersections, where a bicyclist can cross half the roadway and wait in the center for a gap in traffic on the other direction.

Figure 48. Example high-visibility crosswalk with fresh paint and a warning sign with flashing lights.

Ride Out Crashes

Usually occurring when a bicyclist enters the roadway from a driveway, alley or sidewalk or runs a stop sign/red light and does not yield to an oncoming car; ride out crashes are the most common type of crash for child cyclists. This type of crash is also often caused by lack of visibility, frequently due to parked cars impeding the bicyclists' view of oncoming traffic.

Rapid City's Code of Ordinances provides specific regulations for motor vehicles crossing sidewalks:

> *10.12.300 Crossing sidewalks.*
>
> *A. A vehicle shall not cross a sidewalk except where a driveway is provided, and in crossing a sidewalk to or from an alley, lot, building or street, no vehicle shall be driven at a speed greater than 5 mph.*
>
> *B. Every person driving any vehicle to or from an alley, lot, building or street across any sidewalk shall give warning of his or her approach and shall yield the right-of-way to all pedestrians using the sidewalk and vehicles traveling on the street.(Prior code § 28-88)*

Additional crash types under the ride out crash type include:

- Bicyclist left turn in front of traffic
- Bicyclist lost control
- Bicyclist right turn while facing traffic
- Wrong way cyclist

Mitigation

Many ride out crashes can be attributed to inexperienced bicyclists or riders who do not understand safe ways of riding in the street. Nationally, the majority of ride-out crashes are caused by children or intoxicated bicyclists and are exacerbated by cyclists riding incorrectly or unsafely on a sidewalk or the wrong way on the street. Education for cyclists is important for reducing ride out crashes, as well as ensuring that sufficient treated crossings are provided, to prevent a cyclist from having to dart across the street in order to cross.

One solution for a location that has experienced ride out crashes is to limit parking around the driveway or intersection. Cyclists of all ages should be educated about the dangers of this type of behavior, and that they need to follow the same traffic laws as other drivers.

Riding Without Required Equipment

According to U.S. DOT NHTSA, *Fatal Accident Reporting System* (2002), 43 percent of all bicycle fatalities occur in non-daylight hours, and 17 percent of all car-bike collisions happen at night. The State of South Dakota requires that bicyclists have a light on the front visible to 300 feet and a yellow or red light or reflector on the back, visible for at least 200 feet (32-17-25; Figure 49).

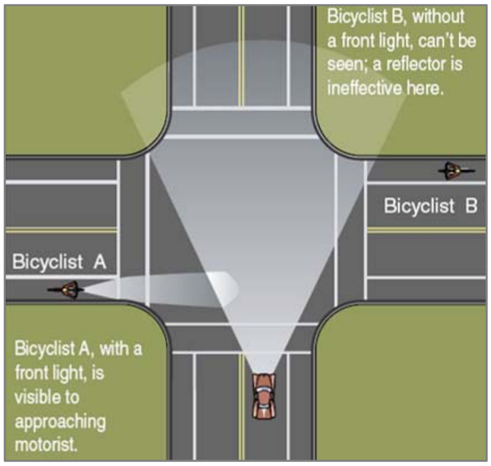


Figure 49. Effectiveness of bike lights. Source: Oregon Department of Transportation

Mitigation

Media campaigns can raise awareness of the importance of bicyclists having proper lighting at night. "Get Lit" campaigns remind cyclists to use proper lighting. Bike light giveaways can also ensure that cyclists have access to required equipment.

Common Unsafe Bicyclist Behaviors

Several common behaviors are not illegal, but can be very dangerous for bicyclists, and should be discouraged. These include sidewalk riding, wrong-way riding and dangerous lane positioning. The MPO should encourage safe bicycling practices and should avoid policies or treatments that foster unsafe behaviors.

Sidewalk Riding

Though riding on the sidewalk may feel safer than riding with motor vehicle traffic in the street, it is often more dangerous and is illegal in many jurisdictions. In Rapid City, it is illegal to ride on sidewalks in the central business districts. Cyclists riding on the sidewalk in other areas are required to yield to pedestrians and provide an audible warning when passing. Reasons why sidewalk riding is less safe than street riding include:

- Cyclists riding on sidewalks can be blocked from view by cars parked along the street and landscaping.
- Motorists and pedestrians do not expect to encounter cyclists on sidewalks. The unexpected appearance of a cyclist can surprise all of the involved parties and result in reduced reaction times and increased likelihood of a crash.
- Cyclists riding on the sidewalk encounter more potential conflict points. Generally, these conflict points are driveways and intersections but they can also include areas where street furniture creates pinch points, and areas where people congregate (e.g., bus stops).
- Cyclists riding on the sidewalk often travel two to three times faster than pedestrians (8 to 10 MPH versus 2-3 MPH) and can be difficult for sidewalk and roadway users to see and respond to.

If cyclists choose to ride on the sidewalk, they should ride slowly, with the flow of traffic, and should be aware of drivers entering and exiting driveways and side streets. Children should be closely supervised by adults and encouraged to ride in the street as they get older and their riding skills improve.

Wrong-Way Riding

Riding against the flow of traffic is a widespread, yet unsafe, cyclist behavior. Though wrong-way riding accounts for only 2.5 percent of all bicycle crashes, it has been shown to be a contributing factor in several common types of crashes (Figure 50).

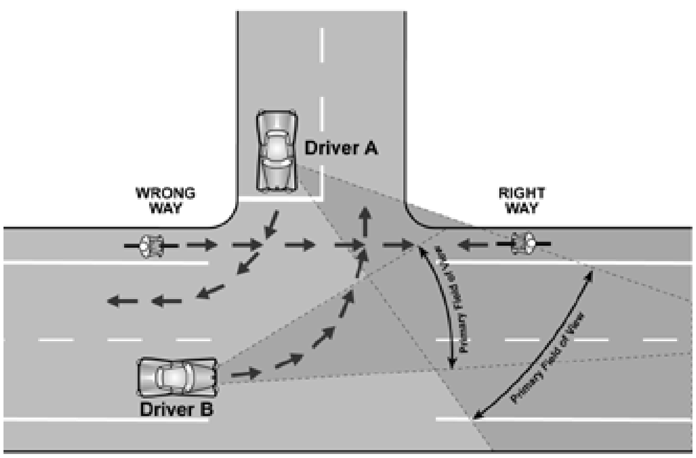


Figure 50. Conflicts caused by wrong-way riding. Source: Oregon DOT Bicyclist's Manual

Wrong way riding puts the bicyclist in a place where drivers do not expect a vehicle. Wrong-way riders also cannot see traffic signs and signals and risk head-on collisions with lawful cyclists.

People ride facing traffic because it is considered the proper way to walk in the street and is what many bicyclists were told to do, because it is convenient not to have to cross the street, or because bicyclists are afraid of being struck from behind.

Dangerous Lane Positioning

Rapid City requires that cyclists ride within four feet of the right–hand curb, except under certain conditions. The Code of Ordinances states,

> *10.64.170 Any person operating a bicycle upon a roadway at less than the normal speed of traffic at the time and place and under the conditions then existing shall ride in the right 4 feet of roadway near the right-hand curb or edge of the roadway, except under any of the following conditions:*
>
> *When overtaking and passing another bicycle or vehicle proceeding in the same direction;*
>
> *When preparing for a left turn at an intersection or into a private road or driveway; and*
>
> *When reasonably necessary to avoid conditions including, but not limited to fixed or moving objects, parked or moving vehicles, bicycles, pedestrians, animals, surface hazards or substandard width lanes that make it unsafe to continue along the righthand curb or edge. For purposes of this section, a SUBSTANDARD WIDTH LANE is a lane that is too narrow for a bicycle and vehicle to travel safely side by side within the lane.*
>
> *Any person operating a bicycle upon a 1-way street or highway with 2 or more marked traffic lanes may ride as near the left-hand curb or edge of the roadway as practicable. Cyclists should stay in the left 4 feet of roadway whenever possible to avoid interfering with traffic.*

These exceptions recognize that bicyclists should ride on the right-hand side of the lane (or the left-hand side of a one-way street) to allow motorists to pass them, and that riding too far to the right can be dangerous. In addition to the concerns listed above, cyclists should avoid riding in the 'door' zone

Getting "doored" is a frequent cause of bicycle crashes in places with on-street parking (Figure 51). Dooring can result in serious injuries and property damage to both bicycles and automobiles. Bicyclists should always ride at least a door's width away from cars. Some cyclists are afraid to ride further out into the travel lane because they believe that they are required to ride all the way to the right, and because they are intimidated by other traffic, but cyclists are much more likely to be involved in a crash with a car door than with an overtaking car. They are never required to ride further to the right than is safe.

In addition, many cyclists try to pass other traffic on the right, particularly where vehicles are waiting at an intersection. This can be dangerous because most drivers do not expect overtaking vehicles to be to their right and motorists have blind spots immediately to the right of their vehicles.

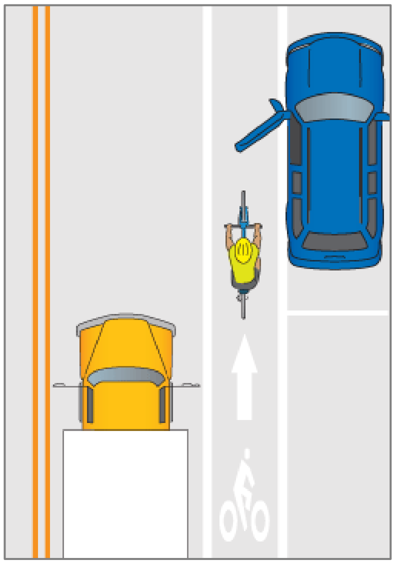


Figure 51. 'Door zone'
Source: Source: Florida Bicycle Association

Rapid City Bicycle and Pedestrian Crash Data

Two data sets were used in this analysis. Data collected for the Rapid City Pedestrian/Bicycle Crash Report (2002-2008) provided valuable background information for this analysis. The 2008 report incorporated police records for the crashes involving bicyclists and pedestrians, and categorized crashes based on crash type, as previously discussed. However, the data set is limited to Rapid City. For crash data outside of the City of Rapid City, the State records from 2004-2008 were used. These records did not collect as much information as the 2008 report; for example, information regarding injury status of the pedestrian or bicyclist is not included. For this reason, as well as the difference in time frame between the data sets, they are discussed separately in the following analysis.

Data were provided by the Traffic Operations Section of the Rapid City Engineering Services Division.

Crash Rate

Between 2002 and 2008, 257 crashes involving bicyclists or pedestrians were reported in Rapid City. Of these, 121 involved bicyclists and 136 involved pedestrians. In addition, State data indicate that seven crashes involving pedestrians and six crashes involving bicyclists occurred in the Rapid City Area but outside of the City of Rapid City from 2004-2008. The city crash data indicate an average of 37 crashes involving bicyclists or pedestrians occurring annually.

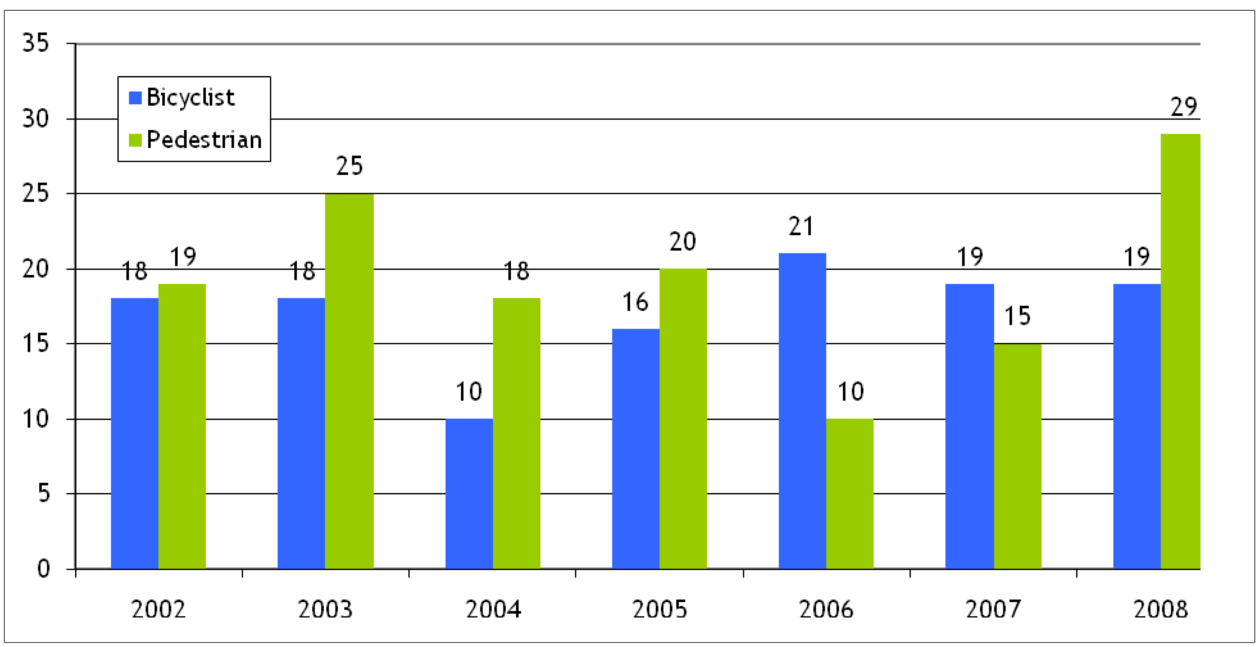


Figure 52. Crashes Involving Bicyclists and Pedestrians by Year, 2002-2008

Monthly crash data shows a relatively even distribution of pedestrian crashes throughout the year. Crashes involving bicyclists were more frequent during the summer months of the seven year period reviewed. This seasonal pattern likely indicates that more residents bicycle in the Rapid City area during summer months. The highest rates of crashes involving bicyclists occur through the summer, with another outlier in October. The majority of the 35 crashes that occurred in October took place in daylight, with clear conditions. However, 24 of those occurred between the hours of 12:00 pm and 7:00 pm, with 14 happening during commute hours (5:00 pm to 7:00 pm). This indicates that there is poor visibility of bicyclists in the afternoon and evening in the fall.

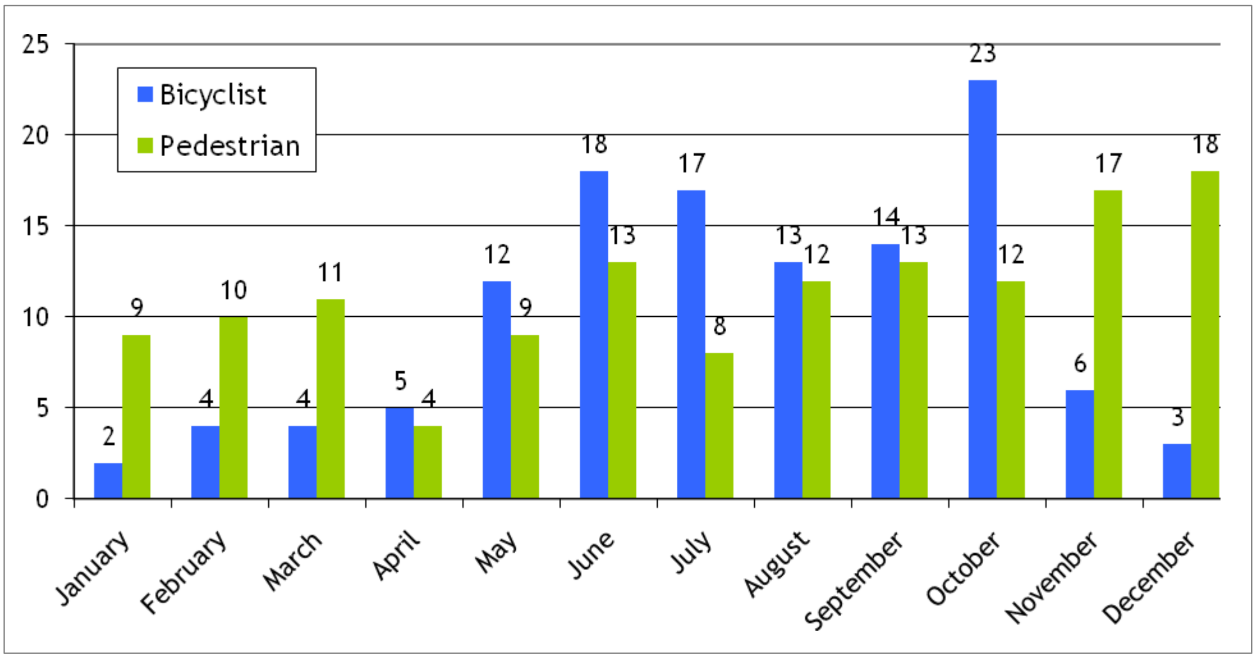


Figure 53. Crashes Involving Bicyclists and Pedestrians by Month, 2002-2008

The majority of crashes experienced from 2002 to 2008 in the Rapid City Area occurred in the afternoon, with 28 percent of crashes occurring between noon and 4 p.m. and another quarter during evening rush hour times. Notably more pedestrian crashes than crashes involving bicyclists occurred after 7 p.m.

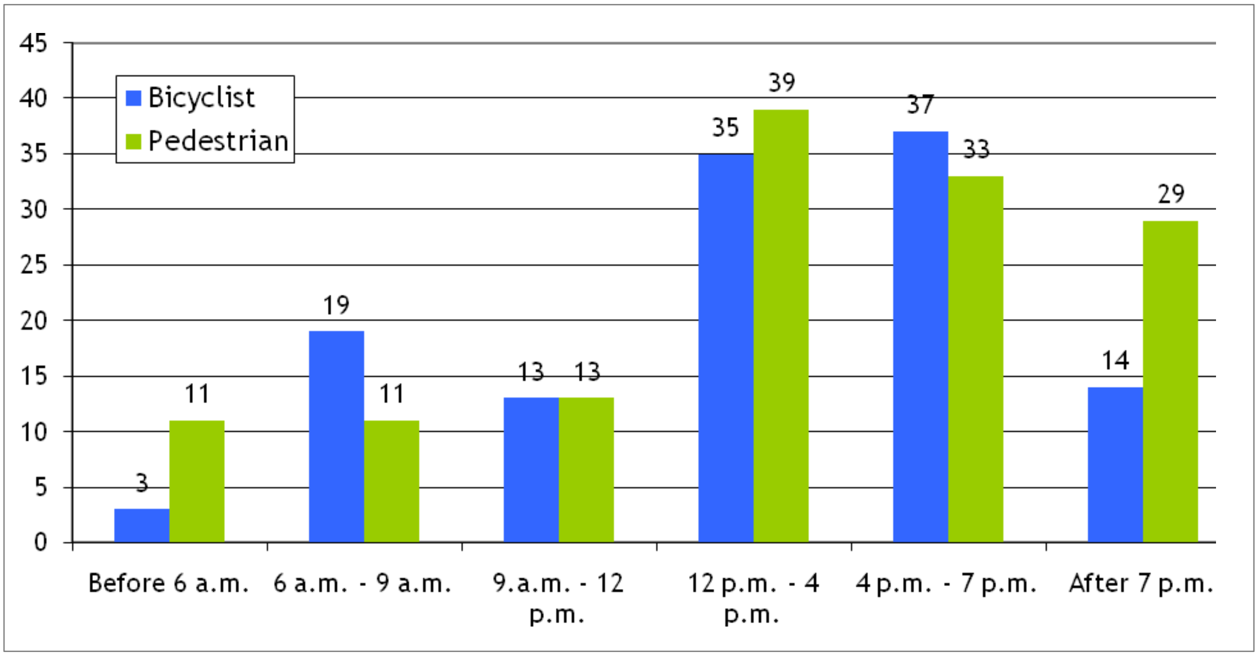


Figure 54. Crashes Involving Bicyclists and Pedestrians by Time of Day, 2002-2008

Bicyclist or Pedestrian Age

Age is another important factor in a crash analysis. As young people cannot drive, a larger proportion of people under 16 walk or ride bicycles. Younger bicyclists and pedestrians may be less aware of safe practices and are more prone to cross a road without checking to see if cars are present. As shown below, over half of bicyclists involved in crashes during the time period were under 20 years of age. The majority of pedestrians involved in crashes were also under 20 years old.

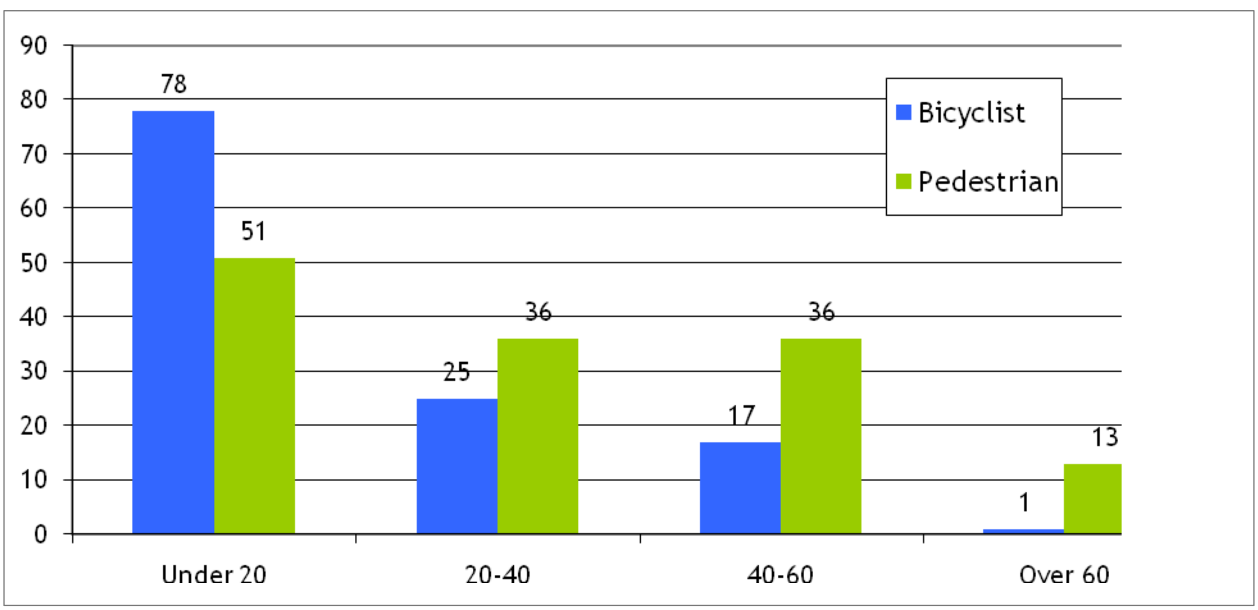


Figure 55. Age of Bicyclists or Pedestrians Involved in Crashes, 2002-2008

Crash Severity

The majority of crashes involving bicyclists and pedestrians during the time period studied resulted in minor injuries. There were six pedestrian fatalities, and no fatalities involving bicyclists (see Figure 56).

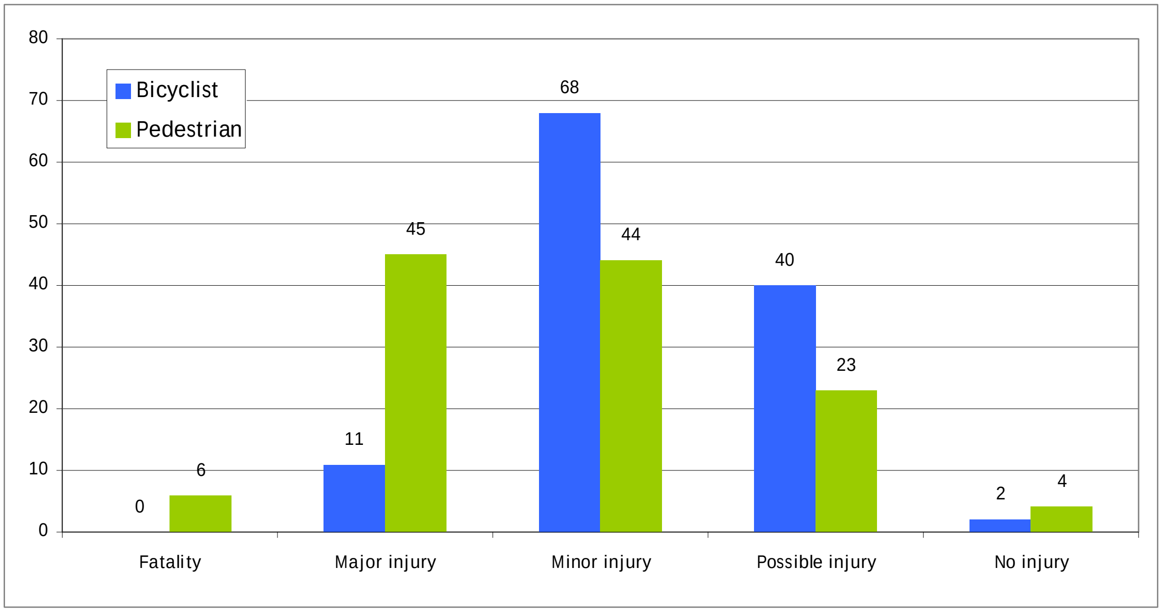


Figure 56. Severity of Crashes Involving Bicyclists and Pedestrians, 2002-2008

The 2008 study provided additional details on three of the fatalities involving pedestrians in 2005 and two in 2008.

- 2002 – Fifth Street, north of Omaha Street, Non-Roadway crash. This crash was caused by a minor-aged driver losing control of the vehicle and leaving the roadway, striking the pedestrian on the sidewalk. The crash occurred during daylight conditions, on dry pavement and no alcohol or drug usage was involved.
- 2005 – Haines Avenue, north of Lawrence Drive, Walking Along Road crash. This crash was caused by a driver driving under the influence of alcohol. The crash occurred during the dawn hours, on dry pavement within a construction zone. The pedestrian was struck when the driver crossed the centerline.
- 2005 – Mt. Rushmore Road, south of St. Cloud Street, Dart/Dash crash. This crash was caused by a pedestrian stepping into a travel lane mid-block. The crash occurred at dusk on dry pavement; alcohol use by the pedestrian was a factor in the crash.
- 2005 – I-90 near I-190, Dart/Dash crash. This crash was caused by a pedestrian stepping into a travel lane. The crash occurred at night

on dry pavement; it is unknown whether or not alcohol or drug use by the pedestrian was a factor in the crash.

- 2008 – E. Omaha Street, west of Cambell Street, Other crash. The pedestrian was lying in the roadway and was run over by a vehicle. The crash occurred at night on dry pavement; alcohol use by the pedestrian was a factor in the crash.
- 2008 – Fifth Street at Oakland Street, Thru Vehicle No Traffic Control crash. The pedestrian was hit while crossing Fifth Street at an unmarked crosswalk. The crash occurred at night on dry pavement; neither alcohol nor drug use was a factor in the crash.

As noted in the 2008 crash report, the City of Rapid City did not experience a bicycle-related fatality. However, the region has a significantly higher bicyclist injury rate than either South Dakota or the United States. Similar to pedestrian crash patterns, 18 percent of crashes involving bicyclists occurred in the central business district.

Contributing Factors

The majority of crashes involving bicyclists and pedestrians in Rapid City occurred during clear conditions (84 percent). Less than an eighth of crashes occurred during cloudy conditions, while rain was a factor in four crashes and snow in three crashes.

Almost three-quarters of crashes occurred during daylight, although 33 pedestrian crashes occurred at night, in a lit area. This finding, combined with the relatively larger number of pedestrians involved in crashes after 7 p.m., may indicate that additional or improved lighting should be provided in key pedestrian areas, such as downtown Rapid City.

Crash Location

Figure 57 shows the locations of all reported crashes involving bicyclists or pedestrians in Rapid City from 2002 through 2008. The map shows that reported crashes are clustered in areas expected to have higher volumes of pedestrians and bicyclists due to commercial development or high population densities.

The crash data also provide an indication of where in the Rapid City Area people are bicycling and walking and where they may experience unclear or dangerous conditions. The 2008 Pedestrian/Bicycle Crash Report noted that the majority of crashes involving pedestrians occurred within Rapid City's central business district (CBD) and along corridors including Mt. Rushmore Road, 5th Street/Haines Avenue, and East Boulevard/East North Street.

Crashes involving bicyclists occurred more commonly along Van Buren Street, Saint Patrick Street, W. Main Street, and Jackson Boulevard, among others. Most of the streets where crashes occurred are busy streets with more than two lanes of traffic that present complicated traffic patterns. In several of these locations, bicyclists are likely using these routes because alternatives do not exist and because they need to access destinations on these streets. Alternate routes can be provided on less busy streets, while a complimentary network of signage can direct cyclists to safer routes. While it may be desirable to provide bicycle facilities to encourage bicycle travel on less trafficked streets, key destinations such as stores, restaurants and employment sites are often located on busy streets. It is thus important to provide facilities to enable bicyclists to safely travel on streets with key destinations. Furthermore, bicyclists sometimes travel on busy streets because they prefer direct and fast routes to their destinations and/or because lower-traffic streets have many stop signs, which can slow bicyclist travel times as much as three times more than another route. Finally, some busy streets do not have a lower volume parallel street that is better suited for bicycles due to a lack of street connectivity. For the above reasons, creating multi-modal streets may be a worthy goal for some of the busier streets in Rapid City.

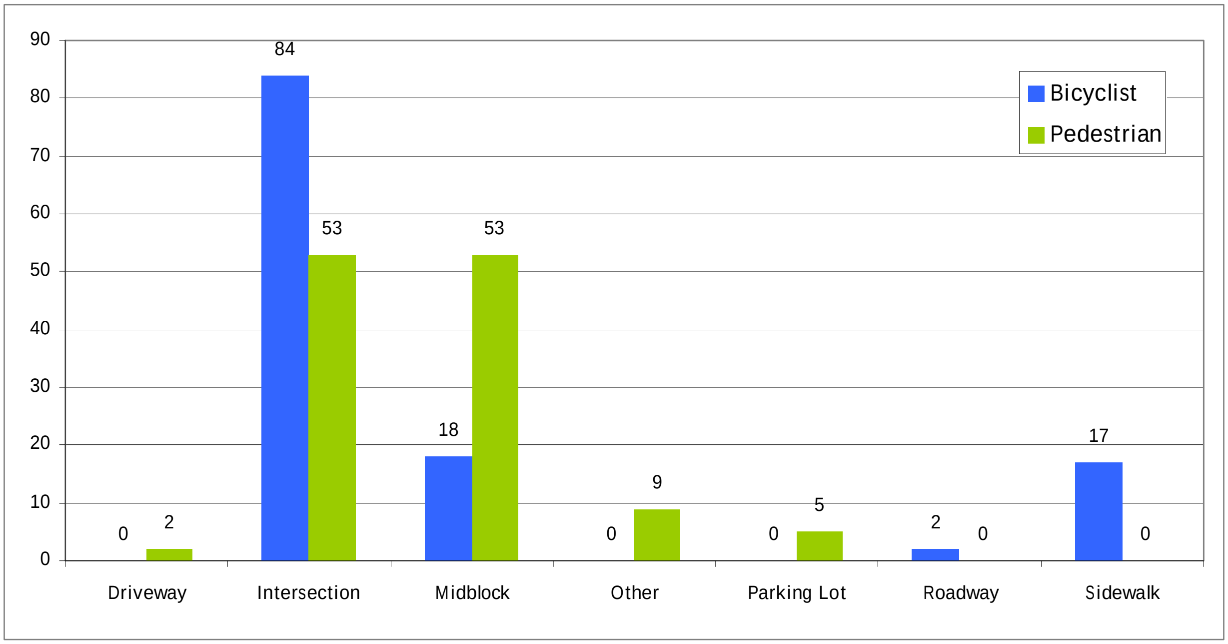
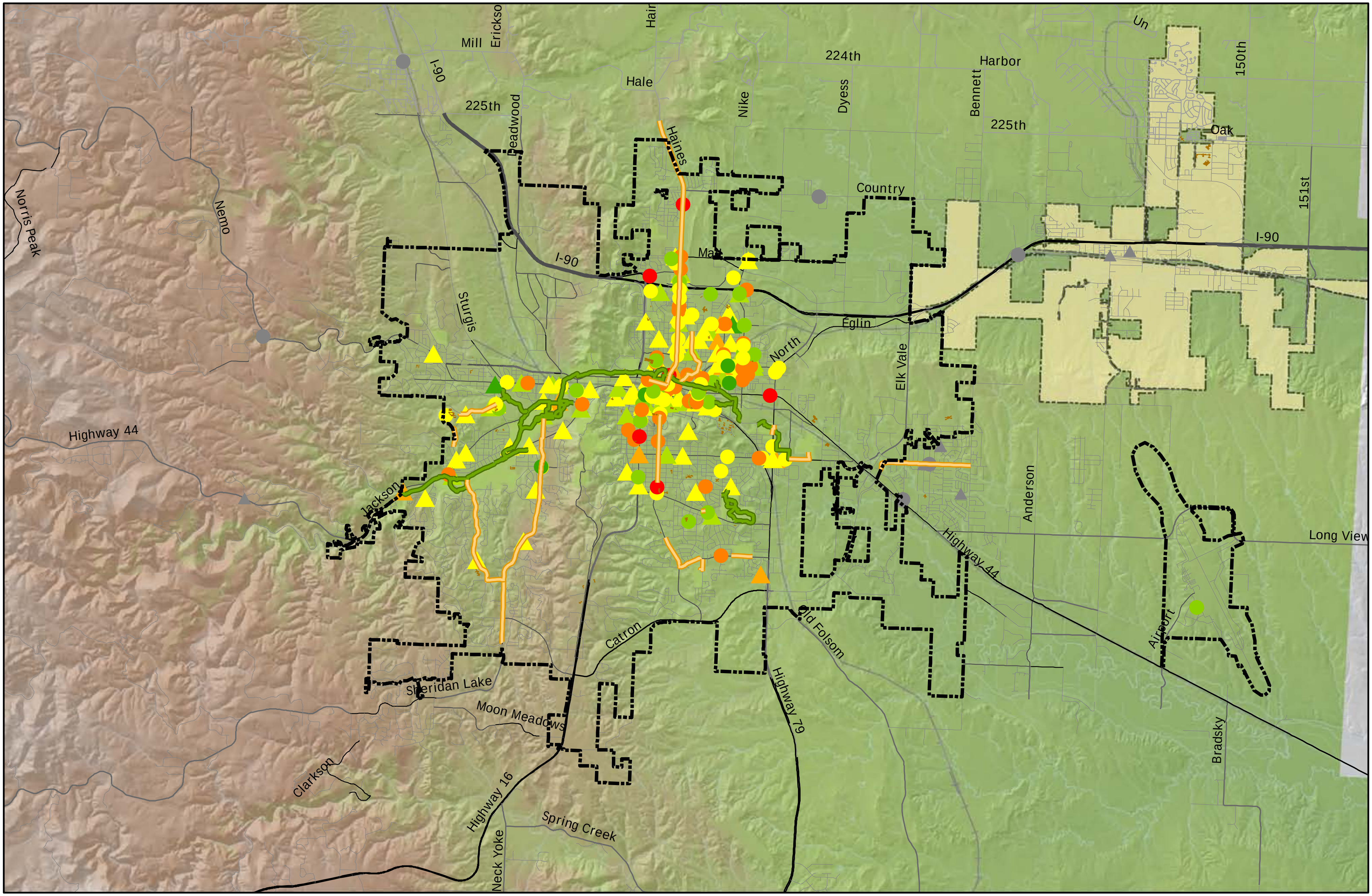


Figure 57. Location of Crashes Involving Bicyclists and Pedestrians, 2002-2008



Map 15. Crashes Involving Bicyclists or Pedestrians, 2004-2008

Rapid City Area
Bicycle and Pedestrian Master Plan
Source: Data obtained from Rapid City MPO
Author: HWK
Date: June 2010

0 1.25 2.5 Miles

- Pedestrian (circle)
- Bicycle (triangle)
- No Injury
- Possible Injury
- Minor Injury
- Major Injury
- Fatality

alta PLANNING + DESIGN

The majority of the crashes involving bicycles and pedestrians took place at an intersection (56 percent of total crashes, and 69 percent of crashes involving bicyclists). In addition, midblock crossings saw a high proportion of crashes (29 percent for all types, and 43 percent of pedestrians). Measures to increase visibility of bicycles and pedestrians at intersections would increase safety for cyclists. Strategies for increasing bicycle visibility include colored bicycle boxes, which place bicycles in front of traffic to increase visibility at intersections and limits right-turn conflicts when the traffic signal changes from the red to the green phase (Figure 57). Colored paint can also be used to alert motorists to the presence of bicycles on intersection approaches. Complicated intersections should be simplified where possible.

Figure 58. Bike boxes have been installed at several intersections in Portland, OR where right-turning motorists conflict with through bicyclists.

Where slip lanes allow drivers to make right turns without slowing, reconstructing the corners can significantly improve bicyclist and pedestrian safety.

The majority of crashes outside of the City of Rapid City occurred along major roadways. In Box Elder, crashes occurred on I-90, on Box Elder Road, and on Douglas Road. In Rapid Valley, two collisions occurred along Twilight Drive, which provides a side path for bicycle and pedestrian travel. Both were located at intersections, one at Sweetbriar Street and the other at Dorothy Drive.


Figure 59. Reducing the radius of a turn reduces traffic speed and greatly improves safety for bicyclists and pedestrians

Fault

According to the analysis of the data presented in the 2008 report, pedestrians were at fault in 40 percent of crashes involving pedestrians, while drivers were at fault in almost 50 percent of these crashes. The most common cause of crashes was found to be dart/dash crossings, wherein a pedestrian crossed the roadway without a signal. While the crashes were judged to be the fault of the pedestrian, these crashes indicate a location where the pedestrians want to cross the roadway, but no appropriate crossing treatment is provided.

The other major cause of injury was related to a turning vehicle (see Figure 60). One mechanism for increasing pedestrian safety at intersections is to reduce the curb radius to force drivers to slow down when making turns (Figure 59).

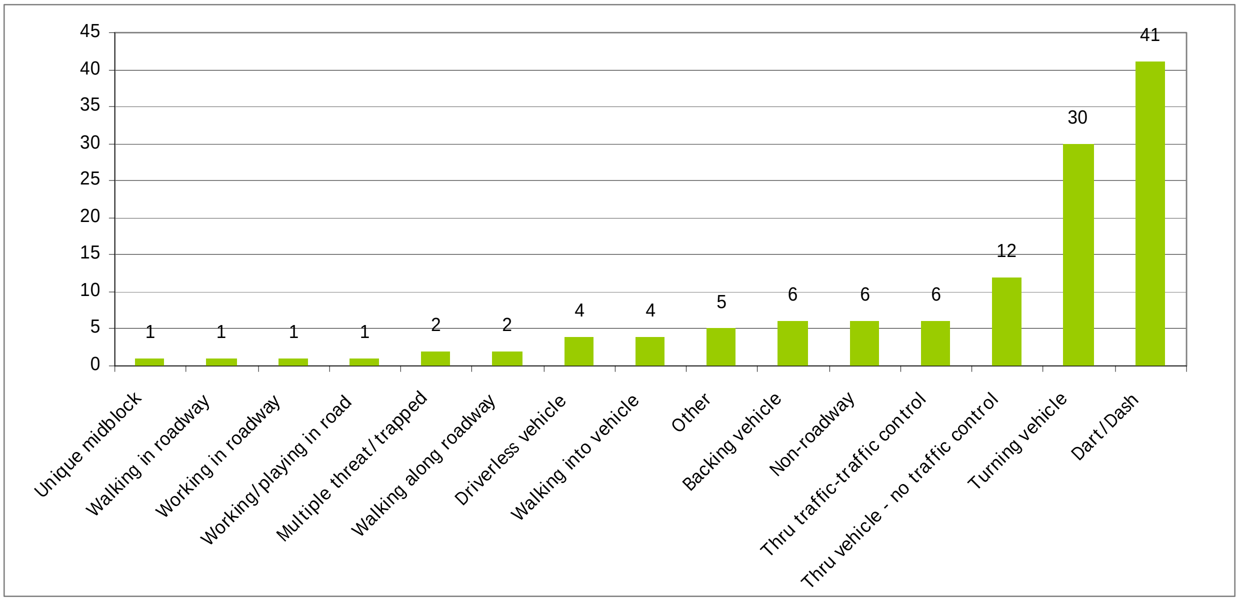


Figure 60. Cause of Crashes Involving Pedestrians, 2002-2008

The largest cause of crashes involving bicyclists was the 'bicyclist ride-out,' which includes many different behaviors and situations. This finding indicates that bicyclist education is an important strategy for improving bicyclist safety. In addition, designating separated space for bicyclists can encourage them to follow the rules of the road. Drivers were found to be at fault in 38 percent of crashes involving bicyclists, and bicyclists were found to be at fault in 60 percent of crashes. The major driver-fault crashes were caused by vehicles pulling out or turning into bicyclists. These issues can be improved by increasing visibility and awareness, both with improving sightlines and through awareness campaigns.

The majority of crashes involving pedestrians occurred along Mt. Rushmore Road and 5th Street/Haines Avenue, as well as in the central business district. In absence of area-wide bicycle and pedestrian counts, this crash data indicates where people bicycle and walk in the Rapid City Area.

As previously discussed, a significant proportion of bicyclists and pedestrians involved in crashes were under 20; almost 40 percent of bicyclists were between the ages of 6 to 13, while another 19 percent were 14 to 19. This indicates the need for greater educational programs to teach students/young people how to safely cross the street and ride a bicycle. Figure 62 shows that the majority of crashes involving people under 20 were categorized as 'bicyclist ride out,' while a significant number involved turning vehicles or dart/dash crashes.

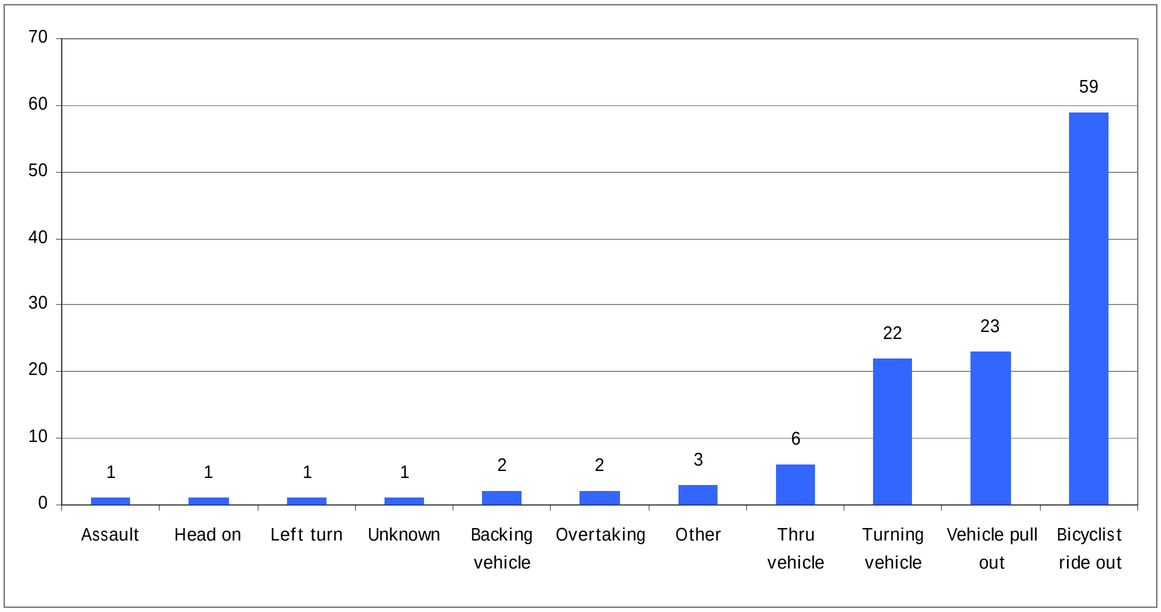


Figure 61. Cause of Crashes Involving Bicyclists, 2002-2008

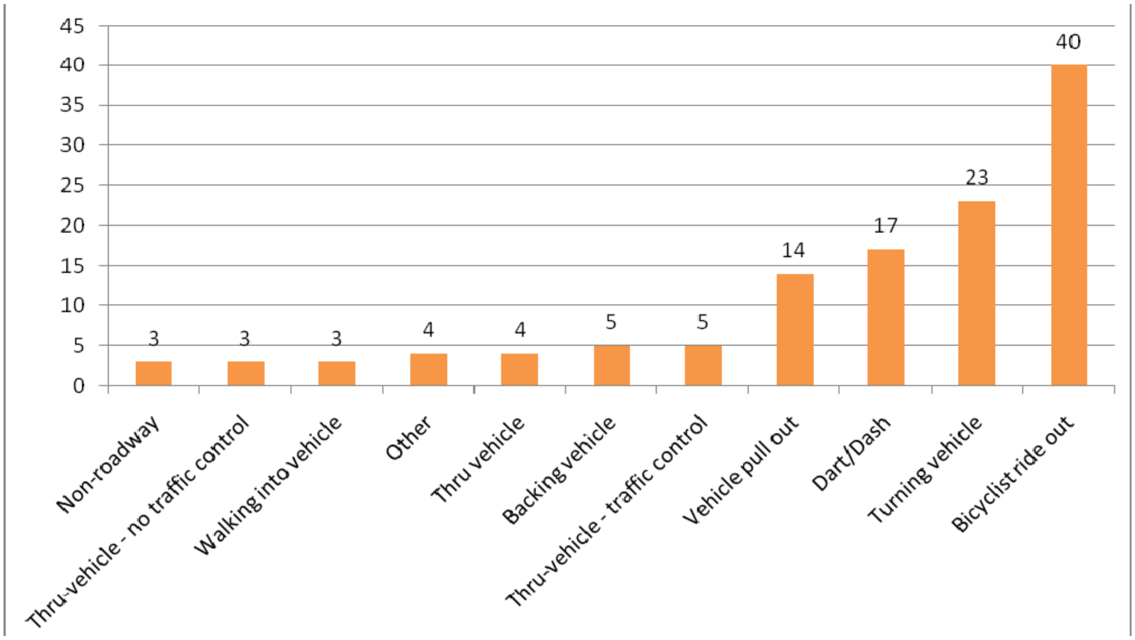


Figure 62. Cause of Crashes Involving Bicyclists or Pedestrians Under 20 Years of Age, 2002-2008

Analysis and Recommendations

The 2008 Pedestrian/Bicyclist Crash Report made the following conclusions:

- Rapid City's pedestrian and bicyclist injury crash rates are generally higher than corresponding statewide and national rates
- No location-specific trends were identified for pedestrian or bicyclist crashes

- There is a general trend for pedestrian crashes to occur within the central business district (CBD) and along the Mt. Rushmore Road, 5th Street/Haines Avenue, and East Boulevard/East North Street corridors
- The age distribution of Rapid City pedestrians and bicyclists involved in crashes is consistent with statewide data
- The most frequently occurring pedestrian crash types are dart/dash and turning vehicle
- Alcohol use by pedestrians is a significant factor in dart/dash pedestrian crashes
- The most frequently occurring bicyclist crash types are bicyclist pull out, vehicle pull out and turning vehicle
- A significant number of bicyclist crashes involved bicyclists who were using the sidewalk at an intersection. Most of the bicyclists involved in crashes at intersections demonstrated a lack of understanding of South Dakota law, specifically that bicyclists must stop before entering a crosswalk or highway from a sidewalk or sidewalk area. Failure to comply with this law is a direct cause of crashes since the higher operating speed of bicycles versus pedestrians (1) makes it difficult for drivers to judge the necessity of yielding to bicyclists who do not stop, and, (2) allows for bicyclists to pass slowing vehicles approaching an intersection leading to drivers being "surprised" by crossing bicycle traffic at the intersection.

Locations that have experienced crashes are prioritized in the Master Plan recommendations. In addition, the types of accidents bicyclists tend to be involved in indicates lack of awareness and a need for improved facilities that offer clear guidance to drivers and cyclists about which mode is expected to yield in different situations.

The prevalence of 'side path' type facilities in the Rapid City Area may contribute to the perception that bicyclists do not stop at intersections. On a facility that crosses many side streets and driveways, a cyclist may not want to come to a full stop at every intersection, similarly to as if they were riding in a bike lane. Having the bicyclist separated from traffic, often with parked cars or trees between the drivers and cyclists, limits driver visibility and increases the rate of crashes.

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Appendix F. Bicycle and Pedestrian Standards and Design Guidelines

Rapid City is interested in implementing pedestrian, on-street bikeway, and shared-use path projects in order to encourage walking and cycling. While the Rapid City area is growing rapidly, it also contains an existing built environment; many future projects will involve retrofitting existing streets and intersections. When looking to implement bike lanes or other improvements on Rapid City's streets, most standard design manuals offer limited solutions.

The design concepts presented in this document are based on current walkway, bikeway, and trail design guidelines provided in federal, state, and local design and standards documents, as well as best practices from several communities throughout the country. The bicycle and pedestrian design guidelines use these documents as a baseline for minimum conditions. The guidelines are intended to find creative solutions to the problem of providing bicycle and pedestrian facilities in a wide variety of conditions. These treatments draw upon creative solutions in use in other states as well as additional treatments in use in other urban areas in the U.S. and abroad.

Key Design Principles

The following are key principles for these pedestrian and bicycle guidelines:

- **The walking and bicycling environments should be designed with safety in mind.** Sidewalks, shared-use paths, roadway crossings, and bicycle routes should be designed and built to be free of hazards and to minimize conflicts with vehicular traffic.
- **The pedestrian and bicycle network should be accessible.** Bicycle and pedestrian facilities should accommodate the needs of people regardless of age or ability. At a minimum, facilities should be designed for the use of experienced cyclists, with a goal of providing for inexperienced bicyclists (especially children and seniors) to the greatest extent possible.
- **The walking and bicycling environment should be clear and easy to use.** Design bicycle and pedestrian facilities so people, including those with mobility and sensory impairments, can easily find a direct route to a destination and delays are minimized.
- **Bicycle and pedestrian improvements should be economical.** Improvements should be designed to minimize construction and maintenance costs as well. Where possible, improvements in the right-of-way should stimulate, reinforce and connect with adjacent private improvements.

References

The following is a list of references and sources utilized to develop design guidelines for the Rapid City Bicycle and Pedestrian Master Plan. Many of these documents are available online and are a wealth of information and resources available to the public.

Federal Guidelines

- *2010 ADA Standards for Accessible Design*, 2010. Department of Justice. http://www.ada.gov/regs2010/2010ADAStandards/2010ADAstandards.htm#curbramps
- AASHTO *Guide for the Development of Bicycle Facilities*,[16] 1999. American Association of State Highway and Transportation Officials, Washington, DC. www.transportation.org
- AASHTO *Policy on Geometric Design of Streets and Highways*, 2001. American Association of State Highway and Transportation Officials, Washington, DC. www.transportation.org
- *Accessibility Guidelines for Buildings and Facilities*, 2002. United States Access Board, Washington, D.C. http://www.access-board.gov/adaag/html/adaag.htm
- *Manual on Uniform Traffic Control Devices* (MUTCD), 2003. Federal Highway Administration, Washington, DC. http://mutcd.fhwa.dot.gov
- *Public Rights-of-Way Accessibility Guidelines* (PROWAG), 2007. United States Access Board, Washington, D.C. http://www.access-board.gov/PROWAC/alterations/guide.htm

State and Local Guidelines

- *Road Design Manual.* (2007). State of South Dakota Office of Road Design. www.sddot.com/pe/roaddesign/plans_rdmanual.asp
- *Standard Specifications for Roads & Bridges.* (2004). State of South Dakota Operations Support Office. www.sddot.com/operations/specifications/specbook_div2_04.htm

Best Practices Documents

- *Berkeley Pedestrian Master Plan.* (2010). City of Berkeley, California. http://www.ci.berkeley.ca.us/ContentDisplay.aspx?id=16124
- *Bicycle Facility Selection: A Comparison of Approaches..* (2002). Michael King, for the Pedestrian and Bicycle Information Center http://www.bicyclinginfo.org/pdf/bikeguide.pdf

[16] The Guide for the Development of Bicycle Facilities is currently being updated, and the new document can not be quoted at the time of this writing. However, many of the facilities under consideration for the update are included in the following pages.

- *Bicycle Parking Design Guidelines.* (No Date). Bicyclinginfo.org http://www.bicyclinginfo.org/engineering/parking.cfm
- *Bicycle Parking Guidelines, 2nd Edition.* (2010). Association of Pedestrian and Bicycle Professionals (APBP). http://www.apbp.org/resource/resmgr/webinars/bpg_exec_summary_4-21-10.pdf
- *City of Chicago Bike Lane Design Guide.* (No Date). http://www.chicagobikes.org/pdf/bike_lane_design_guide.pdf
- *Designing Sidewalks and Trails for Access.* (2001). FHWA. http://www.fhwa.dot.gov/environment/sidewalk2/contents.htm
- *Florida Bicycle Facilities Planning and Design Handbook*. (1999). Florida Department of Transportation. http://www.dot.state.fl.us/safety/ped_bike/ped_bike_standards.htm#Florida%20Bike%20Handbook
- *Oregon Bicycle and Pedestrian Plan.* (1995) Oregon Department of Transportation. http://www.oregon.gov/ODOT/HWY/BIKEPED/planproc.shtml
- *Portland Bicycle Master Plan for 2030.* (2010). City of Portland, Oregon Department of Transportation. http://www.portlandonline.com/transportation/index.cfm?c=44597&a=289122
- Road Diet Handbook: Setting Trends for Livable Streets.. (2006). Jennifer Rosales.
- *Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations.* (2005). FHWA Report HRT-04-100 http://www.tfhrc.gov/safety/pubs/04100/
- *The North Carolina Bicycle Facilities Planning and Design Guidelines.* (1994). North Carolina Department of Transportation Division of Bicycle and Pedestrian Transportation. http://www.ncdot.org/transit/bicycle/projects/resources/projects_facilitydesign.html
- *Wisconsin Bicycle Facility Design Handbook.* (2004). Wisconsin Department of Transportation. http://www.dot.wisconsin.gov/projects/bike.htm

Toolkit

1. On-Street Pedestrian Facilities

Sidewalks, shared-use paths, and roadway shoulders are typically recognized as pedestrian facilities. Pedestrian travel is accommodated by intersection treatments such as crosswalks, curb ramps, as well as boulevards and other amenities. Standards for accessible pedestrian facilities are primarily from the United States Access Board.

1.1. Sidewalks

Design Summary

	Curb	Planting Strip (Buffer)*	Sidewalk Width
Arterials and Collectors	1 ft.	6-8 ft.	8 ft.†
Local Streets	0-1 ft.	6-8 ft.	5 ft. †
Bus Stops	1 ft.	varies	5'x8' area‡
Commercial Walkways	1 ft.	6-8 ft.	6-10 ft.
Mixed Use Center Streets	1 ft.	6-8 ft.	10-12 ft.

** In constrained locations, the full sidewalk width should be provided, with a reduced-width planting strip/buffer.*

† Note: short sidewalk segments can have narrower widths in physically-constrained areas.

‡ Required minimum by ADA and SDDOT Road Design Manual

A well-designed sidewalk provides plenty of pedestrian space.

Discussion

Recommended widths enable two pedestrians (including wheelchair users) to walk side-by-side, or to pass each other comfortably. Proposed sidewalk guidelines apply to new development and depend on available street width, motor vehicle volumes, surrounding land uses, and pedestrian activity levels. Standardizing sidewalk guidelines for different areas of the region, dependent on the above listed factors, ensure a minimum level of quality for all sidewalks. As part of a roadway reconstruction project on a street with a narrow sidewalk corridor, planners should analyze the impact of reclaiming a portion of the existing right-of-way. If this proves impractical, the feasibility of acquiring additional right-of-way should be examined. Acquisition should be considered where cost is reasonable in proportion to the overall project cost.

The SDDOT *Road Design Manual* recommends that construction/reconstruction projects should be designed to follow PROWAG guidelines where practical. Where not practical, the manual allows for ADAAG compliance, except for crosswalk design, which should be based on ADAAG.

Guidance

- United States Access Board. (2002). *Accessibility Guidelines for Buildings and Facilities.*
- United States Access Board. (2007). *Public Rights-of-Way Accessibility Guidelines* (PROWAG).
- SDDOT Road Design Manual.

1.1. Sidewalks

1.1.1. Addressing Sidewalk Obstructions

Design Summary

- Place obstructions such as sign posts, utility and signal poles, mailboxes, fire hydrants and street furniture between the sidewalk and the roadway to create a buffer for increased pedestrian comfort.
- Where sidewalks abut perpendicular or angled on-street parking, use wheel stops to prevent parked vehicles from overhanging in the sidewalk.
- Where sidewalks abut hedges, fences, or buildings, add two feet of lateral clearance for shy distance.

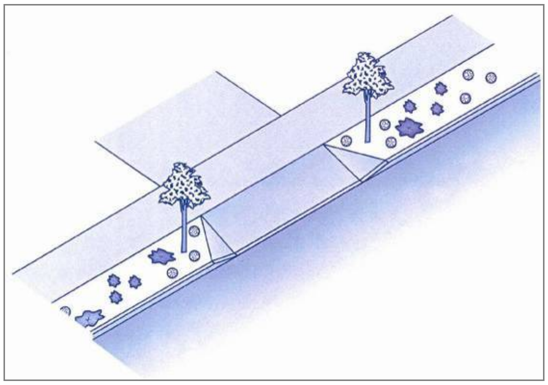
Discussion

Driveways are a common obstacle to the sidewalk network and should be minimized where possible. Where access management is not feasible, options for minimizing the impact of driveways to the sidewalk environment include:

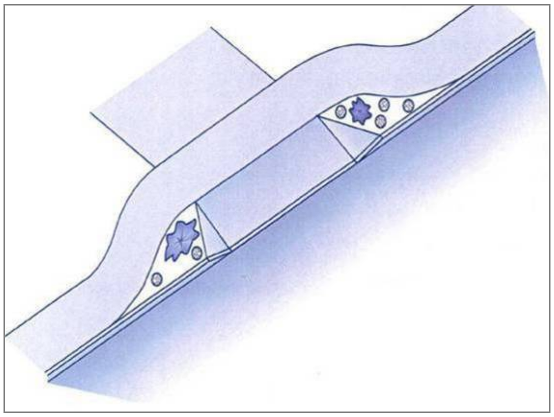
- Provide a planter strip allowing sidewalks to remain level, with the driveway grade change occurring within the planter strip (top graphic).
- Wrap the sidewalk around the driveway (middle graphic). However, this may have disadvantages for visually-impaired pedestrians who follow the curb line for guidance.
- Dip the entire sidewalk at the driveway approach to maintain a constant grade on the cross-slope (bottom graphic). However, this may be uncomfortable for pedestrians where driveways are frequent and could create drainage problems behind the sidewalk.

Guidance

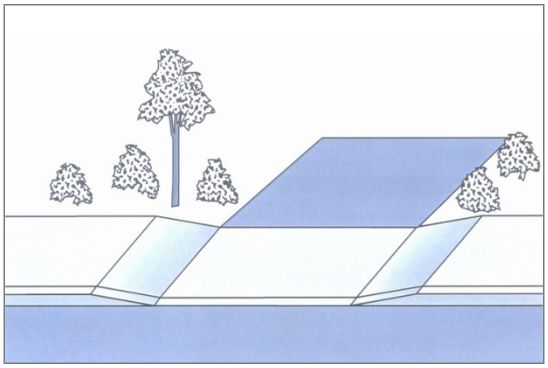
- United States Access Board. (2002). *Accessibility Guidelines for Buildings and Facilities.*
- United States Access Board. (2007). *Public Rights-of-Way Accessibility Guidelines (PROWAG).*



Driveway apron utilizing the planting strip.



Sidewalk wrapped around driveway.



Entire sidewalk dips at driveway.

1.1. Sidewalks

1.1.2. Sidewalk Maintenance

Design Summary

- Minimize barriers for pedestrians, particularly with mobility and sensory impairments, by providing a level surface with a minimum of ¼ inch grade changes.
- Trim tree limbs to leave at least 8 feet of clear space above the sidewalk.

Subsurface tree roots can lift concrete sidewalk slabs, causing the surface to become uneven.

Discussion

Root Protection

Street trees are a desirable part of the street environment, to shade pedestrians and improve aesthetics. However, sidewalk damage can occur, primarily from improper tree selection and from soil freeze and thaw. To minimize sidewalk damage from trees, choose appropriate trees based on water and light availability, the quantity of air, and root space available at the specific location.

Grates

Designers should consider using tree well grates or treatments such as unit pavers in high pedestrian use areas. All grates within the sidewalk should be flush with the level of the surrounding sidewalk surface, and should not interfere with pedestrian zone.

Tree well grates can create uneven sidewalk conditions and should not be placed within the thru-pedestrian zone.

Hatch Covers

Hatch covers should be located within the sidewalk furnishings zone. Hatch covers must have a surface texture that is rough, with a slightly raised pattern. The surface should be slip-resistant even when wet. The cover should be flush with the surrounding sidewalk surface.

Curb Ramp Maintenance

The interface between a curb ramp and the street be maintained adequately. Asphalt street sections typically have a shorter life cycle than a concrete ramp, and can develop potholes at the foot of the ramp, which can catch the front wheels of a wheelchair. Existing ramps, and crossings without ramps, must be brought to current accessibility standards during reconstruction periods.

Guidance

- United States Access Board. (2007). *Public Rights-of-Way Accessibility Guidelines* (PROWAG).

2. Intersections

Design summary

- Intersection frequency on mixed-use streets and other high pedestrian use areas:
  - o Generally not farther apart than 200-300' where blocks are longer than 400'.
  - o Generally not closer together than 150'.
- Intersection frequency on residential or local streets:
  - o Frequency based on adjacent uses. Do not prohibit for more than 400'.
  - o Generally not closer together than 150'.

Intersections with many user types should provide good crossing opportunities and clearly delineate crossing patterns.

Discussion

In general, pedestrians are not inclined to travel very far out-of-direction to access a designated crosswalk, so providing sufficient crossings is critical for a safe pedestrian environment. Crosswalks can also be designed for increased visibility of pedestrians, and curb ramps and vehicle turning radii should also be considered for the pedestrian environment.

In areas of high pedestrian use, the convenience and travel time of pedestrians deserves special consideration when considering signal placement and timing. In these locations, pedestrian mobility and access may need to be weighted against the efficiency of vehicle progression.

Attributes of pedestrian- and bicycle-friendly intersection design include:

- Clear Space — Corners should be clear of obstructions. They should also have enough room for curb ramps, for transit stops where appropriate, and for street conversations where pedestrians might congregate.
- Visibility — It is critical that pedestrians on the corner have a good view of vehicle travel lanes and that motorists in the travel lanes can easily see waiting pedestrians.
- Legibility — Symbols, markings, and signs used at corners should clearly indicate what actions the pedestrian should take.
- Accessibility — All corner features, such as curb ramps, landings, call buttons, signs, symbols, markings, textures, must meet accessibility standards.
- Separation from Traffic — Corner design and construction must be effective in discouraging turning vehicles from driving over the pedestrian area.

Guidance

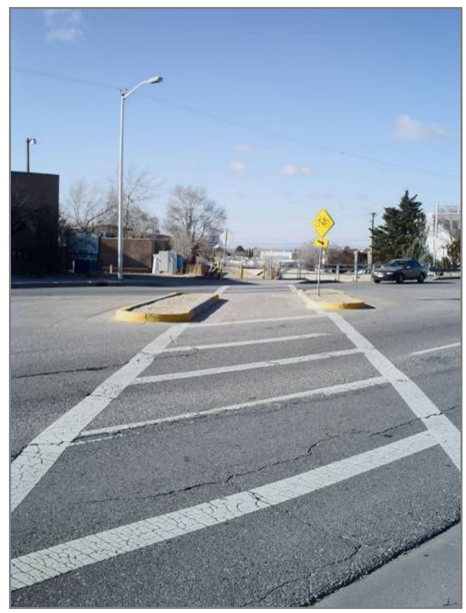
- United States Access Board. (2007). *Public Rights-of-Way Accessibility Guidelines* (PROWAG).

2.1. Marked Crosswalks

Design Summary

- See MUTCD for pavement marking spacing.
- Mark all crosswalks at signalized intersections. At un-signalized intersections, mark crosswalks under the following conditions:
    - At a complex intersection, to orient pedestrians in finding their way across.
    - At an offset intersection, to show pedestrians the shortest route across traffic with the least exposure to vehicular traffic and traffic conflicts.
    - At an intersection with visibility constraints, to position pedestrians where they can best be seen by oncoming traffic.
- At mid-block locations, mark crosswalks where:
    - There is a demand for crossing AND
    - There are no nearby marked crosswalks.

Parallel markings are the most basic crosswalk marking type, and are applied where textured concrete crosswalks are used.



Zebra striped crossings can increase visibility of pedestrians.

Discussion

Marking crosswalks signals to drivers that they should stop for pedestrians, and encourages pedestrians to cross at safer locations. Crosswalk markings also indicate to pedestrians the appropriate route across traffic, to facilitate crossing by the visually impaired and remind turning drivers of potential conflicts with pedestrians.

Use ladder pavement markings at crossings with high pedestrian use or where vulnerable pedestrians are expected, including:

- School crossings.
- Across arterial streets for pedestrian-only signals.
- At mid-block crosswalks.

Guidance

- United States Access Board. (2007). *Public Rights-of-Way Accessibility Guidelines* (PROWAG).
- FHWA. (2005). *Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations Final Report and Recommended Guidelines.* http://www.fhwa.dot.gov/publications/research/safety/04100/

2.1. Marked Crosswalks

2.1.1. High-Visibility Crosswalk Techniques

Design Summary

- Additional treatments can be used to increase visibility of the crosswalk at high-use locations and in locations with high use from school children, elderly pedestrians, or pedestrians with disabilities.

Discussion

<u>Rapid Flash Beacon</u>

Designed to encourage motorists to stop for a pedestrian waiting at a mid-block crossing, rapid flash beacons call attention to the crossing location. These devices use a stutter flash pattern similar to that used on emergency vehicles.

Rapid flash beacon.

<u>Raised Median</u>

A raised median eliminates grade changes from the sidewalk and gives pedestrians greater prominence. Raised crosswalks should be where a special emphasis on pedestrians is desired such as at a mid-block crossing.

Additional guidelines include:

- Use detectable warnings at the curb edges to alert vision-impaired pedestrians that they are entering the roadway.
- Design approaches to the raised crosswalk to be similar to speed humps, so they also act as traffic calming.
- Use post-mounted pedestrian crosswalk signs placed on the median and on the right side of the roadway for each approach.

Raised medians require drivers to slow down.

<u>In-Street "Yield to Pedestrians" Signs and Flashers</u>

In-street "Yield to Pedestrian" signs are flexible plastic 'paddle' signs installed in the center of a roadway to enhance a crosswalk at uncontrolled crossing locations. In-pavement flashers may be appropriate on undivided roadways in densely developed areas that do not offer median refuges for crossing pedestrians.

In-street yield to pedestrian sign.

Guidance

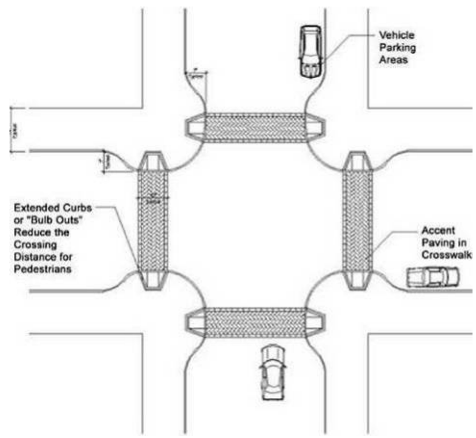
- United States Access Board. (2007). *Public Rights-of-Way Accessibility Guidelines* (PROWAG).

2.1. Marked Crosswalks

2.1.2. Reducing Crossing Distance

Design Summary

- Minimize pedestrian exposure to travel lanes by shortening the crossing distance; 50-feet or four travel lanes is generally the longest uninterrupted crossing of an unsignalized crosswalk.



Curb extensions improve visibility of pedestrians and provide additional sidewalk space at street corners.

Median refuge islands break up a crossing and allow pedestrians to cross one side of a street at a time.

Discussion

<u>Curb Extension</u>

Curb extensions may be constructed where there is a parking lane adjacent to the curb. They can be used as bus stop locations to improve safety for transit riders. However, if there is no parking lane, the extensions may impede bicycle travel (where no bike lane is striped).

Guidelines for use:

- Design curb extensions to transition between the extended curb and the running curb in the shortest practicable distance.
- For street sweeping, use the minimum radius for the reverse curves of 10 feet and balance the two radii to be nearly equal.
- Stop the curb extensions one foot short of the parking zone for bicycle safety.

<u>Median Refuge Island</u>

In addition to narrowing the crossing distance, median refuge islands provide a crossing refuge, allowing pedestrians to gauge safe crossing of "one direction" of traffic at a time, and slowing motor vehicle traffic.

The refuge island must be accessible, preferably with an at-grade passage through the island rather than ramps and landings.

A median refuge island should be at least six-feet wide between travel lanes and at least 20-feet long. On streets with posted speeds over 25 mph, include double centerline marking, reflectors, and "KEEP RIGHT" signs.

If a refuge island is landscaped, the landscaping should not compromise the visibility of pedestrians crossing in the crosswalk. Tree species should be selected for small diameter trunks and tree branches should be no lower than 14 feet. Shrubs and ground plantings should be no higher than one foot, six inches.

Guidance

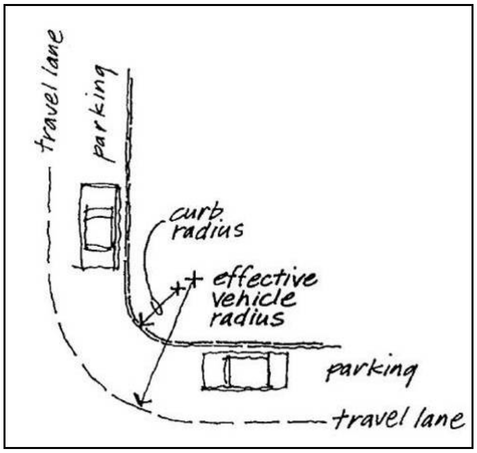
- United States Access Board. (2007). *Public Rights-of-Way Accessibility Guidelines* (PROWAG).

2.1. Marked Crosswalks

2.1.3. Minimizing Curb Radius

Design Summary

- Consider the desired pedestrian area of the corner, traffic turning movements, the turning radius of the design vehicle, the geometry of the intersection, the street classifications, and whether there is parking or a bicycle lane (or both) between the travel lane and the curb.
- Use the smallest possible curb radius for the circumstances:
    - May be three-feet where there are no turning movements.
    - Increase to five-feet where there are turning movements and there is adequate street width and a larger effective curb radius created by parking or bicycle lanes.



An "effective radius" is created by the presence of a parking lane or bike lane.

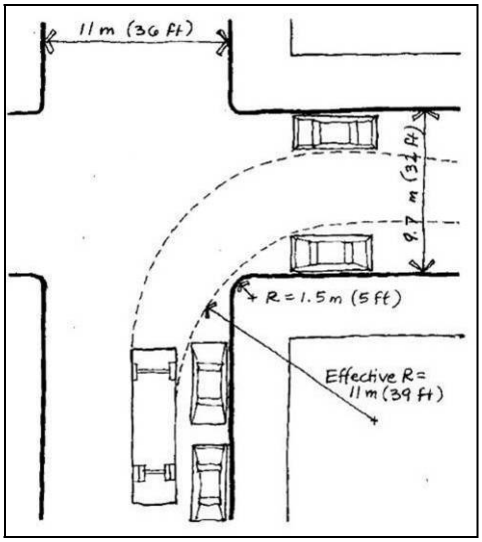
Discussion

Factors that govern the choice of curb radius in any given location include:

- The desired pedestrian area of the corner
- Traffic turning movements
- Turning radius of the design vehicle
- Geometry of the intersection
- Street classifications
- Whether there is parking or a bike lane (or both) between the travel lane and the curb

In general, smaller curb radii are preferred for pedestrians. A tight curb radius provides more pedestrian area at the corner, allows more flexibility in the placement of curb ramps, results in a shorter crosswalk, and requires vehicles to slow more as they turn the corner. A small curb radius is also beneficial for street sweeping.

The presence of a parking or bike lane creates an 'effective radius' that allows the designer to choose a radius for the curb that is smaller than the turning radius required by the design vehicle.



Where there is an effective curb radius sufficient for turning vehicles, the actual curb radius may be as small as 5 ft (1.5 m).

Guidance

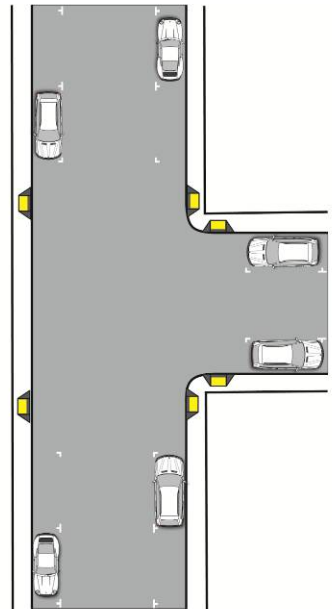
- United States Access Board. (2007). *Public Rights-of-Way Accessibility Guidelines* (PROWAG).

2.1. Marked Crosswalks

2.1.4. Minimizing Conflict with Automobiles

Design Summary

- Separating pedestrians and motor vehicles at intersections improves safety and visibility.



Prohibit parking in advance of intersections and at 'T' intersections to improve pedestrian visibility.

Discussion

Parking Control

Parking control improves visibility in the vicinity of the crosswalk. Prohibit parking within all intersections and crosswalks unless otherwise signed. At "T" and offset intersections, where the boundaries of the intersection may not be obvious, this prohibition should be emphasized with signage.

Advance Yield Bars

Advance yield bars increase pedestrian comfort and safety by stopping motor vehicles well in advance of marked crosswalks, allowing drivers a better line of sight of pedestrians.

They give drivers in the traffic inner lane time to yield to pedestrians, minimizing the danger of a multiple threat crash. Without an advance yield bar, the driver in the outer lane may yield to the pedestrian, but the vehicle in the inner lane proceeds, increasing the possibility of a vehicle-pedestrian conflict.

Pedestrians may also feel more comfortable since motor vehicles are not stopped adjacent to the crosswalk.

Advanced stop bars should be used:

- On streets with at least two travel lanes in each direction.
- Prior to a marked crosswalk
- In one or both directions of motor vehicle travel
- Recommended 30-feet in advance of the crosswalk.
- A "Yield Here for Pedestrians" sign must accompany the advance yield bar.

Advance stop bars alert motorists of pedestrians.

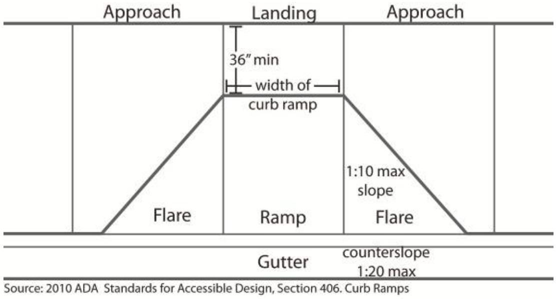
Guidance

- United States Access Board. (2007). *Public Rights-of-Way Accessibility Guidelines* (PROWAG).

2.2. ADA-Compliant Curb Ramps

Design Summary

- Provide a landing at the top of every curb ramp that:
    - o Is at least 4' long
    - o Is at least the same width as the ramp itself.
    - o Slopes no more than 1:50 (2.0%) in any direction
- Maximum ramp slope: 1:12 (8.3%) with a cross slope of no more than 1:50 (2.0%).
- Minimum width of a ramp: 3'
-

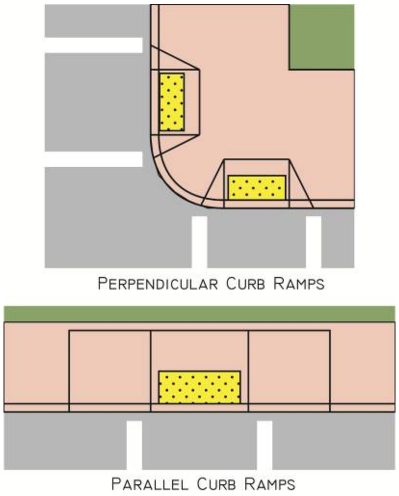


ADA standards for curb ramps.

Discussion

The 2010 ADA Standards (Section 405) define a curb ramp as, "a short ramp cutting through a curb or built up to it." Curb ramps provide a transition from the street to the sidewalk at a street corner. Properly designed curb ramps ensure that the sidewalk is accessible to all types of pedestrians from the roadway. A sidewalk without a curb ramp can be useless to someone in a wheelchair, forcing them back to a driveway and out into the street for access.

The ADA defines two types of curb ramp systems, "perpendicular ramps" and "parallel ramp," shown right. Diagonal curb ramps, which are a single ramp at a corner, are not recommended because they place the pedestrian in the middle of the intersection, rather than at the crosswalk.



Curb ramp options identified by the U.S. Access Board.

Example of an ADA-compliant perpendicular curb ramp

Guidance

- 2010 ADA Accessibility Standards, http://www.ada.gov/regs2010/2010ADAStandards/2010ADAstandards.htm
- United States Access Board. (2007). *Public Rights-of-Way Accessibility Guidelines* (PROWAG).

2.2. ADA-Compliant Curb Ramps

2.2.1. Raised Tactile Devices Used as Detectible Warnings

Design Summary

- Raised tactile devices (also known as truncated domes) alert people with visual impairments to changes in the pedestrian environment and should be used at:
  - The edge of depressed corners.
  - The border of raised crosswalks and intersections.
  - The base of curb ramps.
  - The border of medians.
  - The edge of transit platforms where railroad tracks cross the sidewalk.

A diagonal curb ramp with detectible warning.

Discussion

Contrast between the raised tactile device and the surrounding infrastructure is important so that the change is readily evident. These devices are most effective when adjacent to smooth pavement so the difference is easily detected. The devices must provide color contrast so partially sighted people can see them.

Raised Tactile Devices Used for Wayfinding

Raised tactile devices can also be used for wayfinding along a pathway or across a road. This is particularly useful to visually impaired pedestrians in areas where the pedestrian environment is unpredictable. Complex intersections, roundabouts, wide intersections and open plazas are areas where raised tactile devices could be considered. No standards or guidelines for these devices have been adopted nationally. Raised devices with bar patterns can indicate the proper walking direction. Textured pavement that provides enough material and color contrast can be used to mark the outside of crosswalks, in addition to white paint or thermoplastic.

Guidance

- 2010 ADA Accessibility Standards, http://www.ada.gov/regs2010/2010ADAStandards/2010ADAstandards.htm
- United States Access Board. (2007). *Public Rights-of-Way Accessibility Guidelines* (PROWAG).

2.3. Accommodating Bicyclists and Pedestrians at Signals

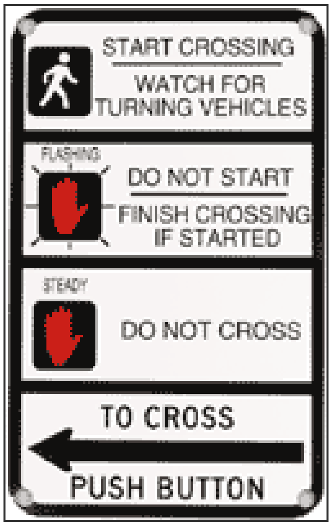
2.3.1. Pedestrian Push-Buttons

Design Summary

- Locate so that someone in a wheelchair can reach the button from a level area of the sidewalk without deviating significantly from the natural line of travel into the crosswalk.
- Mark (for example, with arrows) so that it is clear which signal is affected.
- Raise buttons above or flush with their housing.
- Provide buttons that are large enough for people with visual impairments to see, minimum 2”.
- The U.S. Access Board recommends the force to activate the signals should be no more than 22.2 Newtons.

Example standard pedestrian push button.

(Polara Navigator)



Pedestrian push buttons can be accompanied by informational signage.

Discussion

Pedestrian push buttons are used to permit the signal controller to detect pedestrians desiring to cross. They can be used at an actuated or semi-actuated traffic signal at intersections with low pedestrian volumes, and at mid-block crossings.

Accessible pedestrian signals should be installed whenever major signalized intersection upgrades are undertaken or when new signals are installed.

Signalized crossings in areas of high pedestrian use may automatically provide a pedestrian crossing phase during every signal cycle, excluding the need for pedestrian push-buttons. In high pedestrian use areas, there should be a demonstrated benefit for actuated signals before push buttons are installed. The following are some criteria for that benefit:

- The main street carries through traffic or transit, such as a major city traffic or transit street, or a district collector.
- Traffic volumes on the side street are considerably lower than on the main street.
- The pedestrian signal phase is long (for example, on a wide street) and eliminating it when there is no demand would significantly improve the level of service of the main street.

Where push buttons must be installed in high pedestrian use areas, designers should consider operating the signal with a regular pedestrian phase during off-peak hours.

Guidance

- United States Access Board. (2007). *Public Rights-of-Way Accessibility Guidelines* (PROWAG).

2.3. Accommodating Bicyclists and Pedestrians at Signals

2.3.2. Accommodating Pedestrians at Signals

Design Summary

- Assume a pedestrian walking speed of three feet per second to provide sufficient time for a pedestrian to safely cross during the signal phase (per MIUTCD guidance).
- Assume slower crossing speeds at crossings where older pedestrians or pedestrians with disabilities are expected.
- Provide special pedestrian phases to increase visibility or crossing time for pedestrians at certain intersections.

Pedestrian signal indication.

Discussion

Pedestrian Signal Indication ("Ped Head") and Countdowns

Pedestrian signal indicators use a symbol to indicate when to cross at a signalized crosswalk. All traffic signals are now required to be equipped with pedestrian signal indications except where pedestrian crossing is prohibited by signage. Countdown pedestrian signals are particularly beneficial, as they indicate whether a pedestrian has time to cross the street before the signal phase ends.

Traffic signals should provide sufficient time for pedestrians of all ages and abilities to cross.

Audible Pedestrian Traffic Signals

Audible pedestrian traffic signals provide crossing assistance to pedestrians with vision impairment at signalized intersections. To be considered for audible signals, the location must:

- Be suitable to the installation of audible signals (safety, noise level, and neighborhood acceptance).
- Have a need, demonstrated through a user request.

Audible signals should be activated by a pedestrian push-button with at least a one second-delay to activate the sound.

Pre-Timed Signal

Pre-timed signals use automatic "phasing" concurrent with parallel vehicle traffic, as opposed to actuated signals, where pedestrians push an activation button to trigger the walk signal.

Leading Pedestrian Interval (LPI)

At intersections where there are conflicts between turning vehicles and pedestrians, pedestrians are given a "walk" designation a few seconds before the associated green phase for the intersection.

Guidance

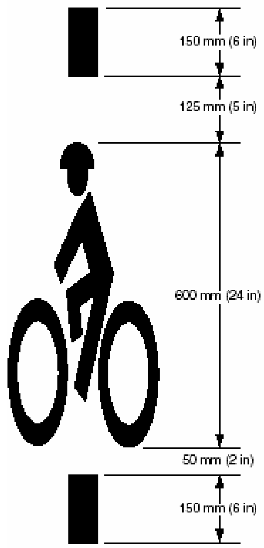
- United States Access Board. (2007). *Public Rights-of-Way Accessibility Guidelines* (PROWAG).
- MUTCD

2.3. Accommodating Bicyclists and Pedestrians at Signals

2.3.3. Accommodating Bicyclists at Intersections

Design Summary

- Provide mechanism for cyclists to trigger signals when cars are not present.
- Avoid requiring cyclists to merge right and dismount to press a pedestrian button.
- It is particularly important to provide bicycle actuation in a left-turn only lane where cyclists regularly make left turn movements.



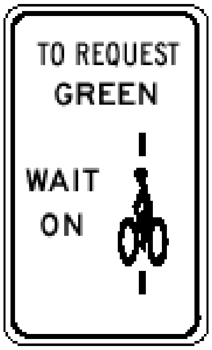
Recommended loop detector marking design.

Discussion

Loop Detectors

Loop detectors are installed within the roadway to allow the presence of a motor vehicle to trigger a change in the traffic signal. They can be calibrated to detect bicyclists, allowing cyclists to stay within the lane of travel rather than having to merge to the side of the road to trigger a push button.

Current loops that are sensitive enough to detect bicycles should have pavement markings to instruct cyclists how to trip them, as well as signs (see right).



Instructional Sign

(MUTCD Sign R10-15).

Detection Cameras

Video detection cameras can also be used to determine when a vehicle is waiting for a signal. These systems use digital image processing to detect a change in the image at the location. Cameras can detect bicycles, although cyclists should wait in the center of the lane, where an automobile would usually wait, in order to be detected. Video camera system costs range from $20,000 to $25,000 per intersection.

Detection cameras are currently used for cyclists in the City of San Luis Obisbo, CA, where the system has proven to detect pedestrians as well.

Remote Traffic Microwave Sensor Detection (RTMS)

RTMS uses frequency modulated continuous wave radio signals to detect objects in the roadway. This method is marked with a time code which gives information on how far away the object is. The RTMS system is unaffected by temperature and lighting, which can affect standard detection cameras.

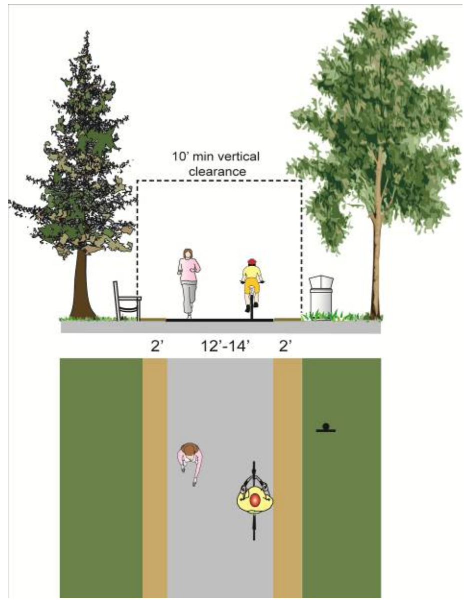
Guidance

- Additional technical information is available at: www.humantransport.org/bicycledriving/library/signals/detection.htm
- ITE Guidance for Bicycle—Sensitive Detection and Counters: http://www.ite.org/councils/Bike-Report-Ch4.pdf

3. Shared-Use Path Design Guidelines

Design Summary

- Width:
  - Minimum for a two-way shared-use path (only recommended for low traffic situations): 10′
  - Recommended for high-use areas with multiple users such as joggers, bicyclists, rollerbladers and pedestrians:12′ or greater
- Lateral clearance: 2′ or greater shoulder on both sides.
- Overhead clearance: 8′ minimum, 10′ recommended.
- Maximum design speed for shared-use paths: 20 mph. Speed bumps or other surface irregularities should not be used to slow bicycles.
- Grade:
  - Recommended maximum: 5%
  - Steeper grades can be tolerated for a maximum of 500 feet



Recommended multi-use path design.

Discussion

A hard surface should be used for shared-use paths. Concrete, while more expensive than asphalt, is the hardest of all shared-use path surfaces and lasts the longest. However, joggers and runners prefer surfaces such as asphalt or decomposed granite due to its relative "softness". While most asphalt is black, dyes (such as reddish pigments) can be added to increase the aesthetic value of the path itself.

When concrete is used the path should be designed and installed using the narrowest possible expansion joints to minimize the amount of 'bumping' cyclists experience on the path.

Multi-use paths should provide sufficient width to accommodate a variety of users.

Guidance

- U.S. Access Board, *Public Rights-of-Way Accessibility Guidelines (PROWAG).*
- FHWA. *Designing Sidewalks and Trails for Access.*

3.1. Managing Multiple Users

Design Summary

- Barrier separation – vegetated buffers or barriers, elevation changes, walls, fences, railings and bollards.
- Distance separation – differing surfaces.
- User behavior guidance signage.

Discussion

Differing surfaces suitable to each user group foster visual separation and clarity of where each user group should be. When shared-use path corridors are constrained, the approach is often to locate the two different surfaces side by side with no separation.

Informing users of acceptable etiquette is a common issue when multiple user types are anticipated. Yielding the right-of-way is a courtesy and yet a necessary part of a safe trail experience involving multiple trail users. Shared-use path right-of-way information should be posted at trail access points and along the path. The message must be clear and easy to understand. Where appropriate, trail etiquette systems should instruct trail users to the yielding of cyclists to pedestrians and equestrians and the yielding of pedestrians to equestrians.

Guidance

- MUTCD

Centerline striping encourages trail users to provide space for other users to pass.

Guidance signage encourages multiple users to share trail facilities.

A commonly used multi-use trail etiquette sign.

3.2. Shared-Use Paths Along Roadways (Side Paths)

Design Summary

- Shared-use paths may be considered along roadways under the following conditions:
  - o The path will generally be separated from all motor vehicle traffic.
  - o Bicycle and pedestrian use is anticipated to be high.
  - o To provide continuity with an existing path through a roadway corridor.
  - o The path can be terminated at each end onto streets with good bicycle and pedestrian facilities, or onto another well-designed path.
  - o There is adequate access to local cross-streets and other facilities along the route.

Example of a substandard side path

Discussion

Also known as "sidepaths", these facilities create a situation where a portion of the bicycle traffic rides against the normal flow of motor vehicle traffic and can result in wrong-way riding where cyclists enter or leave the path. This can create an unsafe situation where motorists entering or crossing the roadway do not notice bicyclists coming from their right, as they are not expecting traffic from that direction. Stopped cross-street motor vehicle traffic or vehicles exiting side streets or driveways may frequently block path crossings. Bicyclists coming from the left may also be unnoticed, particularly if sight distances are poor.

Additional concerns about shared-use paths directly adjacent to roadways (with minimal separation) are:

- When the path ends, cyclists riding against traffic tend to continue to travel on the wrong side of the street, as do cyclists making their way to the path. Wrong-way bicycle travel is a major cause of vehicle/bicycle crashes.
- At intersections, motorists crossing the path often do not notice bicyclists approaching from certain directions, especially where sight distances are poor.
- Bicyclists on the path are required to stop/yield at cross-streets or driveways, unless posted.
- Stopped vehicles on a cross-street or driveway may block the path.
- Because of the closeness of vehicle traffic to opposing bicycle traffic, barriers are often necessary to separate motorists from cyclists. These barriers serve as obstructions, complicate facility maintenance and waste available right-of-way.
- Paths directly adjacent to high-volume roadways diminish users' experience by placing them in an uncomfortable environment. This could lead to a path's underutilization.

As bicyclists gain experience and realize some of the advantages of riding on the roadway, some riders stop using paths adjacent to roadways. Bicyclists may also tend to prefer the roadway as pedestrian traffic on the shared-use path increases due to its location next to an urban roadway. When designing a bikeway network, the presence of a nearby or parallel path should not be used as a reason to not provide adequate shoulder or bike lane width on the roadway, as the on-street bicycle facility will generally be superior to the "sidepath" for experienced cyclists and those who are cycling for transportation purposes. Bike lanes should be provided as an alternate (more transportation-oriented) facility whenever possible.

Guidance

- AASHTO *Guide for the Development of Bicycle Facilities*

3.3. Path/Roadway Crossings

Design Summary

- Type 1: Marked/Unsignalized Unprotected crossings include path crossings of residential, collector, and sometimes major arterial streets or railroad tracks.
- Type 1+: Marked/Enhanced – Unsignalized intersections can provide additional visibility with flashing beacons and other treatments.
- Type 2: Route Users to Existing Signalized Intersection – Shared-use paths that emerge near existing intersections may be routed to these locations, provided that sufficient protection is provided at the existing intersection.
- Type 3: Signalized/Controlled – Shared-use path crossings that require signals or other control measures due to traffic volumes, speeds, and path usage.
- Type 4: Grade-separated crossings - Bridges or under-crossings provide the maximum level of safety but also generally are the most expensive and have right-of-way, maintenance, and other public safety considerations.

An offset crossing forces pedestrians to turn and face the traffic they are about to cross.

Discussion

While at-grade crossings create a potentially high level of conflict between path users and motorists, well-designed crossings have not historically posed a safety problem for path users. This is evidenced by the thousands of successful paths around the United States with at-grade crossings. In most cases, at-grade path crossings can be properly designed to a reasonable degree of safety and can meet existing traffic and safety standards.

Evaluation of path crossings involves analysis of vehicular and anticipated path user traffic patterns, including:

- Vehicle speeds.
- Street width.
- Sight distance.
- Traffic volumes (average daily traffic and peak hour traffic).
- Path user profile (age distribution, destinations served).

Crossing features for all roadways include warning signs both for vehicles and path users.

Consideration must be given for adequate warning distance based on vehicle speeds and line of sight, with visibility of any signing absolutely critical. Catching the attention of motorists jaded to roadway signs may require additional alerting devices such as a flashing light, roadway striping or changes in pavement texture. Signing for path users must include a “STOP” sign and pavement marking, sometimes combined with other features such as bollards.

Guidance

- Federal Highway Administration (FHWA), *Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations.*

3.3. Path/Roadway Crossings

Guidance (continued)

Summary of Path/Roadway At-Grade Crossing Recommendations[17]

Roadway Type	Vehicle ADT ≤ 9,000			Vehicle ADT > 9,000 to 12,0 0			Vehicle ADT >12,000 to 15,000			Vehicle ADT >15,00		
	Speed Limit (mph)											
	30	3	40	30	35	40	30	3	40	30	35	40
2 Lanes	1	1	$1/1^{+}$	1	1	1+	1	1	$1^{+}/3$	1	$1/1^{+}$	$1^{+}/$
3 Lanes	1	1	1^{+}	1	$1/1^{+}$	$1/1^{+}$	$1/1^{+}$	$1/1^{+}$	$1^{+}/3$	$1/1^{+}$	$1^{+}/3$	$1^{+}/3$
Multi-Lane (4^{+}) with raised median ***	1	1	$1/1^{+}$	1	$1/1^{+}$	$1^{+}/3$	$1/1^{+}$	$1/1^{+}$	$1^{+}/3$	$1^{+}/3$	$1^{+}/3$	$1^{+}/3$
Multi-Lane (4^{+} lanes) without raised median	1	$1/1^{+}$	$1^{+}/3$	$1/1^{+}$	$1/1^{+}$	$1^{+}/3$	$1^{+}/3$	$1^{+}/3$	$1^{+}/3$	$1^{+}/3$	$1^{+}/3$	$1^{+}/3$

*General Notes: Crosswalks should not be installed at locations that could present an increased risk to pedestrians, such as where there is poor sight distance, complex or confusing designs, a substantial volume of heavy trucks, or other dangers, without first providing adequate design features and/or traffic control devices. Adding crosswalks alone will not make crossings safer, nor will they necessarily result in more vehicles stopping for pedestrians. Whether or not marked crosswalks are installed, it is important to consider other pedestrian facility enhancements (e.g., raised median, traffic signal, roadway narrowing, enhanced overhead lighting, traffic-calming measures, curb extensions), as needed, to improve the safety of the crossing. These are general recommendations; good engineering judgment should be used in individual cases for deciding which treatment to use.

For each pathway-roadway crossing, an engineering study is needed to determine the proper location. For each engineering study, a site review may be sufficient at some locations, while a more in-depth study of pedestrian volume, vehicle speed, sight distance, vehicle mix, etc. may be needed at other sites.

** Where the speed limit exceeds 40 mi/h (64.4 km/h), marked crosswalks alone should not be used at unsignalized locations.

*** The raised median or crossing island must be at least 4 ft (1.2 m) wide and 6 ft (1.8 m) long to adequately serve as a refuge area for pedestrians in accordance with MUTCD and AASHTO guidelines. A two-way center turn lane is not considered a median.

Key:

1= Type 1 Crossings. Ladder-style crosswalks with appropriate signage should be used.

1/1+ = With the higher volumes and speeds, enhanced treatments should be used, including marked ladder style crosswalks, median refuge, flashing beacons, and/or in-pavement flashers. Ensure there are sufficient gaps through signal timing, as well as sight distance.

1+/3 = Carefully analyze signal warrants using a combination of Warrant 2 or 5 (depending on school presence) and Equivalent Adult Unit (EAU) factoring. Make sure to project pathway usage based on future potential demand. Consider Pelican, Puffin, or Hawk signals in lieu of full signals. For those intersections not meeting warrants or where engineering judgment or cost recommends against signalization, implement Type 1 enhanced crosswalk markings with marked ladder style crosswalks, median refuge, flashing beacons, and/or in-pavement flashers. Ensure there are sufficient gaps through signal timing, as well as sight distance.

[17] This table is based on information contained in the U.S. Department of Transportation Federal Highway Administration Study, " *Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations*," February 2002.

3.4. Path Amenities

Design Summary

Amenities can make a path more inviting to users. Costs vary depending on the design and materials selected for each amenity. Amenities should be designed and located so as not to impede accessibility.

Discussion

Benches

Providing benches at key rest areas and viewpoints encourages people of all ages to use the path by ensuring that they have a place to rest along the way. Benches can be simple (e.g., wood slates) or more ornate (e.g., stone, wrought iron, concrete).

Benches and rest areas encourage path use by seniors and families with children.

Restrooms

Restrooms benefit path users, especially in more remote areas where other facilities do not exist. Restrooms can be sited at trailheads along the path system.

Water Fountains

Water fountains provide water for people (and pets, in some cases), encouraging path users to take a longer trip and improving user comfort.

Bathrooms are recommended for longer paths and in more remote areas.

Bicycle Parking

Bicycle parking allows path users to store their bicycles safely for a short time. Bicycle parking should be provided if a path transitions to an unpaved pedestrian-only area.

Trash Receptacles

Litter receptacles should be placed at access points. Litter should be picked up once a week and after any special events held on the path, except where specially designed trash cans have been installed. If maintenance funds are not available to meet trash removal needs, it is best to remove trash receptacles.

Signs

Informational kiosks with maps at trailheads and signage for other destinations can provide information for path users. They are beneficial for areas with high out-of- area visitation rates as well as the local citizens.

Art installations can provide a sense of place for the path.

Guidance

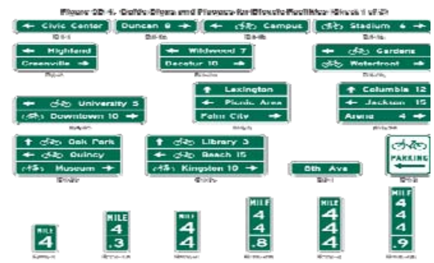
- AASHTO *Guide for the Development of Bicycle Facilities.*

4. Wayfinding Standards and Guidelines

4.1. On-Street Bikeway Signs

Design Summary

- Destinations for on-street signs can include:
  - On-street bikeways
  - Commercial centers
  - Regional parks and paths
  - Public transit sites
  - Civic/community destinations
  - Local parks and paths
  - Hospitals
  - Schools
- Confirmation signs confirm that a cyclist is on a designated bikeway. Confirmation signs can include destinations and their associated distances, but not directional arrows.
- Turn signs indicate where a bikeway turns from one street onto another street. Turn signs are located on the near-side of intersections.
- Decision signs mark the junction of two or more bikeways. Decision signs are located on the near-side of intersections. They can include destinations and their associated directional arrows, but not distances.



Wayfinding sign concept MUTCD sign D1-3C.

Wayfinding that includes distance and time can aid cyclists in route-finding.

Discussion

Signage can serve both wayfinding and safety purposes including:

- Helping to familiarize users with the pedestrian and bicycle network
- Helping users identify the best routes to destinations.
- Helping to address misperceptions about time and distance.
- Helping overcome a "barrier to entry" for infrequent cyclists or pedestrians (e.g., "interested but concerned" cyclists).

Bicycle wayfinding signs also visually cue motorists that they are driving along a bicycle route and should use caution.

Signs are typically placed at key locations leading to and along bicycle routes, including the intersection of multiple routes. Too many road signs tend to clutter the right-of-way, and it is recommended that these signs be posted at a level most visible to bicyclists and pedestrians, rather than per vehicle signage standards. Signs are typically placed at key locations leading to and along bicycle routes, including the intersection of multiple routes.

Guidance

- City of Oakland. (2009). *Design Guidelines for Bicycle Wayfinding Signage.*
- City of Portland (2002). *Bicycle Network Signing Project.*
- MUTCD

4.2. Shared-Use **Path Signing**

Design Summary

- Provide consistent signing style and imagery throughout the shared-use path to provide the trail user with a sense of continuity, orientation, and safety.
- Do not over sign the path. Where possible, incorporate signs into trailside vertical elements such as bollards.

Discussion

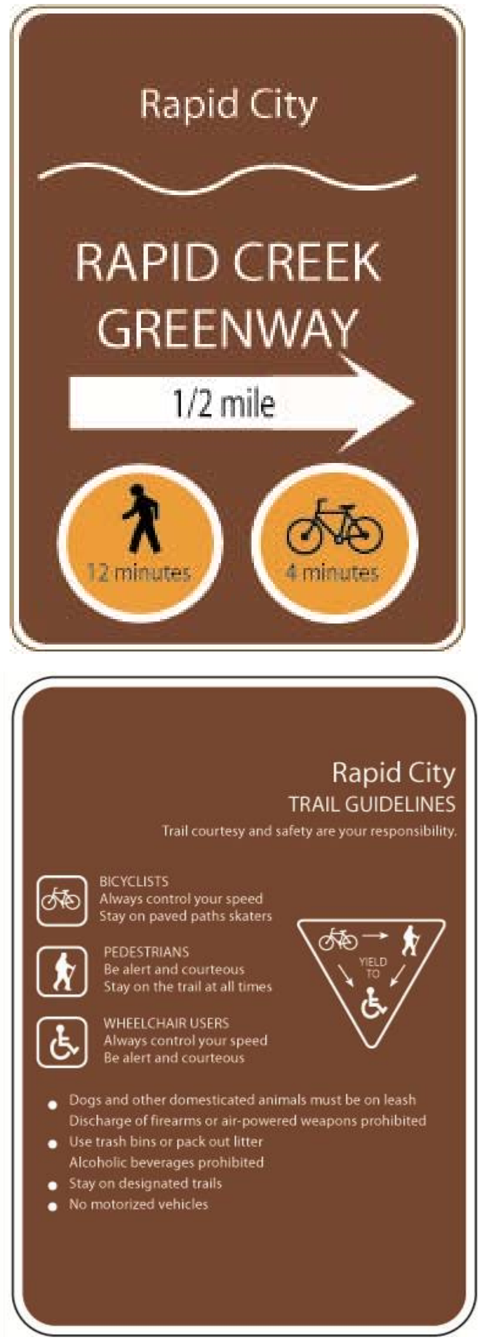
Directional signs may be useful for pathway users and motorists alike. For motorists, a sign reading "Path Xing" along with a Rapid City emblem or logo helps both warn and promote use of the path itself. For path users, directional signs and street names at crossings help direct people to their destinations. The directional signing should impart a unique theme so path users know which path they are following and where it goes. The theme can be conveyed in a variety of ways: engraved stone, medallions, bollards, and mile markers. A central information installation at trailheads and major crossroads also helps users find and acknowledge the rules of the path. They are also useful for interpretive education about plant and animal life, ecosystems, and local history.

Trail Etiquette Signs

Establishing goals and policies sets a common framework for understanding trail rules and regulations. Rights and responsibilities of trail usage should be stated at main trail access points. Once rules and regulations are established, the trail managing agency has a means of enforcement. Local ordinances may be adopted to help enforce trail policies. Penalties such as fines or community service may be imposed in response to non-compliance.

Informational Kiosks

Interpretive signs provide enrichment to the trail user experience, focuses attention on the unique attributes of the local community, and provides educational opportunities. Natural and cultural resources in trail corridors may provide opportunities for interpretation. Including historic signs and photos, boat ramps, and wildlife.



Directional and Shared-Use Path Etiquette Signage

Guidance

- AASHTO *Guide for the Development of Bicycle Facilities*

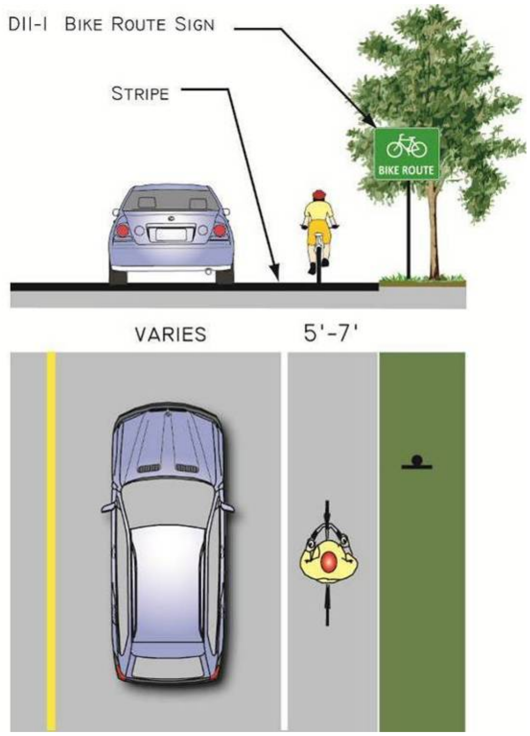
5. On-Street Facility Design Guidelines

A range of bicycle facilities can be applied in various contexts, providing varying levels of protection or separation from automobile traffic.

5.1. Shoulder Bikeways

Design Summary

- Recommended widths (measured from painted edgeline to edge of pavement):
  - 6' on roadways with posted speed limits > 40 mph
  - 5' on roadways with posted speed limits < 35 mph
  - 4' on low-speed, low-volume streets where right-of-way constraints exist
- Can include pavement markings and 'Share the Road" signage.
- See bike lane section for additional guidance for determining if bike lanes are required.



Recommended shoulder bikeway configuration.

Discussion

On streets without adequate space for bike lanes, or on rural roads with a large shoulder, shoulder bikeways can accommodate bicycle travel. Shoulder bikeways are generally used by commuter and long-distance recreational riders, rather than families with children or more inexperienced riders. Parking is generally not allowed along shoulder bikeways.

In many cases, the opportunity to develop a full standard bike lane on a street where it is desirable may be many years. It is possible to stripe the shoulder in lieu of bike lanes if the area is 50 percent of the desirable bike lane width and the outside lane width can be reduced to the AASHTO minimum.

The SD DOT *Road Design Manual* states that, "Where pedestrians and bicyclists are to be accommodated on the shoulders, a minimum usable paved shoulder width, clear of rumble strips, of 4 feet should be used."

Shoulder bikeways are appropriate along wide rural roads where vehicles can avoid passing close to bicyclists.

Guidance

- AASHTO *Guide for the Development of Bicycle Facilities*
- MUTCD

5.2. Bike Lanes

Design Summary

- Recommended widths (minimum-maximum):
  - Adjacent to on-street parallel parking: 6′ (4′-7′)
  - Adjacent to on-street diagonal parking: 6′ (5′-7′)
  - Without on-street parking, no gutter: 6′ (4′-7′)
  - Without on-street parking, curb & gutter: 6′ (5′-8′)
- Place the bicycle lane symbol marking immediately after an intersection and other locations as needed.
- If the word or symbol pavement markings are used, “Bicycle Lane” signs shall also be used, but the signs need not be adjacent to every symbol to avoid overuse of the signs. (AASHTO guidance)

Bike lanes provide a travel lane for bicyclists that is separated from motor vehicle travel and parking lanes.

Discussion

Designated exclusively for bicycle travel, bike lanes are separated from vehicle travel lanes with striping and also include pavement stencils. Bike lanes are most appropriate on arterial and collector streets where higher traffic volumes and speeds warrant greater separation.

Bike lanes help to define the road space for bicyclists and motorists, reduce the chance that motorists will stray into the cyclists’ path, discourage bicyclists from riding on the sidewalk, and remind motorists that cyclists have a right to the road.

One consideration in designing bike lanes in an urban setting is to ensure that bike lanes and adjacent parking lanes have sufficient width so that cyclists have enough room to avoid a suddenly opened vehicle door.

Bike lane pavement markings in Portland provide character to the roadway.

Guidance

- AASHTO *Guide for the Development of Bicycle Facilities*

5.2.1. Bike Lane Adjacent to On-Street Parallel Parking

Design Summary

- Bike Lane Width:
  - 6′ recommended when parking stalls are marked
  - 4′ minimum in constrained locations
  - 7′ maximum (wider lanes may be used by drivers)
- Travel Lane Width
  - 12′ for a shared lane adjacent to a curb face
  - 11′ minimum for a shared bike/parking lane where parking is permitted but not marked on streets without curbs

Discussion

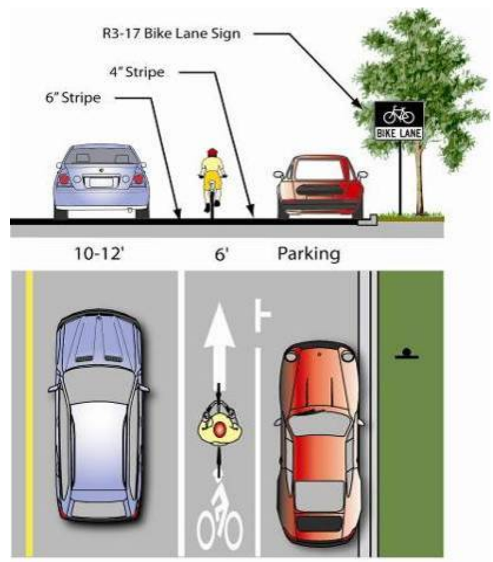
On bike lanes adjacent to on-street parallel parking, suddenly-opened vehicle doors are a common hazard for bicyclists.

However, wide bike lanes may encourage the cyclist to ride farther to the right to maximize distance from passing traffic. Wide bike lanes may also cause confusion with unloading vehicles in busy areas where parking is typically full. Some alternatives include:

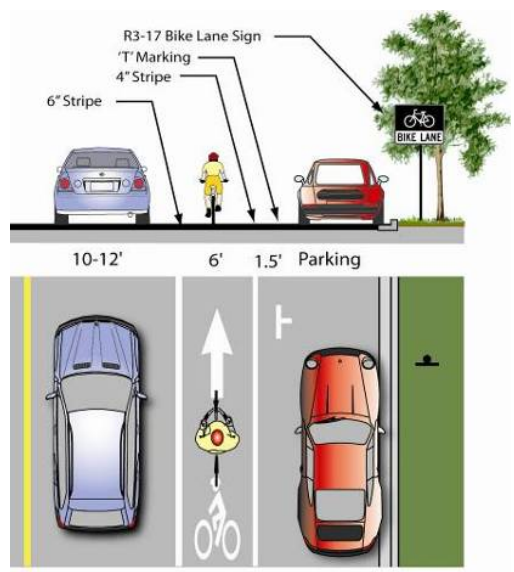
- Installing parking "T's" (top graphic).
- Provide a buffer zone (lower graphic) This design also provides motorists with space to stand outside the bike lane when loading and unloading.

Guidance

- AASHTO *Guide for the Development of Bicycle Facilities*



Design for a bike lane adjacent to on-street parallel parking.



Preferred design if space is available.

5.2.2. Bike Lane Adjacent to On-Street Diagonal Parking

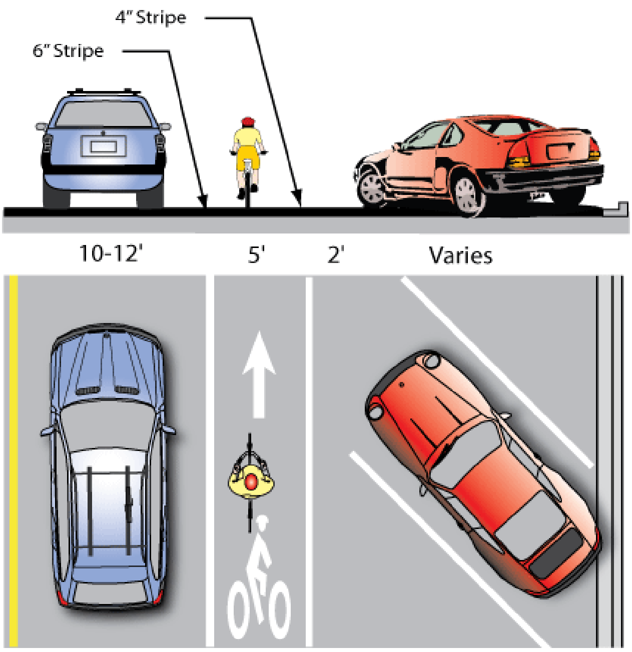
Design Summary

- Bike lane width:
  - o 5' minimum
  - o White 4" stripe separates bike lane from parking bays
  - o Parking bays are sufficiently long to accommodate most vehicles (vehicles do not block bike lane)

Discussion

In areas with high parking demand such as urban commercial areas, diagonal parking can be used to increase parking supply. Conventional "head-in" diagonal parking is not recommended in conjunction with high levels of bicycle traffic or with the provision of bike lanes as drivers backing out of conventional diagonal parking spaces have poor visibility of approaching bicyclists.

The use of 'back-in diagonal parking' or 'reverse angled parking' is recommended over head-in diagonal parking. This design addresses issues with diagonal parking and bicycle travel by improving sight distance between drivers and bicyclists and has other benefits to vehicles including: loading and unloading of the trunk occurs at the curb rather than in the street, passengers (including children) are directed by open doors towards the curb, no door conflict with bicyclists. While there may be a learning curve for some drivers, using back-in diagonal parking is typically an easier maneuver than conventional parallel parking.



Recommended Design

'Back-in' diagonal parking is safer for cyclists than 'head-in' diagonal parking due to drivers' visibility as they exit the parking spot.

Guidance

- Currently slated for inclusion in the upcoming AASHTO *Guide for the Development of Bicycle Facilities.*

5.2.3. Bike Lane Without On-Street Parking

Design Summary

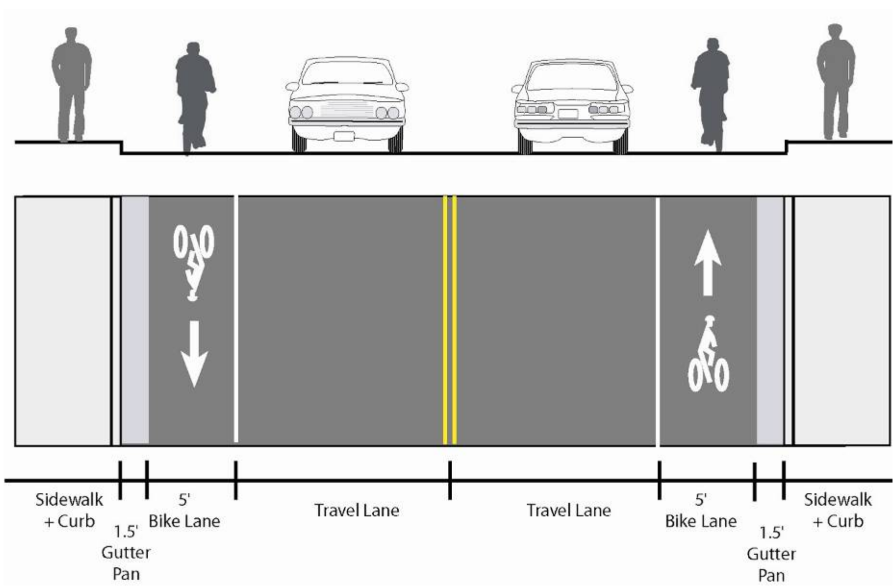
- Bike lane width:
  - o 4′ minimum when no curb & gutter is present
  - o 5′ minimum when adjacent to curb and gutter (3′ more than the gutter pan width if the gutter pan is wider than 2′)
- Recommended width:
  - o 6′ where right-of-way allows
- Maximum width:
  - o 8′ Adjacent to arterials with high travel speeds (45 mph^{+})

Discussion

Wider bike lanes are desirable in certain circumstances such as on higher speed arterials (45 mph+) where a wider bike lane can increase separation between passing vehicles and cyclists. Wide bike lanes are also appropriate in areas with high bicycle use. A bike lane width of 6 to 8 feet makes it possible for bicyclists to ride side-by-side or pass each other without leaving the bike lane, increasing the capacity of the lane. Appropriate signing and stenciling is important with wide bike lanes to ensure motorists do not mistake the lane for a vehicle lane or parking lane.

Recommended Design

Guidance



Two Lane Cross-Section with No Parking*

**Bike lanes may be 4′ in width under constrained circumstances*

5.2.4. Retrofitting Existing Streets with Bike Lanes and Shoulder Bikeways

Most major streets in Rapid City pose physical and other constraints to installing bike lanes or shoulder bikeways, requiring street retrofit measures within existing curb-to-curb widths. As a result, many of the recommended measures effectively reallocate existing street width through striping modifications or roadway widening.

Roadway Widening

Design Summary

- Bike lane /shoulder bikeway width: see appropriate design guidance.

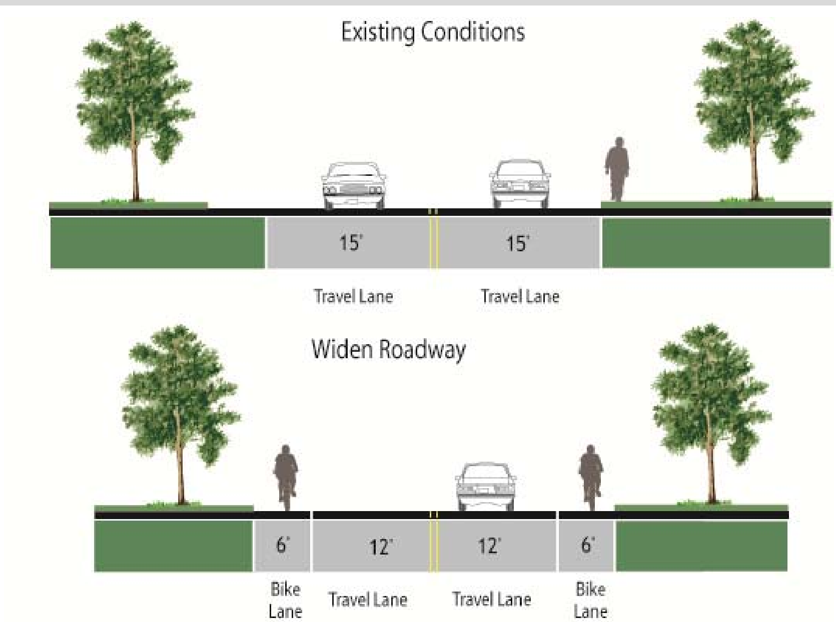
Discussion

Although street widening incurs higher expenses than re-striping projects, shoulder bikeways could be added to streets currently lacking curbs, gutters and sidewalks without the high costs of major infrastructure reconstruction.

As a long-term measure, Rapid City should find opportunities to add bike lanes or shoulder bikeways to major when streets and bridges are widened for additional auto capacity or as property development necessitates street reconstruction.

Roadway widening is preferred on roads lacking curbs, gutters and sidewalks.

Guidance



Example of roadway widening to accommodate shoulder bikeways.

5.2.4. Retrofitting Existing Streets with Bike Lanes and Shoulder Bikeways

Lane Narrowing (Road Diet 1)

Design Summary

- Bike lane width: see bike lane design guidance.
- Vehicle lane widths: before: 12 to 15 feet; after: 10 to 11 feet.

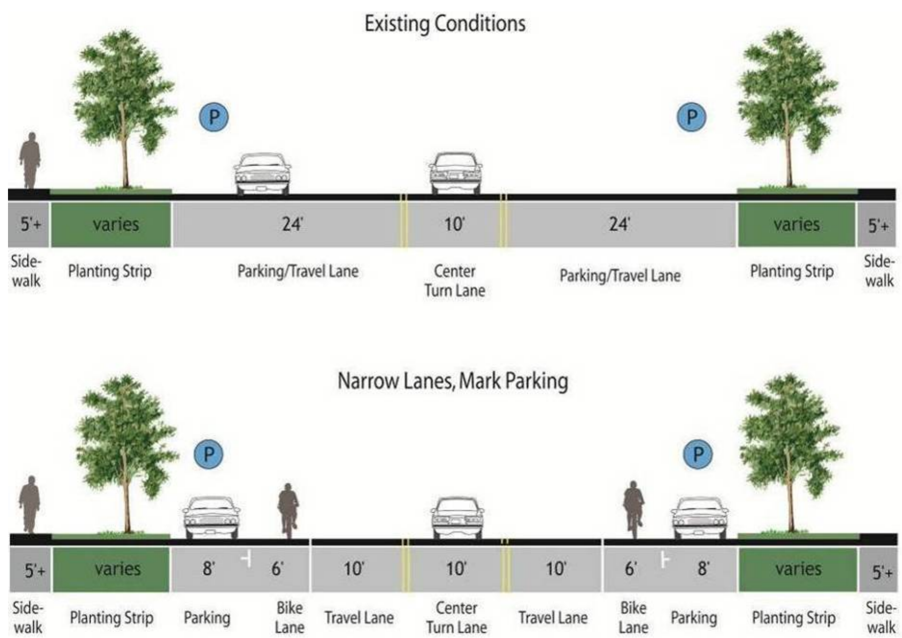
This street previously had 13' lanes, which were narrowed to accommodate bike lanes without removing a lane.

Discussion

Also called a 'Road Diet', lane narrowing utilizes roadway space that exceeds minimum standards to create the needed space to provide bike lanes. Many roadways in the Rapid City area have existing lanes that are wider than those prescribed in local and national roadway design standards, or which are not marked. Most standards allow for the use of 11-foot and sometimes 10-foot wide travel lanes to create space for bike lanes.

Special consideration should be given to the amount of heavy vehicle traffic and horizontal curvature before the decision is made to narrow travel lanes. Center turn lanes can also be narrowed in some situations to free up pavement space for bike lanes.

Guidance



Example of vehicle travel lane narrowing to accommodate bike lanes.

5.2.4. Retrofitting Existing Streets with Bike Lanes and Shoulder Bikeways

Lane Reconfiguration (Road Diet 2)

Design Summary

- Bike lane width: see bike lane design guidance.
- Vehicle lane width: depends on project. No narrowing may be needed if a lane is removed.

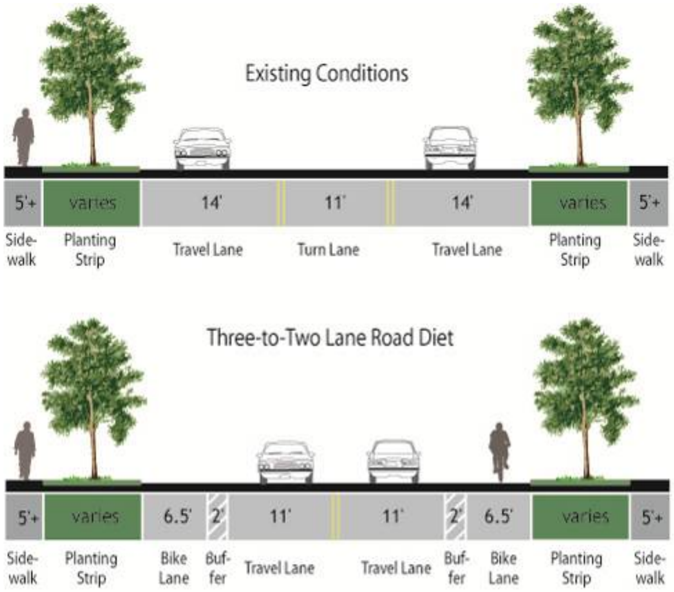
This road was re-striped to convert four vehicle travel lanes into three travel lanes with bike lanes.

Discussion

The removal of a single travel lane will generally provide sufficient space for bike lanes on both sides of a street. Streets with excess vehicle capacity present an opportunity for bike lane retrofit projects. Depending on a street's existing configuration, traffic operations, user needs, and safety concerns, various lane reduction configurations exist. For instance, a four-lane street (with two travel lanes in each direction) could be modified to include one travel lane in each direction, a center turn lane, and bike lanes. Prior to implementing this measure, a traffic analysis should identify impacts.

This treatment is currently slated for inclusion in the upcoming AASHTO *Guide for the Development of Bicycle Facilities.*

Guidance



Example of vehicle travel lane reconfiguration to accommodate bike lanes.

5.2.4. Retrofitting Existing Streets with Bike Lanes and Shoulder Bikeways

Parking Reduction (Road Diet 3)

Design Summary

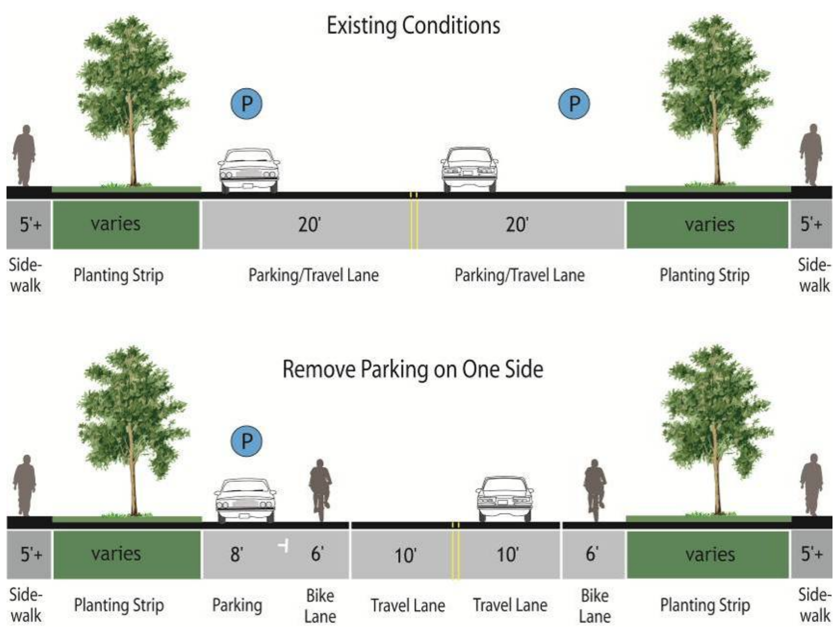
- Bike lane width: see bike lane design guidance.
- Vehicle lane width: depends on project. No narrowing may be needed depending on the width of the parking lane to be removed.

Discussion

Bike lanes could replace one or more on-street parking lanes on streets where excess parking exists and/or the importance of bike lanes outweighs parking needs. For instance, parking may be needed on only one side of a street (as shown below and at right). Eliminating or reducing on-street parking also improves sight distance for cyclists in bike lanes and for motorists on approaching side streets and driveways. Prior to reallocating on-street parking for other uses, a parking study should be performed to gauge demand and to evaluate impacts to people with disabilities.

Some streets may not require parking on both sides.

Guidance



Example of parking removal to accommodate bike lanes

5.2.5. Bike Lanes at Intersections

Bike Lanes With Right Turn Pockets

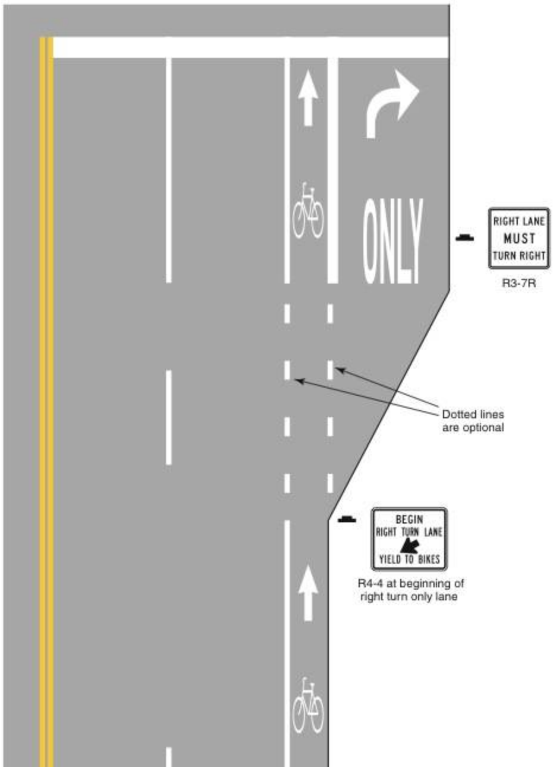
Design Summary

- Bike lane width:continue existing bike lane width; standard width of 5′ to 6′ or 4′ in constrained locations.

Discussion

The appropriate treatment at right-turn lanes is to place the bike lane between the right-turn lane and the right-most through lane or, where right-of-way is insufficient, to drop the bike lane entirely approaching the right-turn lane. The design (right) illustrates a bike lane pocket, with signage indicating that motorists should yield to bicyclists through the conflict area. While the dashed lines in this area are currently an optional treatment, it is recommended that they be an integral part of any intersection with this treatment in Rapid City.

Dropping the bike lane is not recommended, and should only be done when a bike lane cannot be accommodated at the intersection.



Recommended Design

Continuing a bike lane straight while providing a right-turn pocket reduces bicycle/motor vehicle conflicts

Guidance

- AASHTO *Guide for the Development of Bicycle Facilities.*

5.2.5. Bike Lanes at Intersections

Shared Bicycle/Right Turn Lane

Design Summary

- Width:
  - Shared turn lane – min. 12′ width
  - Bike Lane pocket – min. 4′-5′ preferred

Discussion

This treatment is recommended at intersections lacking sufficient space to accommodate a standard bike lane and right turn lane.

The shared bicycle/right turn lane places a standard-width bike lane on the left side of a dedicated right turn lane. A dashed strip delineates the space for bicyclists and motorists within the shared lane. This treatment includes signage advising motorists and bicyclists of proper positing within the lane.

Case studies cited by the Pedestrian and Bicycle Information Center indicate that this treatment works best on streets with lower posted speeds (30 MPH or less) and with lower traffic volumes (10,000 ADT or less).

Advantages of the shared bicycle/right turn lane:

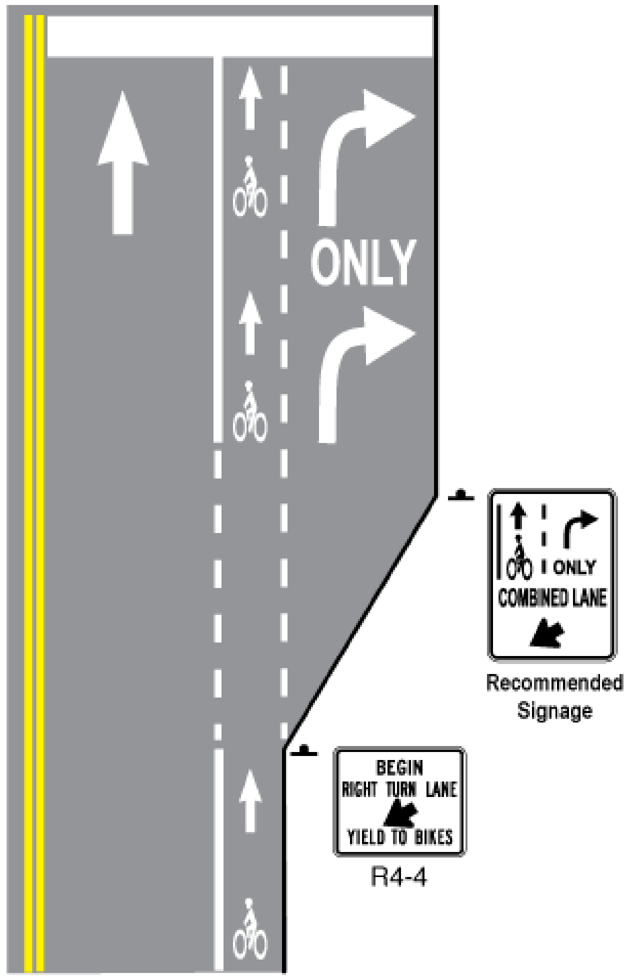
- Aids in correct positioning of cyclists at intersections with a dedicated right turn lane without adequate space for a dedicated bike lane.
- Encourages motorists to yield to bicyclists when using the right turn lane.
- Reduces motor vehicle speed within the right turn lane.

Disadvantages/potential hazards:

- May not be appropriate for high-speed arterials or intersections with long right turn lanes.
- May not be appropriate for intersections with large percentages of right-turning heavy vehicles.

Guidance

- Upcoming AASHTO *Guide For the Development of Bicycle Facilities.*
- Implemented in San Francisco, CA and Eugene, OR.



Recommended Design

Shared bike-right turn lanes require warning signage as well as pavement markings

5.2.5. Bike Lanes at Intersections

Bike Box

Design Summary

- Bike box dimensions: 14' deep to allow for bicycle positioning.
- Use appropriate signs as recommended by the MUTCD. Signs should prohibit 'right turn on red' and to indicate where the motorist must stop.

Discussion

A bike box is generally a right angle extension of a bike lane at the head of a signalized intersection. The bike box allows bicyclists to move to the front of the traffic queue on a red light and proceed first when that signal turns green. Motor vehicles must stop behind the white stop line at the rear of the bike box.

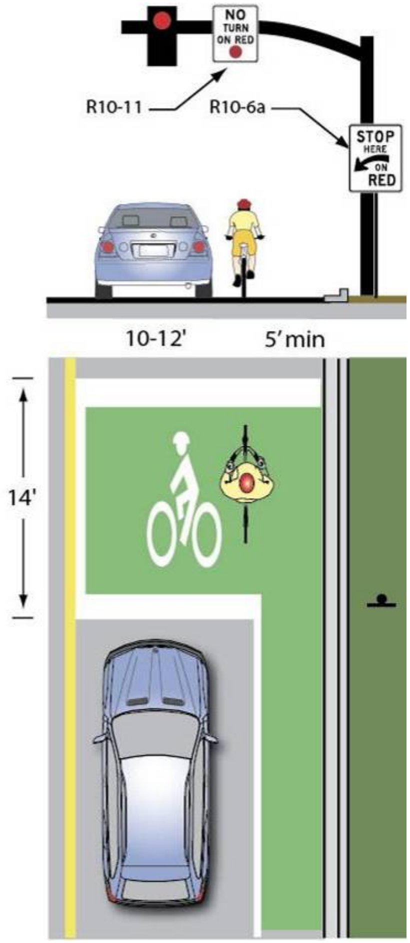
Bike boxes can be combined with dashed lines through the intersection for green light situations to remind right-turning motorists to be aware of bicyclists traveling straight, similar to a colored bike lane treatment. Bike boxes can be installed with striping only or with colored treatments to increase visibility. Use of coloration substantially increases costs of maintenance over uncolored (striping, bicycle symbol, and text only) treatments.

Bike boxes should be located at signalized intersections only, and right turns on red should be prohibited. Bike boxes should be used locations that have a large volume of cyclists, and are often utilized in central areas where traffic is usually moving slowly. Reducing right turns on red improves safety for cyclists and does not significantly impede motor vehicle travel.

On roadways with one travel lane in each direction, the bike box also facilitates left turning movements for cyclists.

Guidance

- Evaluation of Innovative Bike-Box Application in Eugene, Oregon, Author: Hunter, W.W., 2000



Recommended design of a bike box.

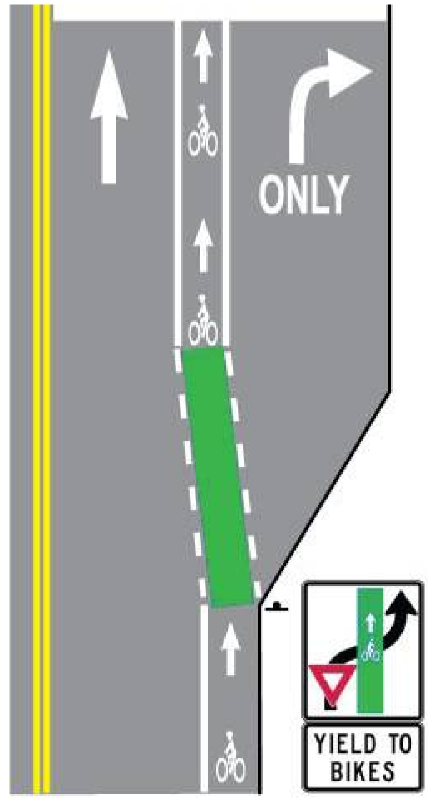
Bike boxes have been installed at several intersections in Portland, OR where right-turning motorists conflict with through bicyclists

5.2.6. Innovative Bike Lane Treatments

Colored Bike Lanes

Design Summary

- Bike lane pocket – min. 4'-5' preferred.
- Use colored pavement through entire merge area.
- Dash lines to indicate that automobiles are crossing the bike lane.
- Provide signs reminding drivers to yield to cyclists in the bike lane.



Recommended colored bike box design.

Discussion

Cyclists are especially vulnerable at locations where the volume of conflicting vehicle traffic is high, and where the vehicle/bicycle conflict area is long. Some cities are using colored bike lanes to guide cyclists through major vehicle/bicycle conflict points. These conflict areas are locations where motorists and cyclists must cross each other's path (e.g., at intersections or merge areas). Colored bike lanes typically extend through the entire bicycle/vehicle conflict zone (e.g., through the entire intersection, or through the transition zone where motorists cross a bike lane to enter a dedicated right turn lane.

There are three colors commonly used in bike lanes: blue, green, and red. Several cities initially used blue; however, this color is associated with amenities for handicapped drivers or pedestrians. Green is the color recommended for use in Rapid City.

Although colored bike lanes are not an official standard at this time, they continue to be successfully used in cities, including Portland, OR, Philadelphia, PA, Cambridge, MA, Toronto, Ontario, Vancouver, BC and Tempe, AZ. This treatment typically includes signage alerting motorists of vehicle/ bicycle conflict points. Portland's Blue Bike Lane report found that significantly more motorists yielded to bicyclists and slowed or stopped before entering the conflict area after the application of the colored pavement.

Portland, OR has implemented blue bike lanes and has since changed them to green.

Guidance

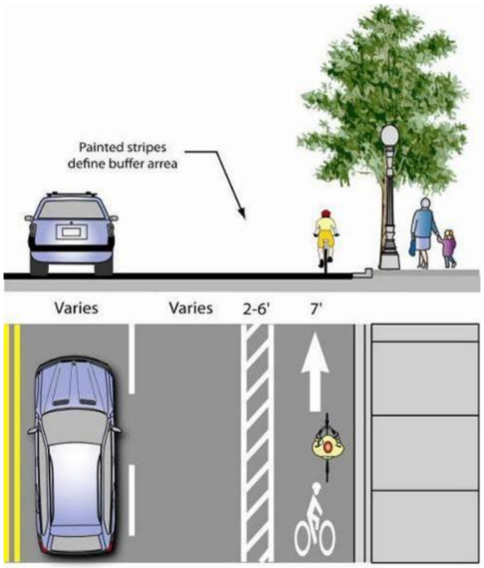
- Portland Office of Transportation (1999). Portland's Blue Bike Lanes: Improved Safety through Enhanced Visibility. *Available: www.portlandonline.com/shared/cfm/image.cfm?id=58842*

5.2.6. Innovative Bike Lane Treatments

Buffered Bike Lanes

Design Summary

- Width: 6′ recommended
- Minimum of 2′ buffer area



Recommended buffered bike lane design.


Buffered bike lanes protect cyclists from fast-moving traffic

Discussion

Bike lanes on high-volume or high-speed roadways can be dangerous or uncomfortable for cyclists, as automobiles pass or are parked too close to bicyclists. Buffered bike lanes are designed to increase the space between the bike lanes and the travel lane or parked cars.

This treatment is appropriate on bike lanes with high automobile traffic volumes and speed, bike lanes adjacent to parked cars, and bike lanes with a high volume of truck or oversized vehicle traffic. Frequency of right turns by motor vehicles at major intersections should determine whether continuous or truncated buffer striping should be used approaching the intersection.

Advantages of buffered bike lanes:

- Provides cushion of space to mitigate friction with motor vehicles on streets with narrow bike lanes.
- Provides space for cyclists to pass one another without encroaching into the travel lane.
- Provides space for cyclists to avoid potential obstacles in the bike lanes, including drainage inlets, manholes, trash cans or debris.
- Parking side buffer provides cyclists with space to avoid the ‘door zone’ of parked cars.
- Provides motorists greater shy distances from cyclists in the bike lane.

Disadvantages / potential hazards:

- Requires additional roadway space.
- Requires additional maintenance for the buffer striping.
- Frequency of parking turnover should be considered prior to installing buffered bike lanes.
- Increases the debris collection in the bike lane.

Guidance

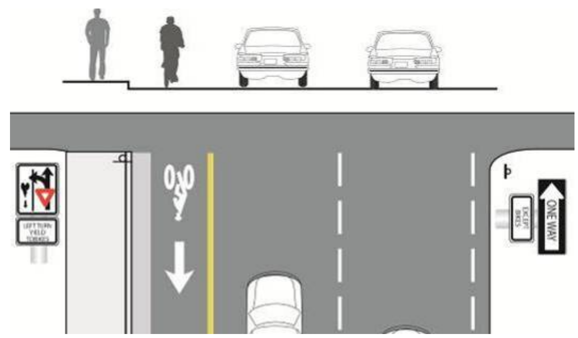
- City of Portland, OR *Bikeway Design Best Practices for the 2030 Bicycle Master Plan*.
- Currently used in Brussels & Bruges, Belgium, Budapest, Hungary, London, UK, Seattle, WA, San Francisco, CA, and New York, NY.

5.2.6. Innovative Bike Lane Treatments

Contraflow Bike Lane

Design Summary

- Width: 5.0 feet to 6.5 feet and marked with a solid double yellow line and appropriate signage.
- Bike lane markings should be clearly visible to ensure that contraflow lane is exclusively for bicycles.
- Coloration should be considered on the bike lane.



Recommended contraflow bike lane design.

Discussion

Contraflow bike lanes provide bi-directional bicycle access along a roadway that is one-way for automobile traffic. This treatment can provide direct access and connectivity for bicyclists, avoiding detours and reducing travel distances for cyclists.

Advantages of contraflow bike lanes:

- Provides direct access and connectivity for bicycles traveling in both directions.
- Influences motorist choice of routes without limiting bicycle traffic.
- Cyclists do not have to make detours as a result of one-way traffic.

Disadvantages / potential hazards

- Parking should not be provided on the far side of the contraflow bike lane.
- Space requirements may require reallocation of roadway space from parking or travel lanes.
- The lane could be illegally used by motorists for loading or parking.
- Conversion from a two-way street requires elimination of one direction of automobile traffic
- Public outreach should be conducted prior to implementation of this treatment.

This contraflow bike lane in Portland, OR (left) provides a key connection along a narrow one-way street.

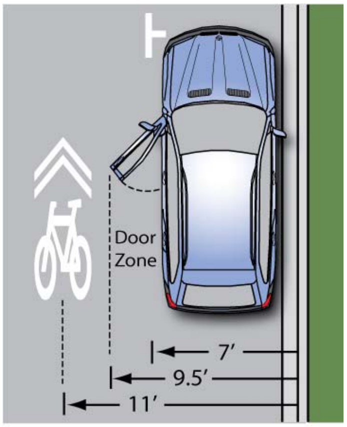
Guidance

- *Wisconsin Bicycle Facility Design Handbook.*
- City of Portland, OR *Bikeway Design Best Practices for the 2030 Bicycle Master Plan.*
- Currently used in Olympia and Seattle, WA; Madison, WI, Cambridge, MA, San Francisco, CA, and Portland, OR.

5.3. Shared Lane Markings

Design Summary

- Place at least 11' from face of curb (or shoulder edge) with on-street parking.
- Place at least 4' from face of curb (or shoulder edge) without on-street parking.
- Place every 100-200 feet.
- Use on roadways with posted speeds of 35 mph or below.



Shared lane marking placement guidance for streets with on-street parking.

Discussion

Shared lane markings are high-visibility pavement markings that help position bicyclists within the travel lane. These markings are often used on streets where dedicated bike lanes are desirable but are not possible due to physical or other constraints.

Shared lane markings are placed strategically in the travel lane to alert motorists of bicycle traffic, while also encouraging cyclists to ride at an appropriate distance from the "door zone" of adjacent parked cars. These pavement markings have been successfully used in many small and large communities throughout the U.S. Shared lane markings made of thermoplastic tend to last longer than those using traditional paint.

This marking has been included in the 2009 update of the MUTCD, which allows shared lane markings to be used in locations with and without on-street parking. Placing shared lane markings between vehicle tire tracks (if possible) will increase the life of the markings.

Shared lane markings can be used on minor and major roadways.

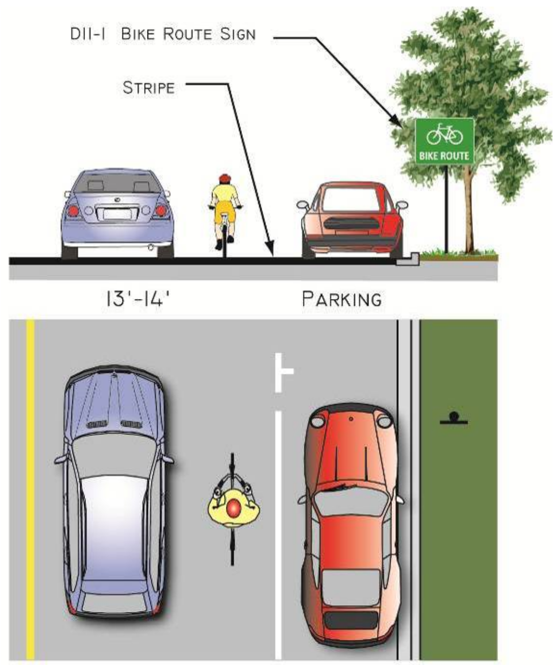
Guidance

- MUTCD

5.4. Signed Shared Roadways

Design Summary

- Any street without specific bicycle facilities, where bicycling is permitted.
- Can be signed connections, often to trails or other major destinations.



Shared roadway recommended configuration.

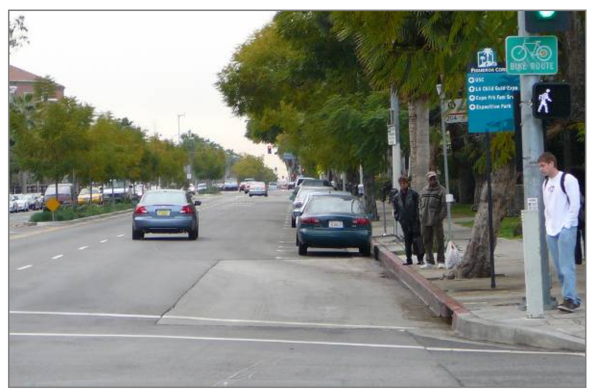
Discussion

A treatment appropriate for commuter riders and those accessing a trail, shared roadways can provide a key connection. Shared roadways are indicated exclusively by signs and provide key connections to destinations and trails where providing additional separation is not possible.

Roadways appropriate for shared roadways often have a centerline stripe only, and no designated shoulders. Bicyclists are forced to share a travel lane with automobiles. This type of facility can be developed on a rural roadway without curb and gutter. It can also be used on an urban road where traffic speeds and volumes are low (photo), although shared lane markings in addition to signage may be more appropriate in these locations.

Guidance

- AASHTO *Guide for the Development of Bicycle Facilities*
- MUTCD



This bike route in Los Angeles provides a wide outside lane adjacent to on-street parking.

Bike Route signs are used to indicate the street is designated for bicycle use.

5.5. Bikeway Intersection Treatments

5.5.1. Bikeway Intersection Treatments at Minor Unsignalized Intersections

Design Summary

- Reduce bicycle travel time by eliminating unnecessary stops and improving intersection crossings.

Discussion

Stop Sign on Cross-Street

Unmarked intersections can be dangerous for bicyclists because cross-traffic may not be watching for cyclists. Stop signs minimize bicycle and cross-vehicle conflicts by identifying which street has the right-of-way. However, placing stop signs at all intersections along bikeways on local street may be unwarranted as a traffic control device (see MUTCD guidance).

Bicycle Forward Stop Bar

A second stop bar for cyclists placed closer to the centerline of the cross street than the first stop bar increases the visibility of cyclists waiting to cross a street. This treatment is typically used with other crossing treatments (i.e. curb extension) to encourage cyclists to take full advantage of crossing design. They are appropriate at unsignalized crossings where fewer than 25 percent of motorists make a right turn movement.

Medians/Refuge Islands

At uncontrolled intersections at major streets, a crossing island can be provided to allow cyclists to cross one direction of traffic at a time when gaps in traffic allow. The bicycle crossing island should be at least 8' wide to be used as the bike refuge area. Narrower medians can accommodate bikes if the holding area is at an acute angle to the major roadway. Crossing islands can be placed in the middle of the intersection, prohibiting left and through vehicle movements.

Guidance

- AASHTO *Guide for the Development of Bicycle Facilities*
- MUTCD

Stop signs effectively minimize conflicts along bikeways on local streets.

Bicycle forward stop bars encourage cyclists to wait where they are more visible.

Medians should provide space for a bicyclist to wait.

5.6. Cycle Tracks

Design Summary

- Use for one-direction bicycle travel (both sides of street).
- 7' minimum to allow passing.
- 12'minimum for two-way facility.

Discussion

A cycle track is an exclusive bicycle facility that combines the user experience of a separated path with the on-street infrastructure of a conventional bike lane. Cycle tracks can be either one-way or two-way, on one or both sides of a street, and are separated from vehicles and pedestrians by pavement markings or coloring, bollards, curbs/medians or a combination of these elements. Cycle tracks provide:

- Increased comfort for bicyclists.
- Greater clarity about expected behavior.
- Fewer conflicts between bicycles and parked cars as cyclists ride inside the parking lane.
- Space to reduce the danger of "car dooring."

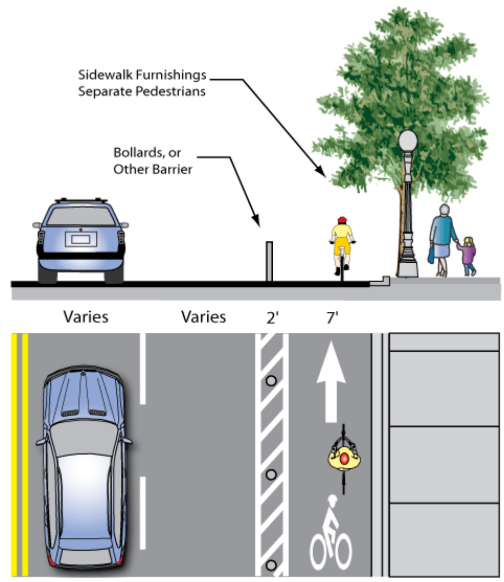
Danish research has shown that cycle tracks can increase bicycle ridership 18-20%, compared with the 5-7% increase associated with bike lanes. However, disadvantages of cycle tracks include:

- Increased vulnerability at intersections.
- Regular street sweeping trucks cannot maintain the cycle track; requires smaller sweepers.
- Conflicts with pedestrians and bus passengers can occur, particularly on cycle tracks that are un-differentiated from the sidewalk or that are between the sidewalk and a transit stop.

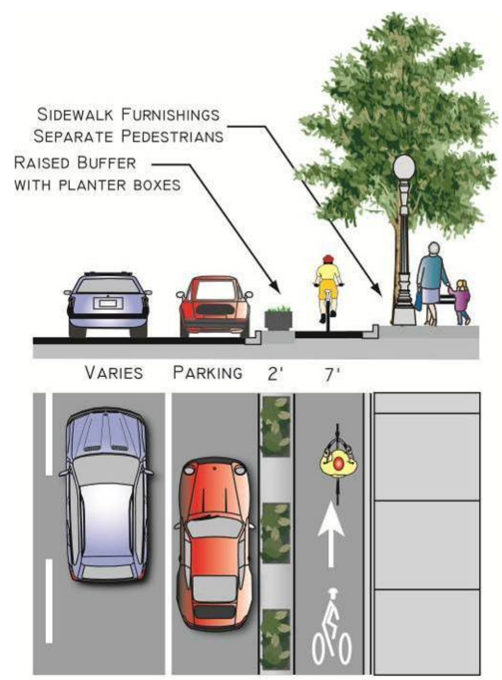
While recently implemented in the US, cycle tracks have been used in European countries for several decades. The cycle track design guidance following was developed using European experience applied to American situations.

Guidance

- *Cycle Tracks: Lessons Learned*, Alta Planning + Design (2009)



Recommended cycle track design without parking, using striping and flexible bollard separation.



Recommended design with on-street parking, using a raised buffer with planter boxes for separation.

6. Bicycle Parking

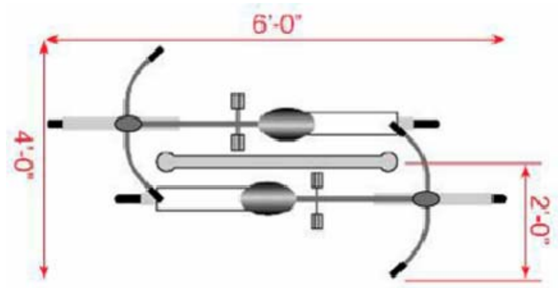
Bicycle parking can be broadly defined as either short-term or long-term parking:

- Short-term parking: parking meant to accommodate visitors, customers, messengers and others expected to depart within two hours; requires approved standard rack, appropriate location and placement, and weather protection.
- Long-term parking: parking meant to accommodate employees, students, residents, commuters, and others expected to park more than two hours. This parking is to be provided in a secure, weather-protected manner and location.

6.1. Short-Term Bicycle Parking

Design Summary

- Location:
  - 50′ maximum distance from main building entrance.
  - 2′ minimum from the curb face to avoid 'dooring.'
  - Avoid fire zones, loading zones, bus zones, etc.
  - Location should be highly visible from adjacent bicycle routes and pedestrian traffic.
- Provide a minimum clear distance of 5′-6′ between the bicycle rack and the property line to allow ample pedestrian movement.
- If two racks are to be installed parallel to each other, a minimum of 2.5′ should be provided between the racks.



Standard bicycle rack

Discussion

Bicycle racks should be located close to the entrances of key destinations such as shops or shopping centres. They are generally appropriate for commercial and retail areas, office buildings, healthcare and recreational facilities, and institutional developments such as libraries and universities.

Guidance

- Association of Bicycle and Pedestrian Planners, *Bicycle Parking Design Guidelines.* (2010).

6.2. Long-Term Bicycle Parking

Design Summary

- Place in close proximity to building entrances or transit exchanges, or on the first level of a parking garage.
- Provide door locking mechanisms and systems.
- A flat, level site is needed; concrete surfaces preferred.
- Enclosure must be rigid.
- Transparent panels are available on some models to allow surveillance of locker contents.
- Integrated solar panels have been added to certain models for recharging electric bicycles.
- Minimum dimensions: width (opening) 2.5'; height 6'; depth 4'.
- Stackable models can double bicycle parking capacity.

Bike lockers at a transit station.

Discussion

Although bicycle lockers may be more expensive to install, they can make the difference for commuters who are deciding whether or not to cycle. Bicycle lockers are large metal or plastic stand-alone boxes and offer the highest level of bicycle parking security available. Some lockers allow access to two users - a partition separating the two bicycles can help ensure users feel their bike is secure. Lockers can also be stacked, reducing the footprint of the area, although that makes them more difficult to use.

Security requirements may require that locker contents be visible, introducing a tradeoff between security and perceived safety. Though these measures are designed to increase station security, bicyclists may perceive the contents of their locker to be less safe if they are visible and will be more reluctant to use them. Providing visibility into the locker also reduces unintended uses, such as use as homeless shelters, trash receptacles, or storage areas. Requiring that users procure a key or code to use the locker also reduces these unintended uses.

Lockers available for one-time use have the advantage of serving multiple users a week. Monthly rentals, by contrast, ensure renters that their own personal locker will always be available. Bicycle lockers are most appropriate:

- Where demand is generally oriented towards long-term parking.
- At transit exchanges and park-and-rides to help encourage multi-modal travel.
- Medium-high density employment and commercial areas and universities.
- Where additional security is required and other forms of covered storage are not possible.

Guidance

- Association of Bicycle and Pedestrian Planners, *Bicycle Parking Design Guidelines.* (2010).

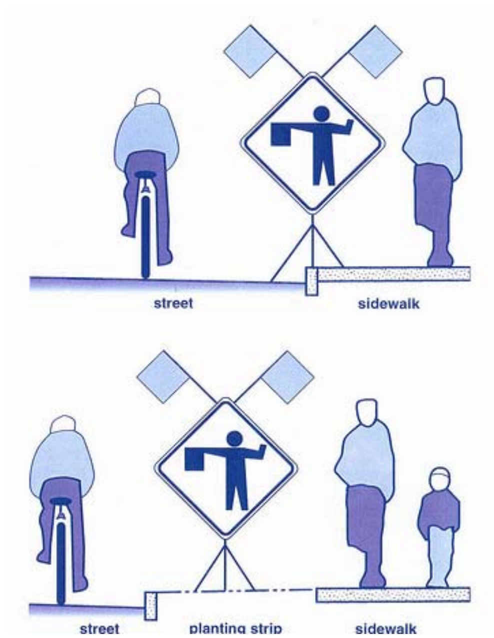
7. Bikeway Maintenance

This section presents guidelines for incorporating bicycle facilities into construction, maintenance and repair activities. The guidelines are a menu of options and considerations for maintenance activities, and not strict guidelines.

7.1. Street Construction and Repair

Design Summary

- Do not lead bicyclists into conflicts with work site vehicles, equipment, moving vehicles, open trenches or temporary construction signage.
- Where possible, re-create a bike lane (if one exists) to the left of the construction zone, or provide signs warning motorists to expect cyclists in the roadway.
- Place construction signage in a location that does not obstruct the path of bicyclists or pedestrians (see right).
- Require that steel plates do not have a vertical edge greater than ¼" without an asphalt lip.



Recommended construction sign placement (source: Oregon Bicycle and Pedestrian Plan)

Discussion

Safety of all roadway users should be considered during road construction and repair. Wherever bicycles are allowed, measures should be taken to provide for the continuity of a bicyclist's trip through a work zone area. Only in rare cases should pedestrians and bicyclists be detoured to another street when travel vehicle lanes remain open.

Steel plates are commonly used during construction and the plates' lip can puncture a bicycle tire and/or cause a cyclist to lose control. These plates can be dangerously slippery, particularly when wet. Non-skid materials are preferred.

Guidance

- ODOT Bicycle and Pedestrian Plan
- MUTCD

7.2. Bikeway Maintenance

Design Summary

- Establish a seasonal sweeping schedule that prioritizes roadways with major bicycle routes.
- On all bikeways, use the smallest possible chip for chip sealing bike lanes and shoulders.
- If the condition of the bike lane is satisfactory, consider chip sealing only the travel lanes.
- Maintain a smooth surface on all bikeways that is free of potholes.
- Maintain pavement so ridge buildup does not occur at the gutter-to-pavement transition or adjacent to railway crossings.
- Inspect the pavement 2 to 4 months after trenching construction activities are completed to ensure that excessive settlement has not occurred.
- Check regulatory and wayfinding signs along bikeways for signs of vandalism, graffiti, or normal wear and replace signs as needed.
- Ensure that shoulder plants do not hang into or impede passage along bikeways.

Recommended Walkway and Bikeway Maintenance Activities

Maintenance Activity	Frequency
Inspections	Seasonal –beginning and end of summer
Pavement sweeping	As needed, weekly in fall
Pavement sealing	5 - 15 years
Pothole repair	1 month after report
Culvert and drainage grate inspection	Before winter and after major storms
Pavement markings replacement	1 – 3 years
Signage replacement	1 – 3 years
Shoulder plant trimming (weeds, trees, brambles)	Twice a year; middle of growing season / early fall
Tree and shrub trimming	1 – 3 years
Major damage response (washouts, flooding)	As soon as possible

Discussion

Bicyclists often avoid shoulders and bike lanes filled with gravel, broken glass and other debris; they will ride in the roadway to avoid these hazards, causing conflicts with motorists. Debris from the roadway should not be swept onto sidewalks (pedestrians need a clean walking surface), nor should debris be swept from the sidewalk onto the roadway. A regularly scheduled inspection and maintenance program helps ensure that roadway debris is regularly picked up or swept.

Bicycles are more sensitive to subtle changes in roadway surface than are motor vehicles. Various materials are used to pave roadways, and some are smoother than others. Compaction after trenches and other holes are filled can lead to uneven settlement, which affects the roadway surface nearest the curb where bicycles travel.

Pavement overlays represent good opportunities to improve conditions for cyclists if done carefully. A ridge should not be left in the area where cyclists ride (this occurs where an overlay extends part-way into a shoulder bikeway or bike lane). Overlay projects offer opportunities to widen a roadway, or to re-stripe a roadway with bike lanes.

Bikeways can become inaccessible due to overgrown vegetation. All landscaping needs to be designed and maintained to ensure compatibility with the use of the bikeways. After a flood or major storm, bikeways should be checked along with other roads, and fallen trees or other debris should be removed promptly.

Guidance

- ODOT Bicycle and Pedestrian Plan
- MUTCD

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