Appendix G

Active Transportation Design Toolbox

May 2015

Halton ACTIVE Transportation Master Plan

Halton REGION

Design Toolbox

IBI

May 2015

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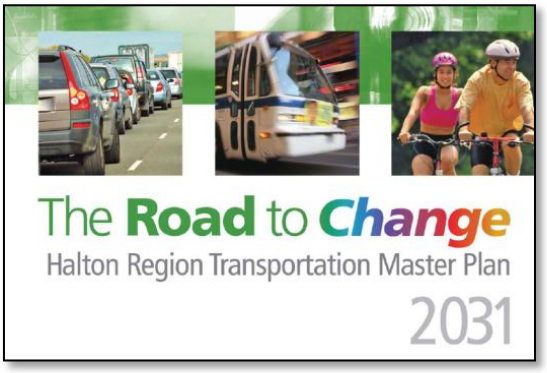
1. Introduction to the Active Transportation Master Plan



The Halton Region Active Transportation Master Plan (ATMP) outlines the strategy, infrastructure, initiatives and programs required to create an active transportation plan that is safe, affordable and sustainable. The ATMP was a recommendation of the Halton Region Transportation Master Plan – The Road to Change to the year 2031 to facilitate and promote active transportation.

1.1 Background

In 2011, Halton Region approved its Transportation Master Plan (TMP) – The Road to Change to address the transportation needs of Halton Region safely and efficiently to 2031. The TMP provides the strategies, tools and policies to develop a sustainable, integrated transportation system that considers all modes (automobile, transit, cycling and walking) and supports the policies and objectives arising out of the Halton Region Official Plan Amendment Review (ROPA 38).

As set out in the TMP, the transportation system identified to 2031 must accommodate growth in travel demand in a manner that supports the vision and guiding principles while maintaining current levels of service. The TMP supports an increase in the use of active transportation as a travel mode option available for all members of the community. It sets a mode share target for active transportation of 5% of all PM peak hour trips by 2031 (currently less than 2%). This target can be realized through investments in cycling and walking infrastructure and the introduction of policies and supportive programs to encourage shifts from auto travel to active modes for trips generally less than 10 km in length.

1.2 What is Active Transportation?

Active transportation is any form of human-powered transportation, including walking, cycling, in-line-skating, skateboarding and moving with mobility devices. It is about getting to work or school, going shopping, running errands, visiting friends and family or other trips by *walking, biking and rolling.* An active transportation network includes sidewalks, multi-use paths, crosswalks, on-road bikeways and off-road trails.

There are many benefits of active transportation:

- Transportation: improve safety, reduce congestion, and increase access and transportation choice
- Environment: improve air quality and contribute to vibrant communities
- Health: increase physical activity and reduce chronic disease
- Economy: reduce household travel costs, and support local business

2 Design Toolbox

Designing for active transportation requires an understanding of the different types of users, their characteristics, the facilities that they use and how they fit within roadway corridors. The Design Toolbox is intended to provide an overview of the key design considerations and best practices for active transportation facilities.

2.1 Purpose of the Design Toolbox

Active transportation infrastructure includes a number of different types of facilities to accommodate the wide range of abilities, skills and experience of pedestrians, in-line skaters, cyclists, pedestrians with mobility devices, visual, hearing or cognitive impairments, skateboarders, etc. The basic facilities on which they travel consist of: sidewalks for pedestrians including those with mobility aids or devices (i.e., wheelchairs, guide dogs, canes, etc.), child cyclists and small-wheeled users like in-line skaters and skate-boarders; multi-use trails that essentially accommodate all active transportation modes; and bikeways such as bike lanes for cyclists only.

The purpose of the design toolbox is to identify guidelines and best practices to be considered in the planning and design of active transportation facilities along Regional roads. It is not intended to replace published design guidelines but to provide an overview of the key design considerations and best practices. Additional information will need to be sought from the original guidelines to develop and refine the design details.

2.2 Report Organization

This report is structured as follows:

- **Section 1** introduces the Active Transportation Master Plan
- **Section 2** outlines the purpose of the Design Toolbox
- **Section 3** recommends various North American design guidelines related to active transportation facilities; a selected bibliography is provide in Appendix A
- **Section 4** describes the characteristics of pedestrians and cyclists and how that influences the facilities they need or prefer

- **Section 5** provides key design considerations and best practices for accessible pedestrian facilities

- **Section 6** provides key design considerations and best practices for bikeways

2.3 Using the Design Toolbox

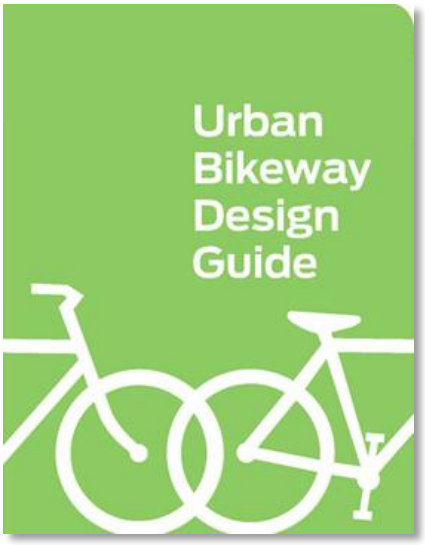
Planners and designers may refer to the design toolbox at various stages of a project: planning, environmental assessment, preliminary design and detail design. It is intended to provide some basic knowledge but is not a replacement for published guidelines nor for planning and engineering judgement.

First-time users should familiarize themselves with Section 4: Active Transportation Users before looking further into design considerations and best practices in subsequent sections.

Other stakeholders may use the Design Toolbox to gain an understanding of the various design options available to Halton Region for Regional roads. However, every individual project will have its own opportunities and constraints that must be considered carefully. Often trade-offs are made and enhancements selected based on a variety of technical, social, economic and political environments.

3 Planning and Design Guidelines

A wide variety of planning and design guidelines exist reflecting the wide range and complexity of facilities for active transportation. Essential North American guidelines are presented below. A more comprehensive list of recommended guidelines is provided in Appendix G1.



3.1 Pedestrians and Cyclists

Planning and Design for Pedestrians and Cyclists: A Technical Guide, Vélo Québec Association (2010)

This is the 3rd edition of Vélo Québec's design handbook expanded to include pedestrian design issues. It is a primary source for cycling and pedestrian planning and design guidance in the Canadian context. This manual summarizes the main characteristics of active transportation, discusses the design characteristics of pedestrians and cyclists, presents ideas on creating walkable and bikable environments, and has a section on planning for active transportation. The design sections cover paths and trails, walkways and bikeways in roadway corridors, ancillary elements such as lighting, signs and pavement markings, street furniture and parking, integration with transit, and maintenance and operation of pedestrian facilities and bikeways.

Designing Walkable Urban Thoroughfares: A Context Sensitive Approach, Institute of Transportation Engineers (ITE), 2010

This recommended design practice of the Institute of Transportation Engineers (Washington DC) is a comprehensive guide to the planning and design of major streets in urban areas. It is comprehensive in that it includes all elements of the roadway, whether they are for motorists, pedestrians or cyclists, as they interact to influence the walkability of the corridor. Chapters in the design section include: design controls, and street-side, travel way, and intersection design guidance.

Promoting Sustainable Transportation Through Site Design: An ITE Recommended Practice, Institute of Transportation Engineers (ITE), 2010

This report recommends site design practices that can be applied through the site development process to promote the use of more sustainable modes of transportation, such as walking, cycling and transit. Its primary purpose is to assist policymakers and professionals involved in the preparation, review and approval of non-residential or mixed-use development proposals to identify and incorporate features that make sites more accessible to travel modes other than the single-occupant vehicle (SOV).

Urban Street Design Guide, National Association of City Transportation Officials (NACTO), 2013

This guide covers a broad scope of best practices for designing city streets in North America from the perspective as corridors for conveying people, goods and services, and as public spaces for social, leisure and business activities. It presents best practices around street design principles, design elements, and interim design strategies; intersection design principles and design elements, and design controls and performance monitoring.

3.2 Pedestrians

Ontario Regulation 413/12: Integrated Accessibility Standards made under the Accessibility for Ontarians with Disabilities Act, 2005.

The amendement to this Ontario Regulation under the AODA regulates accessiblity standards for public spaces (built environment) including Recreational Trails and Beach Access Routes, Outdoor Public Use Eating Areas, Outdoor Play Spaces, Exterior Paths of Travel (outdoor sidewalks or walkways), Accessible Parking, Obtaining Services, and Maintenance. The standards for public spaces will only apply to new construction and planned redevelopment. Public sector organizations will have to meet the requirements by January 1, 2016.

Guide for the Planning, Design and Operation of Pedestrian Facilities, American Association of State Highway and Transportation Officials (AASHTO), 2004

This particular AASHTO guide covers characteristics of pedestrians, planning strategies, and facility design, operation, and maintenance. It is a reputable source, with a broad discussion of both planning and design issues around streets and street crossings.

Accessible Sidewalks and Street Crossings—An Informational Guide, Federal Highway Administration (FHWA), 2003

The design details for U.S. accessibility legislation are contained in the Public Rights-of-Way Accessibility Guidelines (PROWAG) and this FHWA manual acts as an abridged version. Until such time that Ontario publishes thier own standards, this guide provides a summary on making sidewalk and street crossings accessible. It covers understanding users, sidewalk corridors, sidewalk grades and cross slopes, sidewalk surfaces, protruding objects, driveway crossings, curb ramps, providing information to pedestrians, accessible pedestrian signals, and pedestrian crossings. A checklist is also provided.

3.3 Bikeways

Guide for the Development of Bicycle Facilities, 4th Edition, American Association of State Highway and Transportation Officials (AASHTO), 2012

This AASHTO guide spans planning, design, operation and maintenance of bikeways and bicycle parking facilities for the US. Sections include guidance for on-road facilities and shared-use paths. This edition updates earlier versions with details on shared roadways, rumble strips, cautionary use of wide outside lanes due to the higher speeds they induce, strategies for retrofitting bicycle facilities to streets, bicycle boulevards, traffic signal considerations, bicycle travel through interchanges and roundabouts, and addressing conflicts associated with shared-use paths along roadways.

Urban Bikeway Design Guide, National Association of City Transportation Officials (NACTO), 2013

NACTO developed this guide as part of their Cities for Cycling initiative to provide cities with state-of-the-practice solutions to create complete streets that are safe and enjoyable for cyclists. It includes descriptions, benefits, applications, design guidance, renderings, images and case studies for bike lanes, cycle tracks (segregated bike lanes), intersections, bicycle signals, and signing and markings. Most of the treatments are not directly referenced in the AASHTO guide or the U.S. Manual for Uniform Traffic Control Devices.

3.4 Traffic Control

Ontario Traffic Manual Book 15: Pedestrian Crossing Facilities, Queen's Printer for Ontario, 2010

The Ministry of Transportation of Ontario publishes a series of *Ontario Traffic Manuals* to provide information and guidance to transportation practitioners in the design, application and operation of traffic control systems in Ontario. Book 15 provides guidance on the planning, design and operation of pedestrian roadway crossings. It outlines the legal requirements, specifically the rules of the road that govern motorists' and pedestrians' movements at controlled and uncontrolled crossings, and presents the devices, physically separated facilities, and accessibility considerations. An update is expected to respond to proposed amendments to the Highway Traffic Act (Bill 31, 2014), e.g. providing a wide range of pedestrian crossover designs.

Ontario Traffic Manual Book 18: Bicycle Facilities, Ontario Traffic Council, December 2013

The Ontario Traffic Council has developed OTM Book 18 within the series of Ministry of Transportation of Ontario publications to provide information and guidance to transportation practitioners in the design, application and operation of traffic control systems in Ontario. Book 18 provides guidance on the planning, design and implementation of bikeways. It outlines the first ever bicycle facility selection process published in a North American guideline, including a "pre-selection nomograph" for the type of bikeway (shared, separated or segregated) based on the volume and speed of traffic on a two-lane roadway.

Bikeway Traffic Control Guidelines for Canada (2nd edition), Transportation Association of Canada (TAC), 2012

This guide covers regulatory, warning and information signage, and pavement markings for on-road bikeways and where trails intersect a roadway. It was recently updated to include innovative pavement markings such as shared lane markings ("sharrows"), bicycle boxes and bike lanes at roundabouts.

3.5 Bicycle Parking

Bicycle Parking Guidelines, 2nd edition, Association of Pedestrian and Bicycle Professionals (APBP), 2010

In Spring 2002, the APBP published Bicycle Parking Guidelines, a basic guide to the selection and placement of bicycle racks specifically for short-term parking. This second edition updates the original guide and adds material on long-term and sheltered parking, as well as event parking, in-street bicycle parking, and bicycle transit centres. It includes sample site plans and diagrams to help in rack and locker placement, sample quantity requirements for bicycle parking to meet need by land use, and a worksheet for programming bicycle parking for a building or cluster of buildings.

3.6 Multi-Use Trails

Trail Intersection Design Handbook, University of North Carolina's Highway Safety Research Center (HSRC) for Florida Department of Transportation (FDOT)

This handbook discusses design processes and principles of designing trail/roadway intersections. A discussion of risks at trail instersections is provided. It includes information on various crossing types, regulating traffic and site design. It also reviews some European trail crossing guidelines. Guidelines from the Netherlands and development of a bicycle crossing time equation are included in the appendices.

3.7 Halton's Regional Right-of-Way Guidelines

Halton's *Regional Right-of-Way Guidelines* (July 2011), approved as part of the *Halton Region Transportation Master Plan,* provides a set of roadway elements for each classification of Regional road. The Guidelines are to be consulted at the beginning of any planning or design process that involves Regional roads.

The guideline defines three right-of-way categories of Regional roads:

- **Rural / Natural Heritage System**: respect the rural character of the area
- **Corridors**: intensification areas along major roads or higher-order transit, mixed-use development and employment. They will vary in use along their length and design needs to reflect the change in surroundings.
- **Node**: compact, transit-oriented, pedestrian-friendly, mixed-use / residential centres. They are generally located at intersections of major transit corridors within identified intensification areas, and extend approximately 200 to 400 m from the intersection.

Each of the above categories of Regional rights-of-way are further subdivided according to the right-of-way width, number of travel lanes, and absence or presence of priority travel lanes for High Occupancy vehicles (HOV) or transit, as shown in Exhibit 3-1. The design elements identified for each classification code are summarized in The *Regional Right-of-Way Guidelines* should be referred to for explanatory notes and details.

Exhibit 3-1: Regional Right-of-way Categories and Design Elements

	Code	ROW Width (m)	Travel Lanes	Priority Lanes (HOV / Transit)	Trees in Blvd.	Pedestrian Scale Lighting	Building setback	Pedestrian Facility	Bikeway
Rural	R(1)	35	2	-	-	-	-	Paved shoulder	Paved shoulder
	R(2)	42	4						
Corridor	C(1)	42	4	-	Yes	Key areas	Variable	Sidewalk / Multi-use path	Variable
	C(2)	35							
	C(3)	42							
	C(4)	47		2					
	C(5)	50							
Node	N(1)	50	4	2	Yes	Yes	Minimized	Sidewalk	Variable
	N(2)	50							

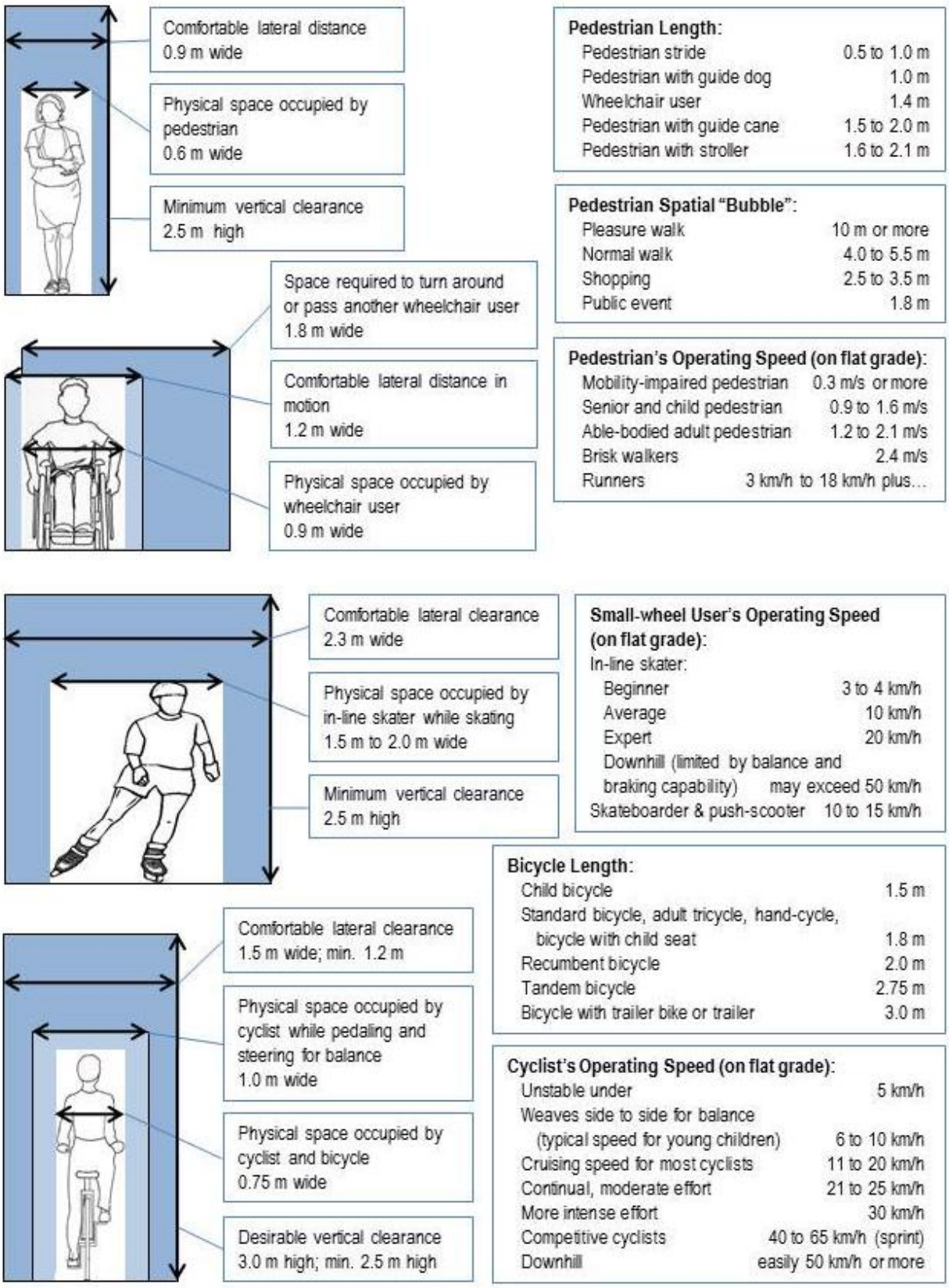
4 Active Transportation Users

The design of transportation facilities regardless of the mode of travel requires an understanding of the characteristics of the users. For pedestrians, accessibility is important and Ontario has accessibility standards for the built environment. For cyclists, their preferences for different types of bikeways and the robustness of the bikeway network will affect when and where they ride.

4.1 Design Characteristics of Active Transportation Users

Similar to the design of roadways for motorists, the design of active transportation facilities requires an understanding of the space occupied by the users when in motion and the buffer space required to ensure comfort and allow reaction time in response to other users. The operating space, buffer space, length and operating speed for various users are illustrated in Exhibit 4-1.

Exhibit 4-1: Design Characteristics of Active Transportation Users



Pedestrian Length:

Pedestrian stride	0.5 to 1.0 m
Pedestrian with guide dog	1.0 m
Wheelchair user	1.4 m
Pedestrian with guide cane	1.5 to 2.0 m
Pedestrian with stroller	1.6 to 2.1 m

Pedestrian Spatial "Bubble":

Pleasure walk	10 m or more
Normal walk	4.0 to 5.5 m
Shopping	2.5 to 3.5 m
Public event	1.8 m

Pedestrian's Operating Speed (on flat grade):

Mobility-impaired pedestrian	0.3 m/s or more
Senior and child pedestrian	0.9 to 1.6 m/s
Able-bodied adult pedestrian	1.2 to 2.1 m/s
Brisk walkers	2.4 m/s
Runners	3 km/h to 18 km/h plus…

Small-wheel User's Operating Speed (on flat grade):

In-line skater:	
Beginner	3 to 4 km/h
Average	10 km/h
Expert	20 km/h
Downhill (limited by balance and braking capability)	may exceed 50 km/h
Skateboarder & push-scooter	10 to 15 km/h

Bicycle Length:

Child bicycle	1.5 m
Standard bicycle, adult tricycle, hand-cycle, bicycle with child seat	1.8 m
Recumbent bicycle	2.0 m
Tandem bicycle	2.75 m
Bicycle with trailer bike or trailer	3.0 m

Cyclist's Operating Speed (on flat grade):

Unstable under	5 km/h
Weaves side to side for balance (typical speed for young children)	6 to 10 km/h
Cruising speed for most cyclists	11 to 20 km/h
Continual, moderate effort	21 to 25 km/h
More intense effort	30 km/h
Competitive cyclists	40 to 65 km/h (sprint)
Downhill	easily 50 km/h or more

4.2 Characteristics of Pedestrian Travel

Pedestrians differ from other modes of travel. These differences present both opportunities and challenges:

- **Walking is very efficient for short distances**—there is no lag time to get to a vehicle (personal or public), and no parking time. For dense employment and service areas, it is the primary mode of transportation throughout the daytime.

- **Pedestrian travel is very "portable"**—they can transition to other modes of travel with relative ease. They don't need, for example, storage facilities such as parking areas before they are able to change modes.

- **Walking trips are short**—The majority of walking trips are less than 2.5 km in length; at an average walking speed of 4.3 km/h (1.2 m/s), a 20 minute walk covers 1.4 km.

- **Pedestrians generally seek the most direct route to destinations—**Since walking trips are short and travel speeds much slower than other modes of transportation, barriers and indirect routes can be significant and may discourage walking. A motorist or cyclist (to a lesser degree), can often tolerate a less direct route than a pedestrian. Even out-of-the-way travel to use a crosswalk in order to get to a destination on the other side of a street can tempt crossing where crosswalks (and thus the right-of-way) are not provided.

- **Pedestrians can travel many places that do not require formalized routes**—Compared to automobiles, transit and bicycles that require roads, or pathways for the latter, pedestrians can and often do use short cuts or informal routes, alleyways, public plazas, routes through buildings or across private yards to get to their destination.

- **Pedestrian travel tends to be more geographically contained in some areas compared to others**—In Waterloo Region, for example, large numbers of pedestrian trips are more likely to occur in business districts than along a suburban multi-use trail. The density, mix and proximity of land-uses within a walkable distance greatly influence the potential for walking trips.

- **Pedestrian travel is "organic"**—The many unique origins and destinations of pedestrian trips with different formal and informal routes available between them result in a more organic, less organized, form of travel.

- **Pedestrians are sensitive to the environment in which they walk**—They will, to a greater degree than other modes of transportation, enjoy the aesthetics, experience the weather, be distressed by noise levels or concerned over lighting, fear for their personal safety, communicate with greater ease with others, socialize as they walk, etc. A journey by walking heightens ones awareness of the micro-environment around them.

- **Pedestrians have a wider range of abilities**—This includes their physical abilities to balance and coordinate their movements with or without mobility aids; their cognitive abilities to interact with others, their environment and to way find; and their abilities to see, hear and thus interpret or react to what is going on around them.

These unique aspects of pedestrian travel influence network planning and design. Short trip lengths and the organic form of travel imply that the location, frequency and convenience of crossings of corridors are as important as the corridors themselves. The wide range of abilities requires understanding of the elements that create an accessible corridor and easy to understand

crossings. Their sensitivity to their surroundings requires providing more than just infrastructure that allows for travel, but an environment that is appealing.

This Design Guide outlines some of the practices used to meet basic pedestrian needs, such as sidewalk width, accessibility requirements and convenient crossings. Land use types, densities and building form, landscaping and other elements will influence the pedestrian trip. Halton Region is encouraged to consider these broader elements that influence the walking trip as the Active Transportation Network is implemented.

4.3 Accessible Sidewalks and Street Crossings

> One in seven people in Ontario have a disability. Over the next 20 years, that number will rise as the population ages.
>
> Creating a province where every person who lives or visits can participate fully makes good sense — for our people, our businesses and our communities.
>
> Ministry of Community and Social Services
> www.mcss.gov.on.ca (2013)

Accessibility for Ontarians with Disabilities Act (AODA, 2005) is intended to create a province where every person who lives or visits can participate fully and includes creating accessible public right-of-ways. Standards have been approved under the AODA through Regulation 413/12 (December 2012) that apply to **public spaces that are new or redeveloped by municipalities on and after January 1, 2016.** Exceptions are permitted when not practicable because of existing constraints that prohibit modification or addition of elements; or would erode the heritage attributes of a property defined under the Ontario Heritage Act. These standards apply to:

- Recreational trails, but…
    - Not cross-country skiing, mountain biking, snowmobiling and ATV trails
    - Not wilderness, backcountry or portage trails not regularly maintained
- Beach access routes
- Outdoor public use eating areas and play spaces
- Exterior paths of travel, that is outdoor sidewalks or walkways that have a functional (not recreational) purpose

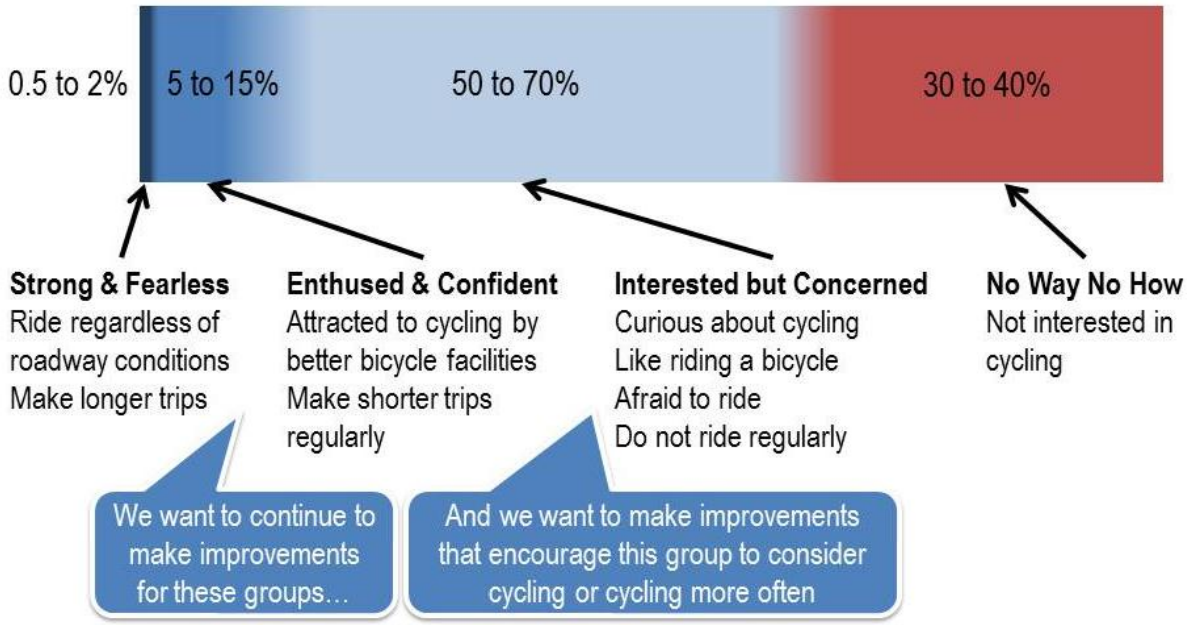
This design guide presents criteria based on the AODA standards; however, the original Regulation as approved and amended should be referenced. U.S. best practices in accessibility are also presented when additional guidance or clarification is warranted.

4.4 Types of Cyclists

Numerous surveys have found that the number one reason people do not cycle as a mode of transportation is because of their fear of sharing the roadway with automobiles. This has been documented and reported in transportation literature across the United States, Canada and Europe. Addressing concerns about personal safety, interaction with motorized vehicular traffic and comfort is the key to creating a region where cycling is recognized as both a mode of transportation and a recreational activity.

Generally, cyclists can be divided into four categories based on their comfort level while riding on a roadway with traffic as outlined below and illustrated in Exhibit 4-2.

Exhibit 4-2: Types of Transportation Cyclists by Proportion of Population[1]



Some communities are using these cyclist types to describe the potential for people to choose cycling as a mode of transportation or recreational activity. It is important to note that the lines between these categories are blurry. People across this spectrum may use a bicycle for recreation; but the goal here is to describe groups of people as they relate to transportation trips.

- **The Strong and the Fearless—**0.5 to 2% of the population will ride regardless of the roadway conditions.

- **The Enthused and Confident—**About 5 to 15% of the population is comprised of people attracted to cycling by the significant advances a city has made developing its bikeway network and supporting infrastructure. They may be comfortable sharing the roadway with motorists, but they prefer to do so operating in their own facilities. They are attracted to riding because of streets that have been redesigned to make them work for bicycling. They appreciate bicycle lanes and bicycle boulevards (local traffic-calmed streets). The primary reason why bicycle commuting doubled in the U.S. between 1990 and 2000 (U.S. Census) and increased by more than 300% in Portland OR from early 1990s to 2006 (Willamette River bridge counts) is credited to an increase in enthused and confident cyclists. Their numbers will continue to increase as bikeway networks expand.

- **The Interested but Concerned—**Approximately 50 to 70% of the population is curious about cycling. They are hearing messages from a wide variety of sources about how easy it is to ride a bicycle, and about the need for people to lead more active lives. They like riding a bicycle, remembering back to their youths, or to the ride they took last summer on a local trail, and they would like to ride more. But, they are afraid to ride. They don't like cars speeding down their streets. They get nervous thinking about what would happen to them on a bicycle when a driver runs a red light, or passes too closely, or too fast. Very few of these regularly ride—perhaps less than 0.5 percent will ride

[1] Roger Geller, "Four Types of Cyclists", Portland Office of Transportation http://www.portlandoregon.gov/transportation/44597?a=237507 (January 2013)

through their neighbourhoods to the local park or coffee shop, but who will not venture out onto arterials to the major commercial and employment destinations they frequent. They would ride if they felt safer on the roadways—if cars were slower and less frequent, and if there were more quiet streets with few cars and paths without cars at all.

- **No Way No How—**Perhaps 30 to 40% of the population is not interested in cycling at all, for reasons of topography, inability, or simply a lack of interest.

The separation between these four broad groups is not generally as clear-cut as described above. There is likely quite a bit of blurring between the "enthused," the "interested," and those not at all interested. However, it is a reasonable way to understand a city's existing and potential cyclists. In general, we want to continue to make improvements for the "strong" and "enthused". This will support modest growth in cycling as a mode of transportation. And we need to make improvements that attract the "interested but concerned" to see a more substantial shift to cycling as a mode of transportation.

4.5 Bikeways and Cycling Networks

4.5.1 The Role of Infrastructure in Encouraging Cycling

Numerous research efforts have been undertaken to understand the role of cycling infrastructure in creating a positive cycling culture, where using a bicycle for daily trips is considered normal, and cycling trips make up a significant portion of all trips. One such study[2] of Portland, Oregon, a city with a network of bike lanes, paths and bicycle boulevards (local traffic-calmed streets), concluded:

> A network of different types of infrastructure appears necessary to attract new people to bicycling. For people concerned with safety and avoiding traffic, a well-connected network of bicycle boulevards, that is local traffic-calmed streets, may be more effective than adding bike lanes on major streets with high volumes of motor vehicle traffic.
>
> The role of bike lanes should not be dismissed in planning for a bicycle-friendly community. A disproportionate share of the bicycling occurs on streets with bike lanes, indicating their value to bicyclists. These facilities may provide important links in the network, connecting neighborhoods when low-volume streets cannot.

Buehler and Pucher[3] analyzed the variation in bike commuting in 90 large American cities, with a focus on assessing the influence of bike paths and lanes on levels of cycling. The study confirmed that cities with a greater supply of bike paths (typically multi-use, not just for cyclists, in most of the cities studied) and lanes have significantly higher bike commute rates—even when controlling for land use, climate, socioeconomic factors, gasoline prices, public transit supply, and cycling safety. Both off-street paths and on-street lanes have a similar positive association with bike commute rates in U.S. cities.

4.5.2 Bikeway Preferences Versus Risk

Recent research through the Cities for Cycling Research Team (UBC, Simon Fraser University and other partners, http://cyclingincities.spph.ubc.ca/) has been evaluating bicycle facilities based on two studies. One considered motivators, deterrents, and perceptions of risk about 16 different route types from a survey of adult cyclists and potential cyclists in Metro Vancouver. The other quantified

[2] Jennifer Dill, *Bicycling for Transportation and Health: The Role of Infrastructure*, Journal of Public Health Policy 2009, 30, S95–S110 r 2009 Palgrave Macmillan 0197-5897/09 http://www.palgrave-journals.com/jphp/journal/v30/nS1/full/jphp200856a.html (accessed July 2012)
[3] Ralph Buehler and John Pucher, Cycling to work in 90 large American cities: new evidence on the role of bike paths and lanes, 6 July 2011 Springer Science+Business Media, LLC, July 2011 http://policy.rutgers.edu/faculty/pucher/ (accessed July 2012)

the injury risk associated with 14 types of routes[4], the Bicyclists' Injuries and the Cycling Environment (BICE) study, in Vancouver and Toronto.

It should be noted that in the studies multi-use paths were defined as either alongside city streets or away from streets (e.g., in parks); bike paths were for cyclist use away from streets, (e.g., in parks); shared lane had pavement markings indicating shared bike-HOV lane, shared bike-bus lane, or sharrows indicating bikes and motor vehicles share space; and cycle tracks were meant for cyclist use alongside major streets, separated by a physical barrier (e.g., a curb or bollards).

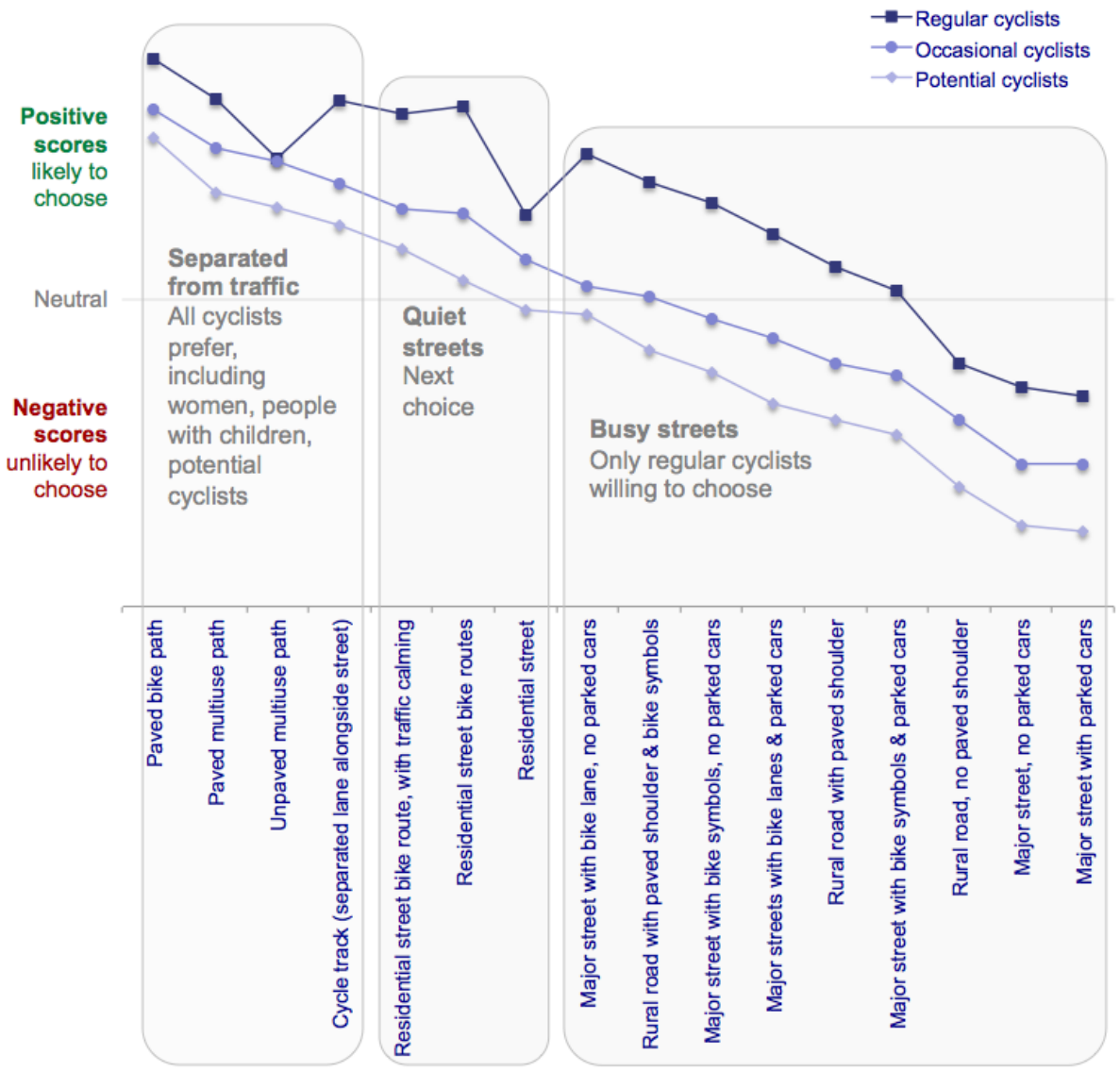
A few interesting results are as follows:

- Of the 16 different types of routes, off-street paths, cycle paths (segregated bike lanes) adjacent major streets and bicycle routes on traffic-calmed residential streets were the top route preferences ("likely to choose"), as shown in Exhibit 4-3. Women and people with children scored routes similarly to occasional and potential cyclists, that is, only routes separated from traffic or on quiet streets received positive average scores. This evidence suggests that to motivate people who cycle least often, the most desirable routes – those separated from traffic – should be the focus of development.

- Route infrastructure affects risk of cycling injuries. Major streets with parked cars and no bike infrastructure had the highest risk. Multi-use paths, sidewalks and other major street configurations (with shared lanes or with no bike infrastructure) all had high relative risk. Route types that had significantly lower risks included major streets without parked cars and with no bike infrastructure, major streets without parked cars and with bike lanes, local streets with no bike infrastructure, local streets designated as bike routes, and cycle tracks. Combining route preferences with risk of injury by route infrastructure results in a relationship between perceived risk and observed risk, as shown in Exhibit 4-4. Preferences and safety largely agree. Major streets are less safe and not preferred. Bike-specific routes are safer and preferred. The main disagreement was that multi-use paths are preferred, but were not particularly safe. Sidewalks are less safe than multi-use paths but were not included in the preference survey. Cyclists may also be less familiar with cycle tracks so may have trouble gauging its risk.

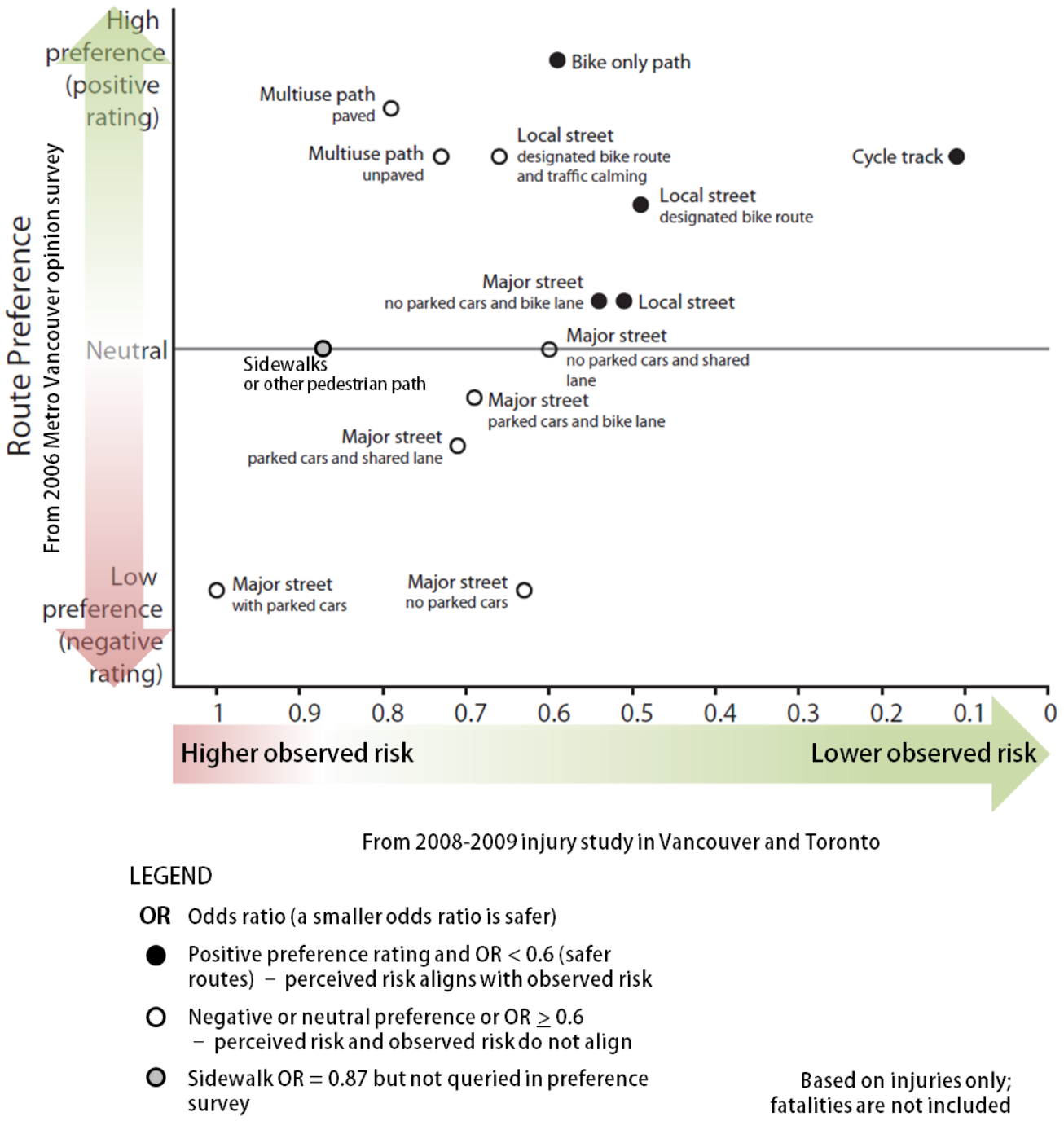
[4] Meghan Winters, PhD, Shelina Babul, PhD, H.J.E.H. (Jack) Becker, MBA, Jeffrey R. Brubacher, MD, MSc, Mary Chipman, PhD, Peter Cripton, PhD, Michael D. Cusimano, MD, PhD, Steven M. Friedman, MD, M. Anne Harris, PhD, Garth Hunte, MD, Melody Monro, MPA, Conor C.O. Reynolds, PhD, Hui Shen, MSc, Kay Teschke, PhD, "Safe Cycling: How do Risk Perceptions Compare with Observed Risk?", Canadian Public Health Association, Volume 103, Supplement 3, pp. S42-S47, November / December 2012.

Exhibit 4-3: Bicycle Route Types, Average Likelihood of Choosing by Cyclist Type[5]



[5] Cycling in Cities Research Program, Motivators & Deterrents, http://cyclingincities.spph.ubc.ca/opinion-survey/ (accessed January 2013), April 2012.

Exhibit 4-4: Route Preference Versus Route Safety[6]



[6] Meghan Winters, PhD, Shelina Babul, PhD, H.J.E.H. (Jack) Becker, MBA, Jeffrey R. Brubacher, MD, MSc, Mary Chipman, PhD, Peter Cripton, PhD, Michael D. Cusimano, MD, PhD, Steven M. Friedman, MD, M. Anne Harris, PhD, Garth Hunte, MD, Melody Monro, MPA, Conor C.O. Reynolds, PhD, Hui Shen, MSc, Kay Teschke, PhD, "Safe Cycling: How do Risk Perceptions Compare with Observed Risk?", Canadian Public Health Association, Volume 103, Supplement 3, pp. S42-S47, November / December 2012.

5 Pedestrian Facilities

The design tool box for pedestrians contains best practices in addressing accessibility, the urban braille system, types of pedestrian facilities for Regional roads, and the design of sidewalks, accessible and convenient pedestrian street crossings. These will contribute to improved safety, convenience and comfort of walking in Halton Region.

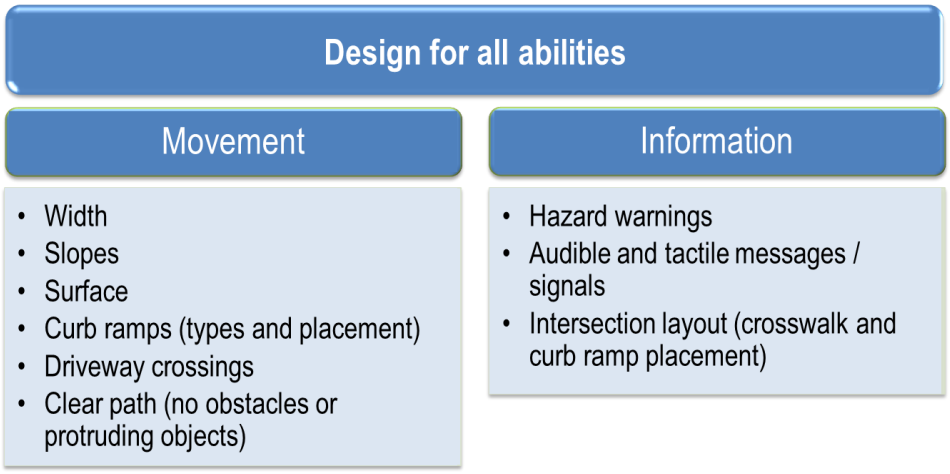
5.1 Accessibility

Pedestrians need access to the sidewalk system. They have various abilities in agility, balance, cognition, coordination, endurance, flexibility, hearing, strength, vision and walking speed. Individual's access to the sidewalk system depends on overcoming movement and information barriers, as summarized in Exhibit 5-1 and described below.

- **Movement barriers** restrict a person's ability to physically move along or within the environment, and for pedestrians this means along and across streets. Movement barriers include curbs, steep slopes, obstacles within the path such as utility poles or street furniture, widths not wide enough to allow passage, rough surfaces, and the placement of pedestrian aids such as push-buttons for signals in locations that one cannot reach.

- **Information barriers** restrict a person's use of information, that is, to recognize, receive or understand the information within the pedestrian environment that is required to make a decision, take action. Information barriers include complex intersections, diverted paths such as at work zones, and lack of information to cross a street.

Exhibit 5-1: Barriers to Pedestrians with Differing Abilities



5.2 Urban Braille

Urban braille is a system of tactile information serving the needs of the visually impaired. It uses both tonal and textural contrast to provide information to assist them in navigating through the urban environment. The urban braille system consists of a variety of elements:

- A pedestrian “clear way” free of all obstructions, with a hard surface of consistent colour and texture such as broom-finished concrete.
- “Shore lines” about 0.25 m wide with tonal and textural contrast on both sides of the adjacent pedestrian clear way. For example, a dark grey concrete stamped with a brick pattern provides contrast to a broom-finished concrete sidewalk. Where sidewalks are located in grass boulevards, shore lines are not required; the grass provides tonal and textural contrast to the sidewalk.
- Textured bands crossing through the sidewalk perpendicular to and between the shore lines indicate intersections with the clear way. They are placed before and after driveways, at corners of intersections, and at other decision points.
- Bus stop detectable strip with tonal and textural contrast extending from the outer shore line, through the sidewalk to the curb at the bus stop.
- Street name plates in the sidewalk located at all corners of an intersection indicating the name of the street perpendicular to the direction of travel.
- Textured symbols, such as a diamond, stamped in the sidewalk where there is more than one possible route to travel or entrances to adjacent buildings.

All elements must meet the Ontario Regulation 413/12: Integrated Accessibility Standards.

City of Hamilton has standardized a system of urban braille elements for use in the designated downtown area, consistent with their *Urban Braille System* guidelines. Examples of the various elements used in Hamilton are shown in Exhibit 5-2.

Exhibit 5-2: Examples of Urban Braille in Downtown Hamilton

The pedestrian “clear way” is free of obstacles. It is bordered by “shore lines” of darker concrete stamped with a brick pattern providing tonal and textural contrast to the broom-finished concrete sidewalk. All signs, amenities, landscape, etc. are kept outside the clear way.

Textured bands crossing through the sidewalk between the shore lines indicate intersections such as driveways.

A bus stop detectable strip extends through the sidewalk from shore line to the curb at the bus stop.

Street name plates are placed in the sidewalk at all corners of an intersection indicating the name of the street perpendicular to the direction of travel.

The textured diamond stamped in the sidewalk indicates an alternate pedestrian route (left photo) or entrances to buildings (right photo)

5.3 Types of Pedestrian Facilities

Pedestrians can be accommodated in Regional rights-of-way using the facilities described below and summarized in Exhibit 5-3.

- Along **Rural** Regional roads where **pedestrian activity is expected to be lower**, paved shoulders can accommodate occasional pedestrian use. Granular shoulders can facilitate pedestrians in spring through fall but are difficult to keep clear of snow and ice in the winter months. Sidewalks or walkways on one or both sides of the roadway may

be desirable in rural settlement areas to serve schools, shops, transit stops or other services.

- Along **Corridor** Regional roads where **pedestrian activity is expected to be moderate**, sidewalks for the exclusive use of pedestrians or boulevard multi-use trails shared with cyclists, in-line skaters, skateboarders and other active transportation are suitable. In those areas where residents and destinations are located on both sides of the road, a pedestrian facility is needed on both sides of the road. Providing a multi-use trail on one side and a sidewalk on the other side encourages cyclists to ride on the sidewalk to access destinations on that side in the absence of other bikeways such as bike lanes. Thus when a multi-use trail functions as the pedestrian and cycling link within a corridor, it is needed on both sides of the road.

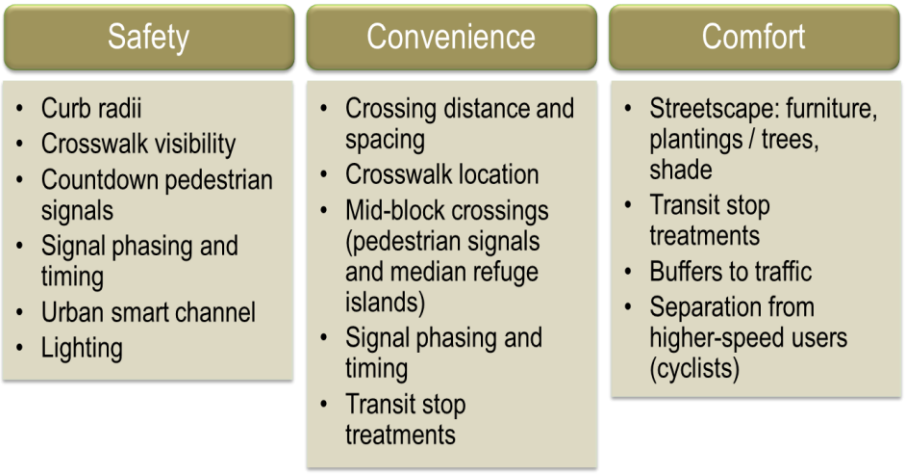
- Along **Node** Regional roads where **pedestrian activity is expected to be high**, sidewalks for pedestrian use only, not shared with cyclists, are needed. Typically residences and destinations are located on both sides of the road so a sidewalk is provided on both sides for pedestrian access.

Any particular category of Regional road may have characteristics of other categories for short or intermittent sections. Transitions between facilities must be considered. For example, multi-use trails in the boulevard along a Corridor Regional road can transition to sidewalks and segregated bike lanes along a Node Regional road where higher pedestrian activity is anticipated. However, if these sections are short, the design and operation of the transitions may be inconvenient or unsafe for the users; consistent facilities to avoid the transitions would be desirable in this case.

Exhibit 5-3: Types of Pedestrian Facilities by Regional Road Category and Activity Levels

A pedestrian network consists not only of the above facilities but also various “enhancements” that address the safety, convenience and comfort of pedestrians and other road users of the network. Some of the more common enhancements in use in North America are listed in Exhibit 5-4.

Exhibit 5-4: Pedestrian Enhancements in use in North America



5.4 Pedestrian Facility Selection Guide

The types of accessible pedestrian facilities and enhancements suitable for different routes or corridors are influenced by their activity levels and the speed and volume of other users of the corridor. Expected activity levels will be foremost influenced by the type and form of land use that the corridor serves. Higher density development and a mix of land uses will result in shorter distances between destinations that can be accessed by walking. However, the decision to walk, or not, will also be influenced by the perceptions of safety, convenience and comfort. In rural areas, a focus on pedestrian safety is recommended; in suburban and urban areas, where walking trips are more viable, a greater effort to increase convenience and improve comfort is recommended.

For pedestrian facilities, the *Regional Right-of-way Guidelines* considers the provision of sidewalks or multi-use paths for the Corridor category and sidewalks in the Node category. In addition, the guidelines recommend considering the following to encourage the presence of pedestrians on the street by addressing perceived and actual safety and comfort:

- Integration of pedestrian crossings at all street intersections, where possible
- Provide pedestrian-scale lighting
- Avoid right-turn channelized islands at intersections, where possible
- Design facilities according to regulations of the *Accessibility for Ontarians with Disabilities Act* (AODA)

In order for Halton Region to reach its vision and targets for active transportation, pedestrians must be accommodated by accessible facilities to move along and across Regional roads, along with features that enhance their safety, convenience and comfort reflecting the local context.

Expanding on the *Regional Right-of-way Guidelines*, the types of pedestrian facilities and enhancements recommended for the various right-of-way classifications are illustrated in Exhibit 5-5.

Exhibit 5-5: Pedestrian Accommodation Selection Guide for Regional Rights-of-way

Accessibility	Where Sidewalks and Multi-use Trails are provided	Accessible Pedestrian Facility and Street Crossings		
Regional ROW Categories	Rural (R1 and R2)	Corridor (C1, C2 and C3)	Corridor (C4 and C5)	Node (N1 and N2)
Activity Level	Low	Moderate to High		High
Facility Type	Paved Shoulders both sides Sidewalk or Boulevard Multi-use Trail one side	Sidewalk or Boulevard Multi-use Trail both sides		Sidewalk both sides
Minimum Enhancements	Safety	Safety & Convenience	Safety, Convenience & Comfort	Safety, Convenience & Comfort

This selection guide should be read in conjunction with the Bikeway Selection Guide for Regional Road Rights-of-way, Exhibit 6-3, page 57.

5.5 Sidewalks

The *Regional Right-of-way Guidelines* identified an area in the boulevard 3.0 m wide to accommodate a sidewalk or multi-use path. Specific criteria for accessible sidewalks are provided below. A description of the various elements that are part of the pedestrian realm, such as landscape areas, trees and pedestrian lighting are provided in the *Regional Right-of-way Guidelines*.

5.5.1 Basic Design Criteria for Sidewalks

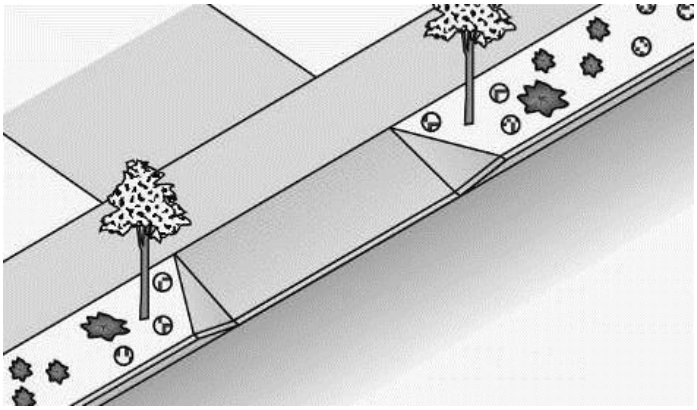
- Clear width:
  - Minimum 1.5 m (AODA)
  - Preferred 1.8 m to allow two wheelchairs to pass
  - Provide wider sidewalks adjacent to shops, institutions and public areas with moderate to high existing or anticipated pedestrian volumes
  - May reduce sidewalk width to 1.2 m where it connects to curb ramps (AODA)
- Provide on both sides of Regional Corridor or Node roads unless an alternate pedestrian route such as a multi-use path is provided
- Surface must be slip resistant, firm and stable (AODA)
  - Preferred material poured in-place, broom-finished concrete
  - Reduce joints in surface by saw-cutting contraction joints 5 mm wide to a depth of D/4 every 2.5 m (instead of tooled joints) and providing expansion joints every 30 m (City of Burlington) or as recommended by design engineer

- Continuous through driveways
- Landscaping, sign boards, and street furnishings to remain outside minimum pedestrian sidewalk at all times, i.e., locate in the buffer or furniture zones
- Preferred max. running slope 5%; can be greater than 5% but not steeper than slope of the adjacent roadway (AODA)
- Cross slope:
  - Maximum 5% (AODA)
  - 2% preferred up to 4% (OPSD)
- At changes in level (AODA):
  - Between 6 and 13 mm—bevel at 50% slope
  - Between 14 and 74 mm—include 10% to 12.5% slope
  - Between 75 mm and 200 mm—include 81/3% to 10% slope
  - Greater than 200mm—include ramp (see curb ramp)
- Openings in the surface must not allow passage of an object that has a diameter of more than 20 mm, and elongated openings such as grating must be oriented approximately perpendicular to the direction of travel (AODA)
- When the head room clearance is less than 2.1 m, a rail or barrier edge that is cane detectable must be provided around the object that is obstructing the head room clearance (AODA)
- Colour and tonal contrast (difference 70%: light on dark, or dark on light) may be used to distinguish edges and from vehicular routes (U.S. guidance)

5.5.2 Sidewalks through Driveways

Accessible sidewalks through driveways require a level pedestrian access route a minimum of 1.2 m wide and with maximum cross slope of 5% with 2% preferred. There are various options for providing continuous, accessible sidewalks through driveways that take into consideration sidewalk width, boulevard width, curb height and available right-of-way, as illustrated in Exhibit 5-6. The Ontario Provincial Standard Drawing for Concrete Sidewalk Entrance Details (OPDS-310-050) illustrates partially depressing the sidewalk across the driveway changing the cross slope from 2 to 4%. It is preferable to keep the sidewalk cross-slope constant, as illustrated in the options provided in Exhibit 5-6.

Exhibit 5-6: Accessible Sidewalk Driveway Options

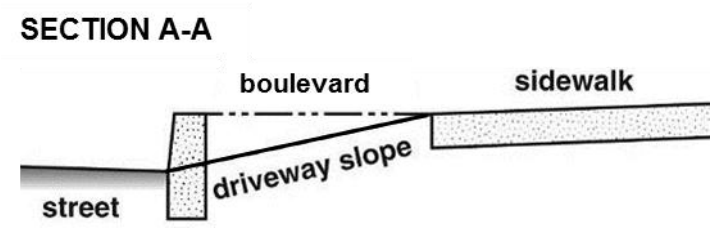


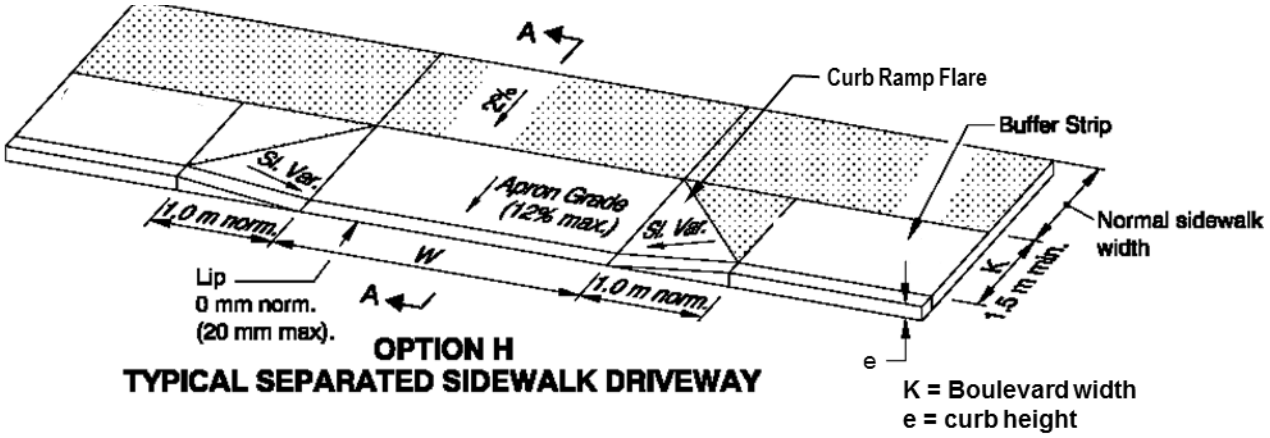
Best Solution:

Boulevard between sidewalk and roadway allows for a level (2% to 5% cross slope), uninterrupted sidewalk

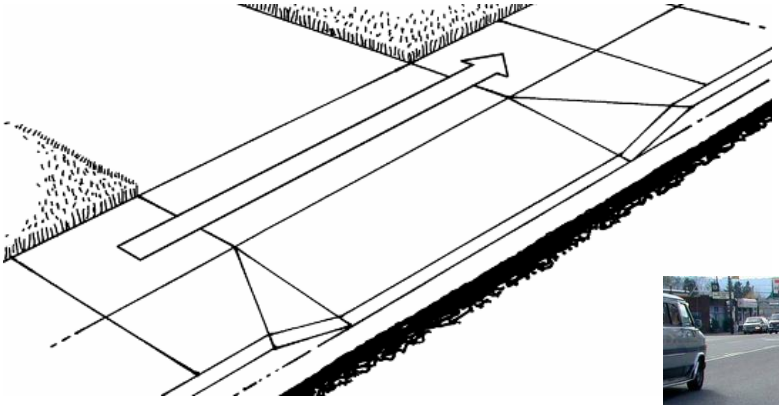
Elevation change for driveway occurs in the boulevard

Use concrete flares adjacent driveway ramp if the boulevard is hard surfaced (see Option H below) or barrier curb and curb return radius adjacent planting strip (see photo below)





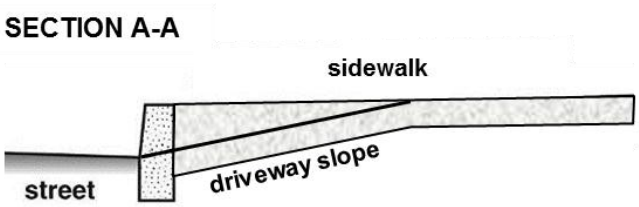
From Oregon Department of Transportation Standard Drawings

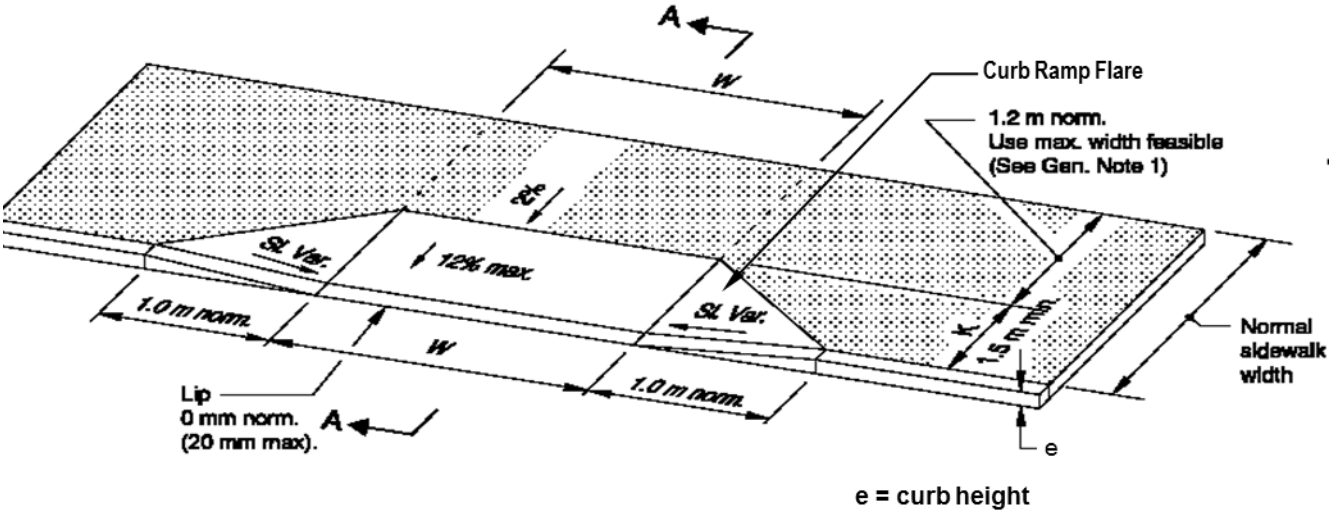


Good Solution:

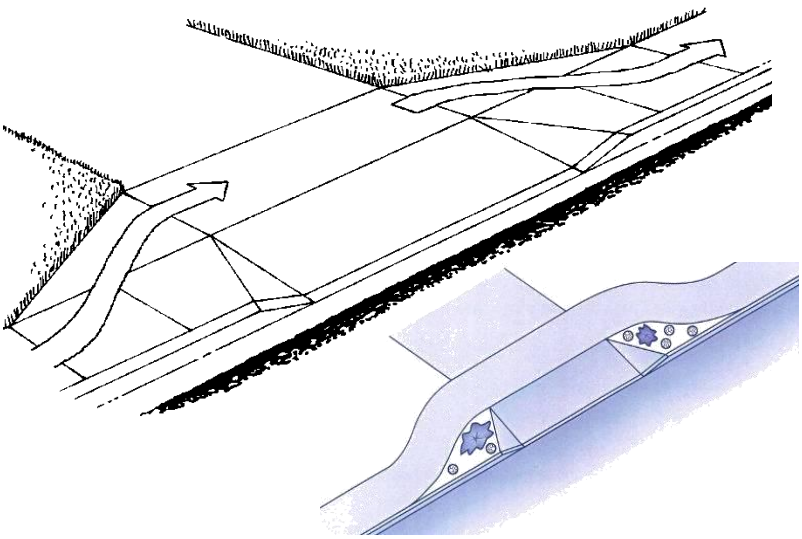
Wide curb-faced sidewalk with level (2% to 5% cross slope) pedestrian access route at the back of the sidewalk

Elevation change for driveway occurs in the boulevard





From Oregon Department of Transportation Standard Drawings

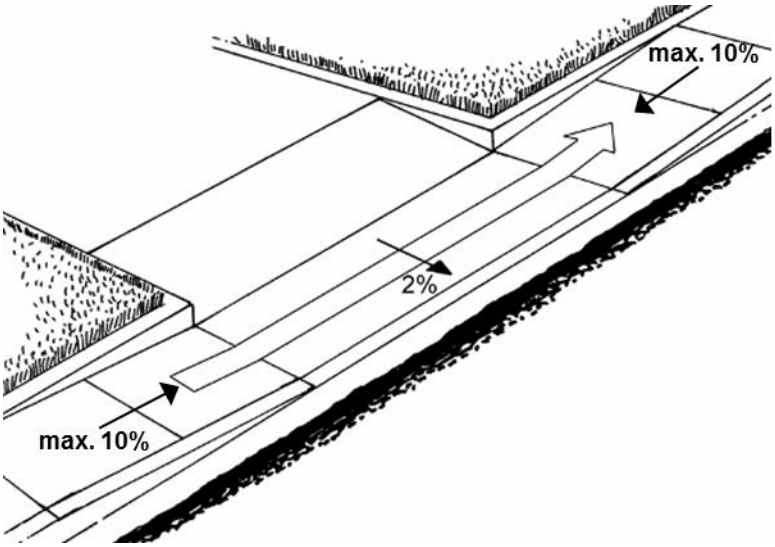


Good Solution:

Narrow curb-faced sidewalk with level (2% to 5% cross slope) pedestrian access route diverted behind driveway apron

Longer tapers preferred

Can add landscaping by increasing the setback area or sidewalk taper



Acceptable Solution:

Narrow curb-faced sidewalk lowered to fit driveway apron level

Users must negotiate two ramps

Allows motorists to turn at higher speeds

A short lip will improve drainage and provide cue for visual impaired pedestrians; however may de-stabilize cyclists using driveway. Tactile walking surface indicators required where sidewalk is flush with roadway.

5.6 Accessible Street Crossings

Accessible street crossings are required where sidewalks or trails intersect with roadways at pedestrian crossings and crosswalks. Elements of an accessible street crossing include crosswalk placement (when crosswalks are permitted under the regulations of the Highway Traffic Act), ramps to bring the sidewalk to street level, and hazard indicators built into the walking surface to warn the visual impaired of hazards such as entering a roadway.

5.6.1 Curb Ramps

Curb ramps allow access between the sidewalk or a multi-use trail and the street. There are many users: people with mobility devices such as walkers and wheelchairs, with strollers, delivery carts, or rolling luggage, children cycling, etc. It is important to realize that the curb ramp not only provides access to the street, but also provides access from the street to the trail or sidewalk. Not providing a curb ramp and associated curb cut may slow users from entering the street but will also trap users in the street unable to access the sidewalk or trail.

There are five basic types of curb ramps:

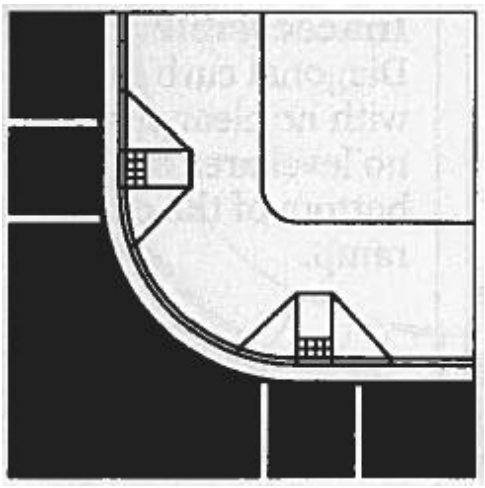
- Perpendicular—two per corner with flares or returned curbs
- Diagonal—one located at the corner of an intersection: NOT RECOMMENDED
- Parallel—two per corner; require less right-of-way than perpendicular ramps
- Combined parallel and perpendicular
- Depressed corners

Optimal and good design for the different types of recommended curb ramps and their placement are illustrated in Exhibit 5-7.

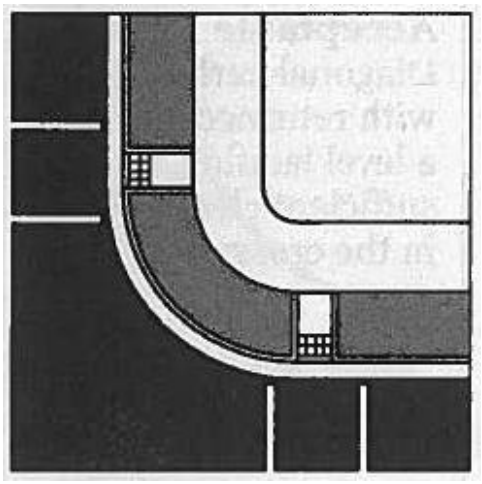
Exhibit 5-7: General Recommended Curb Ramp Design and Placement

Optimal design: two perpendicular ramps placed at 90 degrees to one another with flares (curb faced sidewalks) or returned curbs (grass boulevard)—require wide sidewalks to permit a level landing

Perpendicular with flares

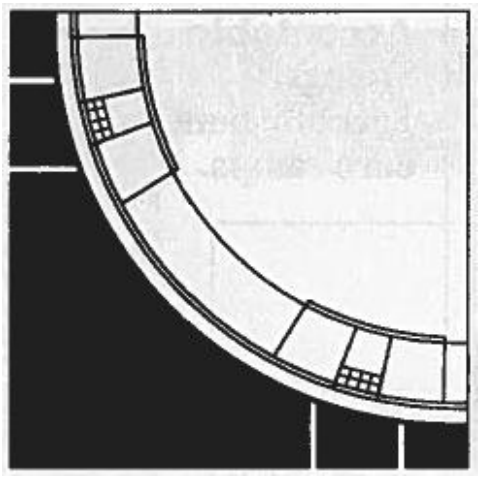


Perpendicular with returned curbs



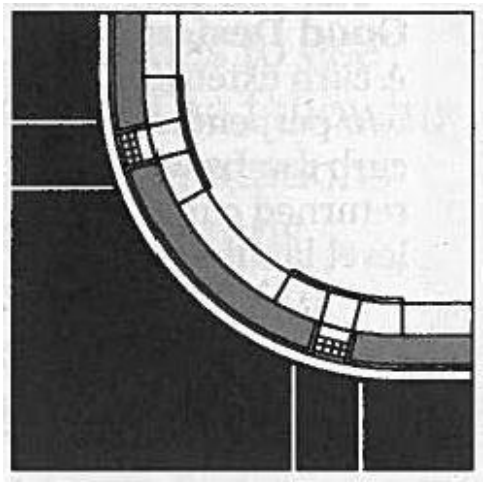
Acceptable design: two parallel curb ramps on a wide turning radius—fit narrow sidewalks

Parallel



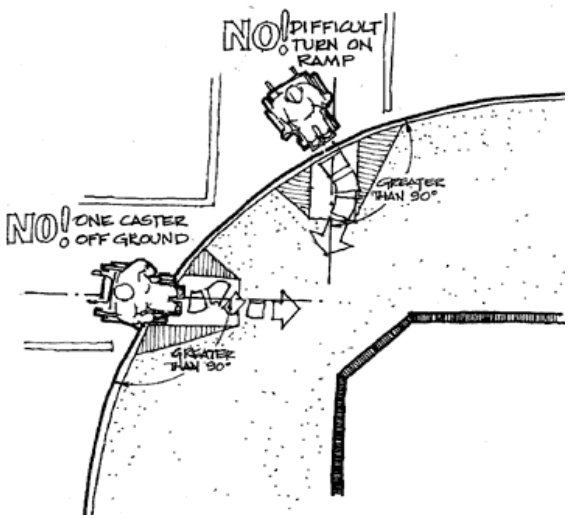
Acceptable design: two combination curb ramps on a corner with a wide turning radius—fit narrow sidewalks; parallel ramp lowers the elevation of the landing and the perpendicular ramp bridges the remaining elevation to the roadway

Combination



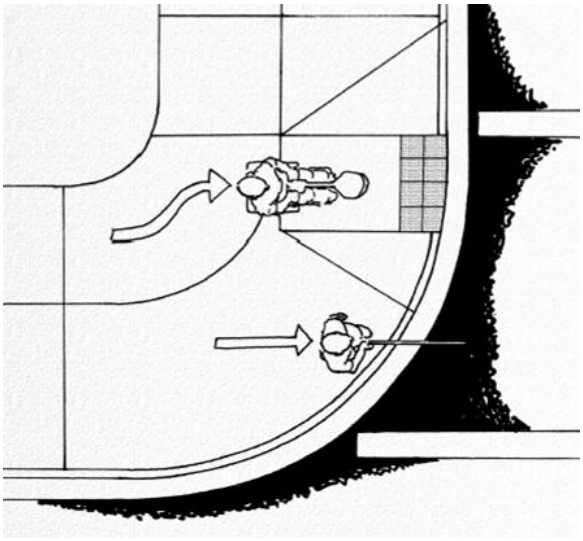
In practice, the design and construction of curb ramps can be complicated based on the layout of the sidewalk or trail leading to the crossing, the roadway or intersection configuration, the presence of other elements in the boulevard such as poles, street furniture, signs, etc. and the terrain. Some of the issues that are commonly encountered are described in Exhibit 5-8.

Exhibit 5-8: Common Issues Associated with Curb Ramp Design and Placement

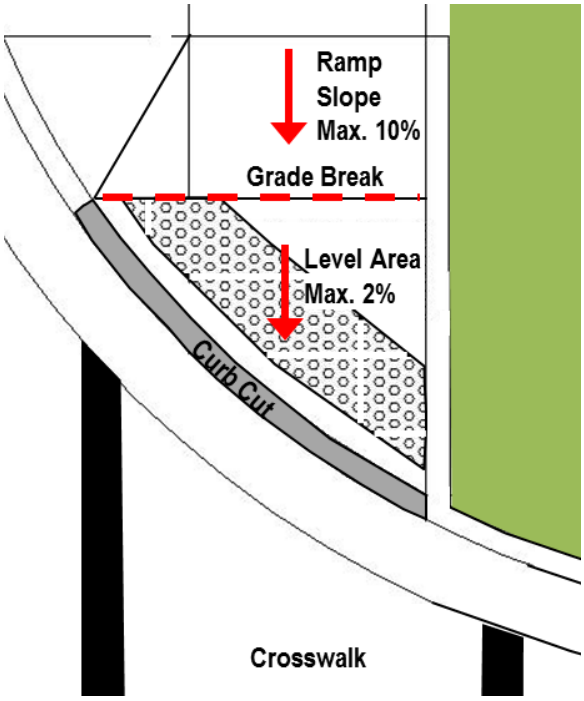


Curb ramps aligned with crosswalks are effective in orientating users to the crossing

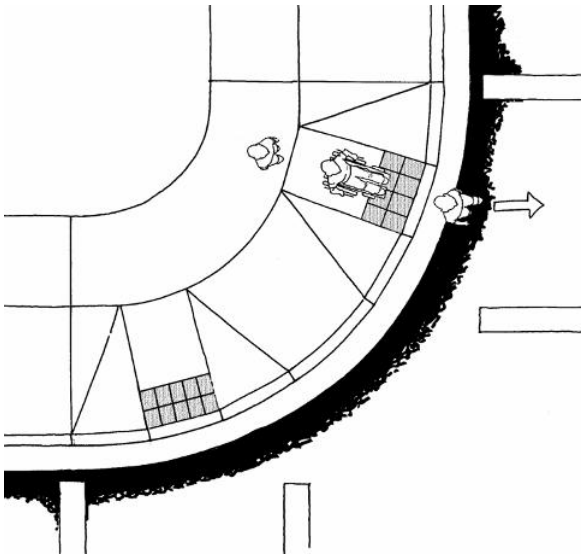
Grade breaks on curb ramps must be perpendicular to the ramp slope direction in order to be useable by wheelchairs. Otherwise, the user must negotiate the changing grades and changing cross-slope simultaneously and turn at the grade transition. This requires changing direction at the grade transition and can result in one wheel lifting off the ground, de-stabilizing or stopping the user.



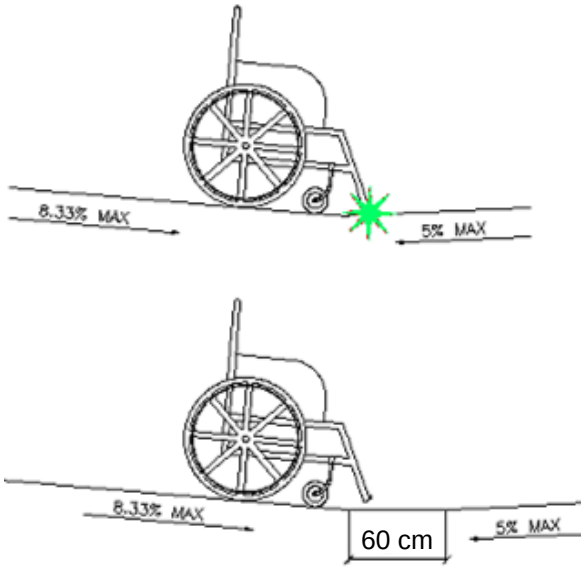
Best design: On small radius corners, curb ramp can be aligned with crosswalk and be perpendicular to curb



Good design: On large radius corners align the curb ramp with the crosswalk and set grade break at toe of ramp, not at curb cut



Acceptable design: On large radius corners place curb ramps perpendicular to curb

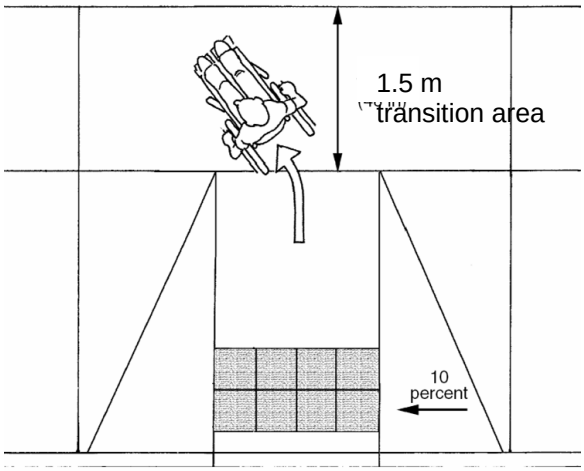


Change in Grade

Maximum running slope of curb ramp is 10% and of counter slope at gutter / roadway is 5%

Lower slope is better

Good practice: provide 60 cm level area for transition

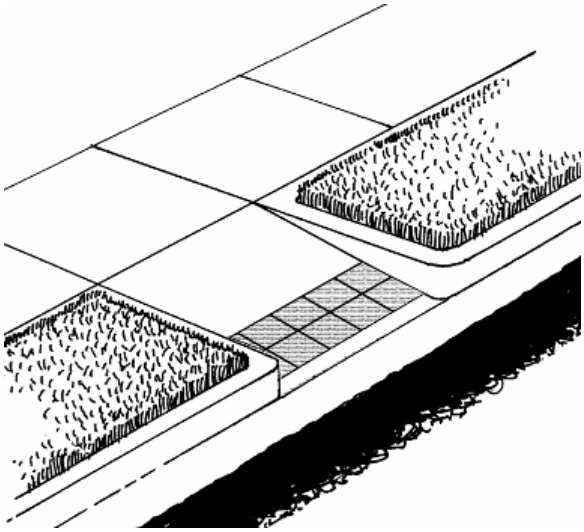


Flares

Flares are not part of pedestrian access route

They transition the curb ramp within a concrete / hard-surface area and should be used wherever the curb ramp might create a tripping hazard

Maximum slope is 10%



Curb Return

Curb returns at curb ramps are preferred to flares

They can be used instead of flares where the ramp is shielded by a fixed object or landscaping

They provide directional cues, promoting way-finding, and reduce the area of concrete

Good design: Flare on one side adjacent concrete, and curb return on other side adjacent grass boulevard

Basic Design Criteria for Curb Ramps

- Align with the direction of travel (AODA)
- Perpendicular to curb cut (U.S. guidance):
- Min. clear width 1.2 m (exclusive of flares) (AODA)
- Running slope (AODA):
  - 10% to 12.5% when elevation is less than 75 mm
  - 8 1/3% to 10% when elevation is between 75 mm and 200 mm
- Max. cross slope on ramp: 2% (AODA)
- Max. cross slope on flare: 10% (ADOA)
- Max. counter slope at gutter / roadway: 5% (U.S. guidance)
- Transition area (or level landing): clear width of 1.2 m at level of vehicular route (U.S. guidance) and level of sidewalk where it connects with a curb ramp (AODA)

5.6.2 Tactile Walking Surface Indicators

Curbs identify the boundary between the sidewalk and the street; tactile walking surface indicators at curb ramps and other street transitions replace that cue (the curb) for pedestrians with visual impairments. Ontario's AODA standards require the tactile walking surface indicators at the bottom of the curb ramp. They are also necessary at refuge median islands, raised crosswalks, depressed corners, multi-use trail crossings or other locations where the pedestrian way is at the same level as the vehicular way.

Tactile walking surface indicators are available in various materials. The Ministry of Transportation Ontario published standards for proprietary cast iron plates.

Example of cast iron tactile walking surface indicator, London ON and new installation Kitchener ON

Basic Considerations and Design Criteria for Tactile Walking Surface Indicators

- Locate at the bottom of the curb ramp set back between 150 mm to 200 mm from the curb edge (AODA)
- Extend the full width of the curb ramp (AODA)
- Min. depth: 610 mm (AODA)
- Surface of truncated domes: height of 5 mm; base diameter of 23 mm; organized in a regular pattern 60 mm on centre
- Less than 6 mm above or below the surrounding surface (AODA), 3 mm or less preferred
- Colour and tonal contrast between curb ramp and tactile walking surface indicator desirable; yellow is recommended; other colours that provide a difference of 70% can be used

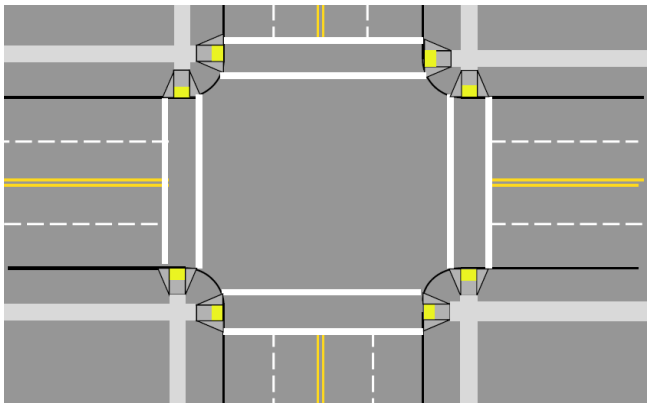
5.6.3 Pedestrian Crosswalks

Ontario's Highway Traffic Act permits marking crosswalks where pedestrians can be given right-of-way over motorists due to traffic control, i.e. at traffic control signals, stop signs, yield signs, or signed school crossings with school crossing guards.

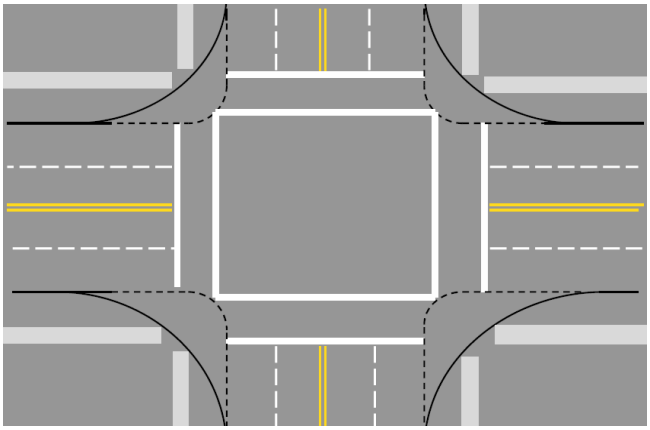
For accessibility, the locations of the pedestrian crosswalk considers the alignment of the crosswalk with the sidewalk and curb ramps, and the provision of a level landing at the bottom of the curb ramp within the crosswalk. Crosswalk placement requires balancing crosswalk length, setback and ramp placement, as illustrated in Exhibit 5-9.

Exhibit 5-9: Considerations for Crosswalk Placement

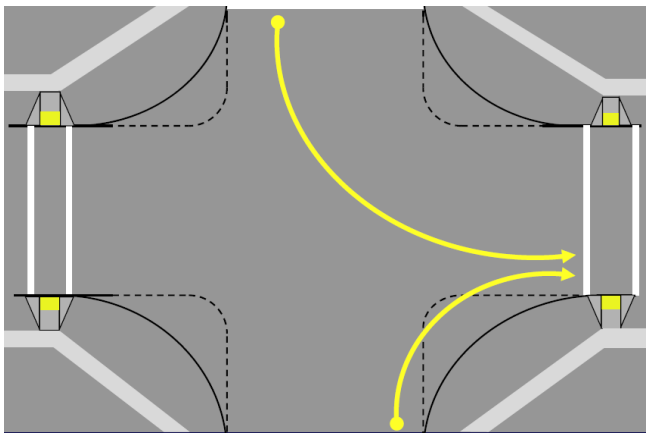
Small corner radii allow two curb ramps, shortest crosswalks and a direct travel path to sidewalks



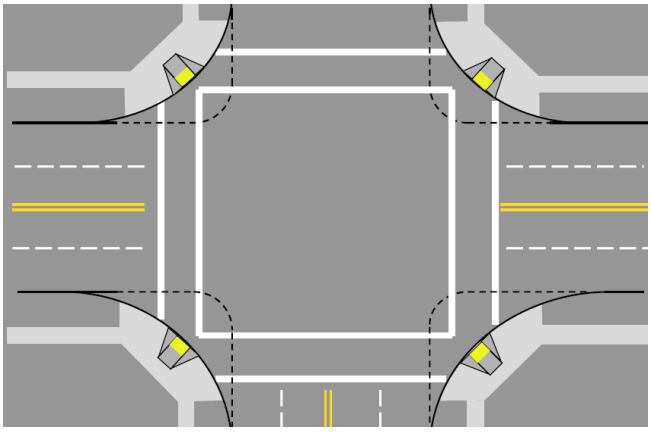
Larger corner radii create large undefined areas



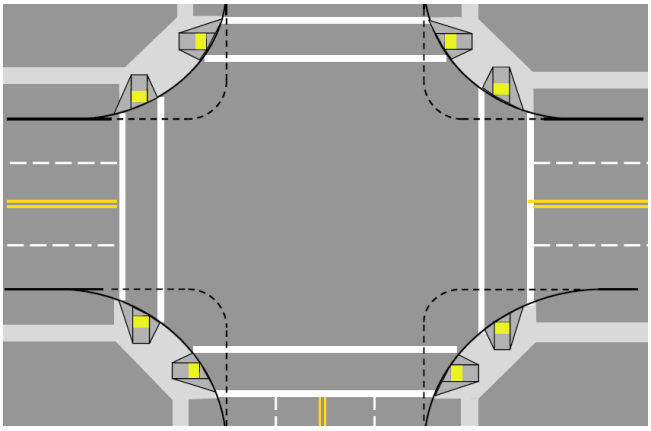
With large corner radii, crosswalks at shortest crossing result in longer walking distances, and drivers turning left and right do not see the crosswalk



With large corner radii, single ramp reduces crosswalk setback but lengthens crosswalk, and does not provide a separate curb ramp for each crossing for easier navigation by the visually impaired.

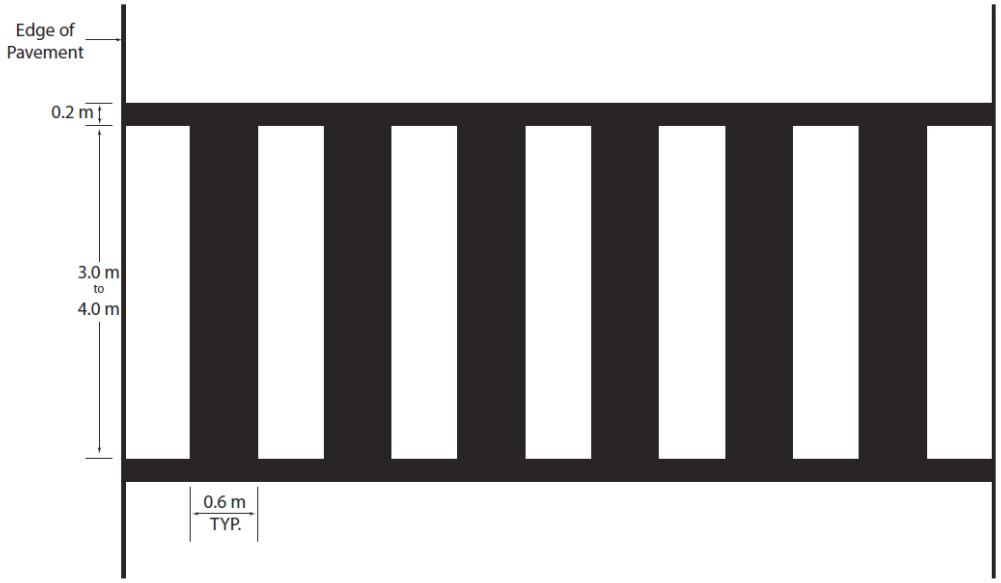


With large corner radii, balance goals for length crosswalk, two separate curb ramps, crosswalk setback and overall walking distance.



The Ontario Traffic Manual (Book 15 Pedestrian Crossing Facilities) introduces the ladder crosswalk marking: the transverse crosswalk lines are enhanced with longitudinal stripes aligned perpendicular to the pedestrian direction of travel as illustrated in Exhibit 5-10. The larger shapes and tonal contrast of the marking on asphalt increases the visibility of the crosswalk to motorists, in particular, since they see them from a low angle of about 1 m above the ground.

Exhibit 5-10: Ladder Crosswalk Marking (from OTM Book 15 Pedestrian Crossing Facilities)



Basic Considerations and Design Criteria for Pedestrian Crosswalks

- Min. width 2.5 m; typically 3 to 4 m in urban areas (OTM Book 15); 3.5 m preferred
- Outer edge typically 1.0 m from stop bar (OTM Book 15)
- Pavement markings:
  - Transverse lines min. 200 mm wide (OTM Book 15)
  - Longitudinal stripes 0.6 m wide spaced 0.6 m (OTM Book 15)
  - Colour / tonal contrast (difference 70%: light on dark, or dark on light) distinguish it from the vehicular route / roadway
  - Retro-reflective for visibility in low light conditions (OTM Book 11)
- Location:
  - Line up with sidewalks and dropped curbs
  - Inner edge min. 0.5 m from through edge of pavement of the parallel roadway for posted speed under 80 km/h; and 1.0 to 1.5 m for posted speed at or above 80 km/h (OTM Book 15)
  - Path of travel perpendicular to vehicular route where possible
  - Desirable 2.0 m separation at curb radii between inner edge lines of the two crosswalks (OTM Book 15)
- At skewed intersection, inner edge of crosswalks can intersect at curb (not cross in roadway)
- Should not force pedestrians with mobility devices outside the crosswalk lines due to angle of curb ramps
- As short as possible without compromising other design factors

5.6.4 Accessible Pedestrian Signals

Accessible pedestrian signals (APS) are technologies that supplement conventional traffic control signal technology to assist pedestrians with vision impairments in their road crossings. These technologies provide audible AND vibro-tactile indications that act as the “walk” signal. The Transportation Association of Canada produced *Guidelines for Understanding Use and Implementation of Accessible Pedestrian Signals* (2008). It provides guidance on establishing APS installation priorities, the preferred means of operating APS, design criteria considered desirable for the effective operation of APS, installation procedures, and operational adjustments, monitoring and maintenance requirements.

Basic Considerations for Accessible Pedestrian Signals

- Include both audible and vibro-tactile indicators for indicating the walk phase
- Locator tone to find pushbutton must be distinct from a walk indicator tone
- Pushbutton must have tactile arrow that aligns with the direction of the crossing
- Install the pushbutton within 1.5 m of the edge of the curb, mounted 1.1 m above ground level
- Where two pushbuttons are installed on the same corner, must be a min. 3.0 m apart
- Two pushbuttons can be assembled on one single post if spacing is limited by site constraints; must include a verbal announcement clearly stating which crossing is active

5.7 Convenient Pedestrian Street Crossings

In order to make walking a viable mode of transportation, pedestrians need to be able to safely and conveniently access the destinations. This means creating safe, convenient and easy to use pedestrian crossings of Regional roads at signalized intersections and non-signalized locations.

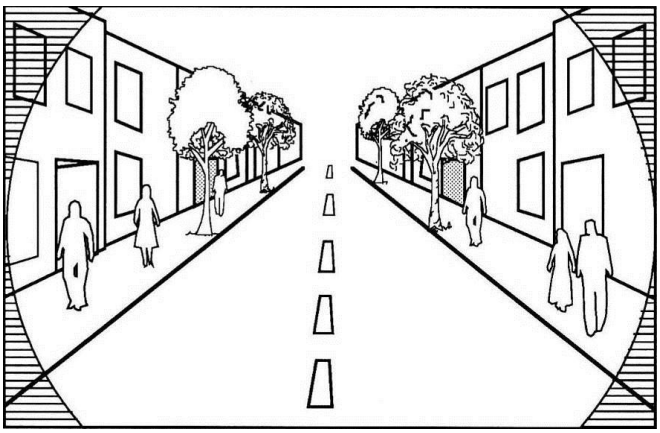
Pedestrian safety countermeasures at street crossings typically focus on the speed of motorists. Speed affects:

- Drivers' field of vision and ability to see pedestrians: drivers focus less on surroundings at higher speeds
- Drivers' ability to react and avoid a collision: the reaction time and stopping distances required are longer
- Collision severity: high speeds lead to a greater chance of pedestrian serious injury and death

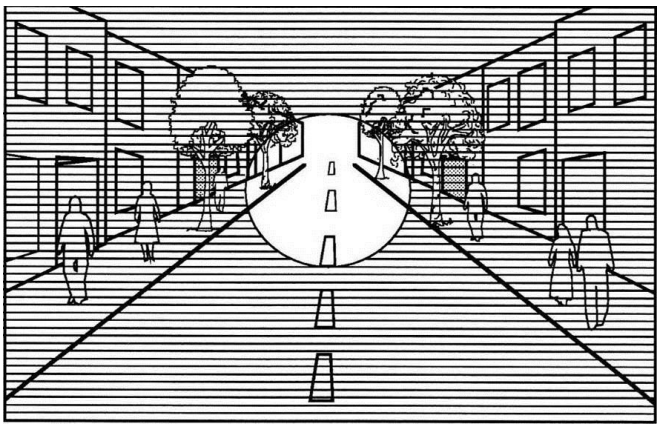
These effects are illustrated in Exhibit 5-11, Exhibit 5-12 and Exhibit 5-13.

Exhibit 5-11: Effect of Speed on Field of Vision

As speed increases, driver focuses less on surroundings



At 20 km/h nearby pedestrians are within field of vision



At 50 km/h nearby pedestrians are outside field of vision

Exhibit 5-12: Effect of Speed on Collision Avoidance

High speeds equate to longer distance travelled during time to react and stop the vehicle

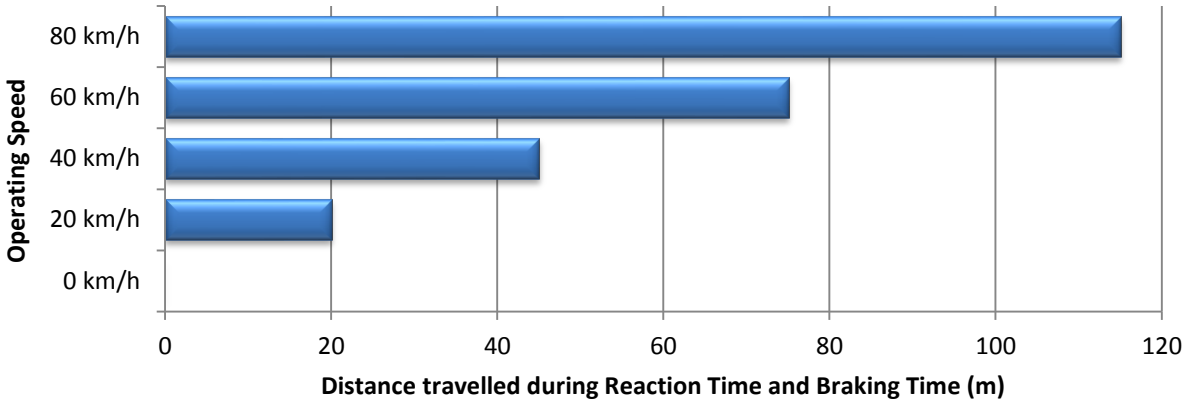
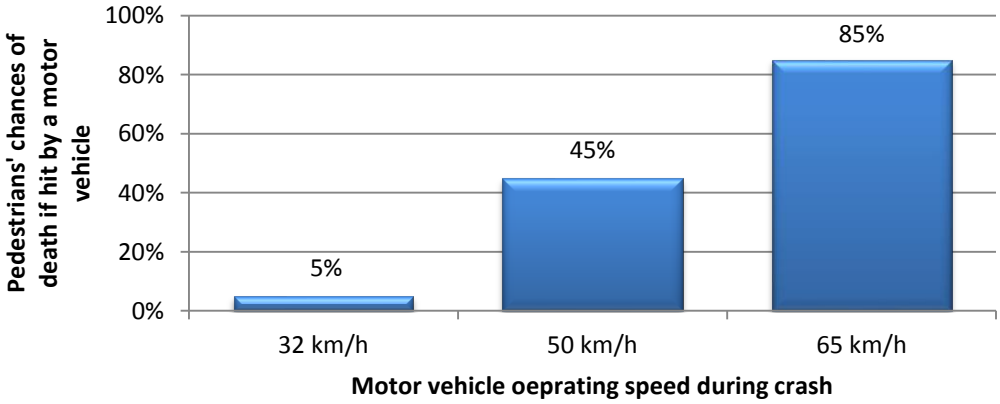


Exhibit 5-13: Effect of Speed on Collision Severity

High speeds lead to a greater chance of serious injury and death
Source: *Killing Speed and Saving Lives*, UK Department of Transportation (1992)



5.7.1 Pedestrian Crossings at Signalized Intersections

Pedestrian-friendly signalized intersections are tight, simple, square, operate at slow speeds, are easy to understand, and avoid free-flow vehicular movements. Complex intersections can be simplified by breaking the pedestrian crossings into smaller steps.

Signalized intersections can be improved for pedestrian safety by:

- Using geometric design that integrates recommended practice in intersection alignment, sight distance, corner radii, auxiliary turn lanes, medians, etc.

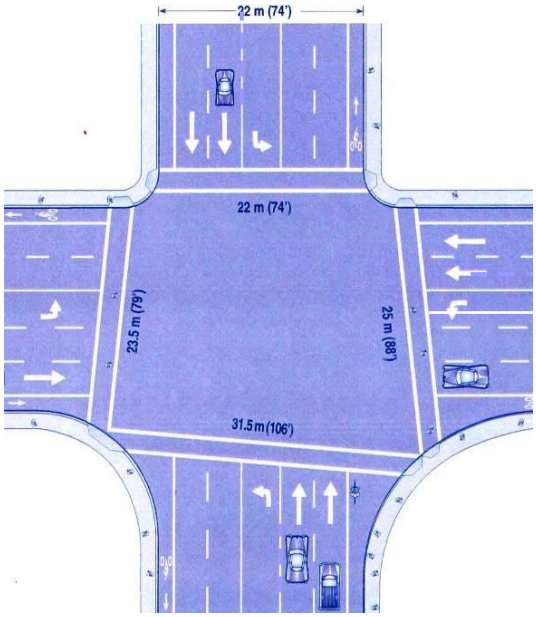
- Placing islands to break up complex crossings based on increased number of traffic lanes, turn lanes, transit lanes, etc. Islands can reduce exposure to the number of potential conflicts along different sections of a crossing. Islands can also provide refuge areas for those that need more time to cross in stages or rest before crossing the next section of the intersection.

- Placing crosswalks in logical or standardized locations
- Improving the convenience and ease of use of pedestrian pushbuttons and signals
- Using techniques to reduce conflicts with turning vehicles

Examples of these types of improvements are illustrated in Exhibit 5-14.

Exhibit 5-14: Examples of Improvements for Pedestrian Crossings at Signalized Intersections

Smaller curb radius: reduce crossing distance, make curb ramps and crosswalk locations easier, and reduce speed of turning vehicles. Larger vehicles can still be accommodated at slower speeds and making use of the full width of the receiving roadway / lanes. Choose the smallest of the large vehicles expected on an hourly basis as the design vehicle for turning.



Curb extensions: reduce crossing distance, improve visibility for motorists and pedestrians at the crossing, calm traffic and provide space for street furniture and landscaping. Applications are typically limited to where there is on-street parking.

← Cobourg ON

High visibility crosswalks: visible to drivers at a lower driver eye height than pedestrian eye height – See Section 5.6.3.

Pedestrian pushbutton placement: AODA Regulation 413/2 requires the accessible pedestrian signal push-button to be located within 1.5 m of the curb, a max. of 1.1 m above ground level and 3 m a part if there are two at the same corner). It must be in reach of the accessible sidewalk and near the curb ramp.

Poor pushbutton placement
Too far from curb ramp

Behind vegetation and not within reach of the accessible sidewalk

Pedestrian traffic signal head placement: prefferably aligned with the middle of the crosswalk, but acceptable within the crosswalk, visible to pedestrians (not behind other poles, signs or vegetation).

Pedestrian countdown signals Better understood by pedestrians than walk symbol and flashing / solid hand don't walk symbol. With countdown signals, more people cross during the pedestrian clearance phase (minimum time to clear the crosswalk during the vehicle green signal) but fewer people initiate walk late in the pedestrian clearance phase, and very few pedestrians are in the crosswak during the solid don't walk phase (yellow and red signal phase). Drivers do not tend to accelerate during the vehicle clearance phase (yellow and red signal).

5.7.2 Traffic Control Signal Phasing / Timing Improvements for Pedestrians

Motorists' turning movements account for most pedestrian collisions at signalized intersections. Traffic control signal phasing can improve the convenience, operations and safety of pedestrians crossing at the intersection. Techniques include the following:

- **Short cycle length (less than 90 sec)**: long wait times for pedestrians cause queuing. Pedestrians will wait in the street and will cross against the signal.

- **Recall to walk**: walk phase comes up automatically. At high-use crosswalks, pedestrians should receive the walk signal with every signal cycle. Set the recall to "walk" when the major street is set to recall to "green". These are planned at high activity areas and transit corridors.

- **Protected left-turn phase**: Allow left-turns by motorists on a protected phase that does not allow the pedestrians to cross the conflicting crosswalk during that phase. Pedestrians cross after the protected left-turn phase. The Collision Reduction Factor for converting permissive left-turns (left-turns allowed during the "green" through phase) to protected on the major intersection approach is 99% for all left-turn collisions and 42% for all collision. Alternatively, allow protected – permissive left-turn phasing but revert to protected phasing when the pedestrian pushbutton is activated or during higher pedestrian times of day.

- **Restrict right-turns on "red"**: This is detrimental to traffic capacity but there are some conditions when it should be considered. Consider no right turns during the red phase when sight distance is poor between motorists and pedestrians; when there have been a higher than expected number of pedestrian collisions with turns on red, or there is an exclusive pedestrian phase or a leading pedestrian phase (see below). A Collision Reduction Factor for vehicle / pedestrian collisions is not currently available. A new phasing / signal head used in the US is a changeable message sign stating "no turn on red" when a pedestrian activates the pedestrian phase. This type of sign has been installed on the QEW / Waterdown Road E to N-S ramp to replace a static sign (sight lines restrict right turn on red).

- **Exclusive pedestrian phase** (also known as pedestrian scramble or Barnes Dance): All motorists stop and pedestrians can cross in any direction. Right-turns on red must be prohibited. Delay for pedestrians is higher for they must wait through the phasing for both directions of traffic before receiving the exclusive pedestrian phase. The Collision Reduction Factor is 50% for vehicle / pedestrian collisions, but the efficiency of the intersection is decreased. Use only where there is an extremely high number of

pedestrians (1,200 or more per day) and turning motorists. Should be coupled with Accessible Pedestrian Signals since pedestrians with vision impairments usually rely on the sound of motorists moving to start across the crosswalk.

- **Leading Pedestrian Interval (LPI):** The pedestrian walk phase comes generally 4 to 6 sec prior to the parallel green signal for motorists allowing pedestrians to enter the crosswalk before turning vehicles. The Collision Reduction Factor is around 40% for vehicle / bicycle and vehicle / pedestrian collisions. It should be coupled with Accessible Pedestrian Signals since pedestrians with vision impairments usually rely on the sound of motorists moving to start across the crosswalk. LPI is one of the measures for municipalities to consider recommended by the Office of the Chief Coroner for Ontario in *Pedestrian Death Review*[7] to reduce pedestrian deaths.

- **Walk speed for pedestrian crossing times**: The Ontario Traffic Manual (Book 12 Traffic Signals) recommends a minimum Walk phase of 7.0 sec. It also recommends that the Flashing Don't Walk phase be calculated based on a normal walking speed of 1.2 m/s, and 1.0 m/s if the crossing is frequented by young children, seniors or special needs persons, along with the curb to curb crosswalk distance. As an alternative, the Ontario Traffic Manual method can be tested against using a 0.9 m/s walking speed to cross starting at the location of the pushbutton (or 2 m from the curb if no pushbutton) to the curb on the other side, as illustrated in Exhibit 5-15.

Exhibit 5-15: Test for Slower Walking Speed for Pedestrian Phase at Traffic Control Signals

Ontario Traffic Manual Book 12 method	Test for Slower Walking Speed
Example 1—OTM Method: 18 m wide crosswalk (curb to curb) Walk speed 1.2 m/s Walk phase = 7.0 sec Flashing Don't Walk phase = 18 m ÷ 1.2 m/s = 15 s **Total Walk plus Flashing Don't Walk = 22 s**	Example 1—0.9 m/s Test: 18 m wide crosswalk (curb to curb) plus 2 m for starting from pushbutton location Walk speed 0.9 m/s **Total Walk plus Flashing Don't Walk = 20 m ÷ 0.9 m/s = 22 s** **PASSES TEST!**
Example 2—OTM Method: 22 m wide crosswalk (curb to curb) Walk speed 1.2 m/s Walk phase = 7.0 sec Flashing Don't Walk phase = 22 m ÷ 1.2 m/s = 18 s **Total Walk plus Flashing Don't Walk = 25 s**	Example 2—0.9 m/s Test: 22 m wide crosswalk (curb to curb) plus 2 m for starting from pushbutton location Walk speed 0.9 m/s **Total Walk plus Flashing Don't Walk = 24 m ÷ 0.9 m/s = 27 s** **FAILS TEST! Add 2 additional seconds to Walk phase**

- **Pedestrian activated quick response**: At signalized, mid-block pedestrian crossings with low to moderate pedestrian volumes, once a pedestrian activates the signal, if there is a delay in providing the pedestrian phase, they may choose to cross during a gap in traffic. Then once the pedestrian phase comes on, the motorist is faced with stopping even though the pedestrian has already crossed. This can lead to frustration for both

[7] Office of the Chief Coroner for Ontario, *Pedestrian Death Review: A Review of All Accidental Pedestrian Deaths in Ontario from January 1st, 2010 to December 31st 2010*

users. A "quick" response will eliminate this frustration and is unlikely to affect overall capacity at these locations except in the case of corridors with co-ordinated signals.

5.7.3 Pedestrian Mid-block Refuge Islands

Mid-block refuge islands provide convenient locations for pedestrians to cross major roadways in areas where there are infrequent intersection crossings or where the nearest intersection crossing creates substantial out-of-direction travel. Pedestrians will expose themselves to traffic to cross where necessary to get to their destination conveniently and directly. Installing mid-block refuge islands (or providing pathways through existing median islands) can help channel pedestrians to the safest location, provide visual cues to motorists to anticipate pedestrian activity and provide pedestrians with reasonable opportunities to cross heavy traffic.

Example of pedestrian mid-block refuge island added as part of the road reconstruction, Kitchener ON

Pedestrians will use median islands on multi-lane roadways to cross in gaps in traffic, one direction at a time (two stages), particularly during off-peak traffic times when there can be long gaps. Adding pathways and curb cuts through these islands will improve their safety, convenience and comfort. They will be able to leave the roadway more quickly without barrier curbs or landscaping in the way and have a comfortable resting area without trip hazards. On roadways with six or more lanes, gaps in traffic long enough to facilitate a pedestrian crossing during some times of the day should be available, otherwise the frequency of pedestrian crossings with traffic control should be evaluated. Posted speed limits should also be less than 60 km/h.

Crosswalks should not be provided at these locations since there are no traffic controls to stop traffic and give the right-of-way to pedestrians. The warning signs, "Wait for Gap" (OTM Book 15, Wc-28) may be installed where pedestrians are not waiting for appropriate gaps (determined through field observations) along with "Pedestrian Ahead" signs (OTM Book 15, Wc-7).

Basic Considerations and Design Criteria for Pedestrian Mid-block Refuge Islands

- Min. width 1.8 m; preferred width 3.0 m
- Preferred area: 20 m^2
- Provide a level concrete pathway with curb cuts or curb ramps for users with tactile walking surface indicators (one on each end of the median pathway)
- Provide sidewalks and curb ramps on both sides of the road at the island
- Design tapers and signage as per Ontario Traffic Manual Books
- Install Keep Right (Rb-25) and Object Marker (Wa-33L) on both ends of the refuge island
- Install Pedestrian Ahead (Wc-7), Playground Ahead (Wc-3) or Trail Crossing Ahead (Wc-32) signs; Pedestrians Yield to Traffic (Wc-28) sign; and No Parking (Rb-51) sign within 30 m of crossing
- Paint the vertical face of the median island yellow
- Provide illumination on both sides of the unmarked pedestrian crossing 6 to 8 m in advance of the crossing for approaching traffic
- Do not paint a crosswalk of any type
- Do not include railings because of the hazards to road users if struck

- Roadway posted speed should be less than 60 km/h
- Suitable for roadways 5 lanes wide or less; if 6-lanes or more consider if appropriate gaps in traffic for pedestrians to use are available some of the day when there is some pedestrian demand (no warrants exist, but 100 pedestrians in 8 hours is being used in some jurisdictions, or lower demand if there is a history of collisions)
- Generally do not locate with 100 m of a controlled pedestrian crossing
- Adequate sight distance for both motorists and pedestrians must be available

5.7.4 Pedestrian Crossings at Roundabouts

Roundabouts are used to control traffic and assign right-of-way at intersections. In Halton Region they are an alternative to installing traffic control signals. The advantages of roundabouts over signals are that they reduce speeds, reduce some types of vehicle collisions and, in particular, their severity, and can increase the vehicle capacity of the intersection. For pedestrians, the crossing of the entry or exit to a roundabout is simpler than at a signal: the vehicle approaches from one direction and generally in the full view of the pedestrian. Observations of pedestrian and driver behaviour at crossings of roundabouts in the Region of Waterloo have found that, although they rarely do, people who point to indicate that they want to cross, driver response by yielding. In addition, the use of "Yield Here to Pedestrians" signs increased the rate of yield from 37% to 63%[8]

Many Canadian cities are successfully implementing roundabouts, however, concerns over pedestrian mobility and safety, particularly those with vision impairments, remain. The main concerns revolve around the following issues:

- Generally motorists do not yield to pedestrians at roundabouts because the crossing is not signal controlled. In Ontario, there is no formal right-of-way for pedestrians at roundabouts— it is considered an uncontrolled crossing unless some form of traffic control, typically a yield sign, is provided at the crossing thus allowing the marking of a crosswalk.

- Noise from circulating traffic may make it difficult for pedestrians with visual impairments to audibly detect gaps in traffic.

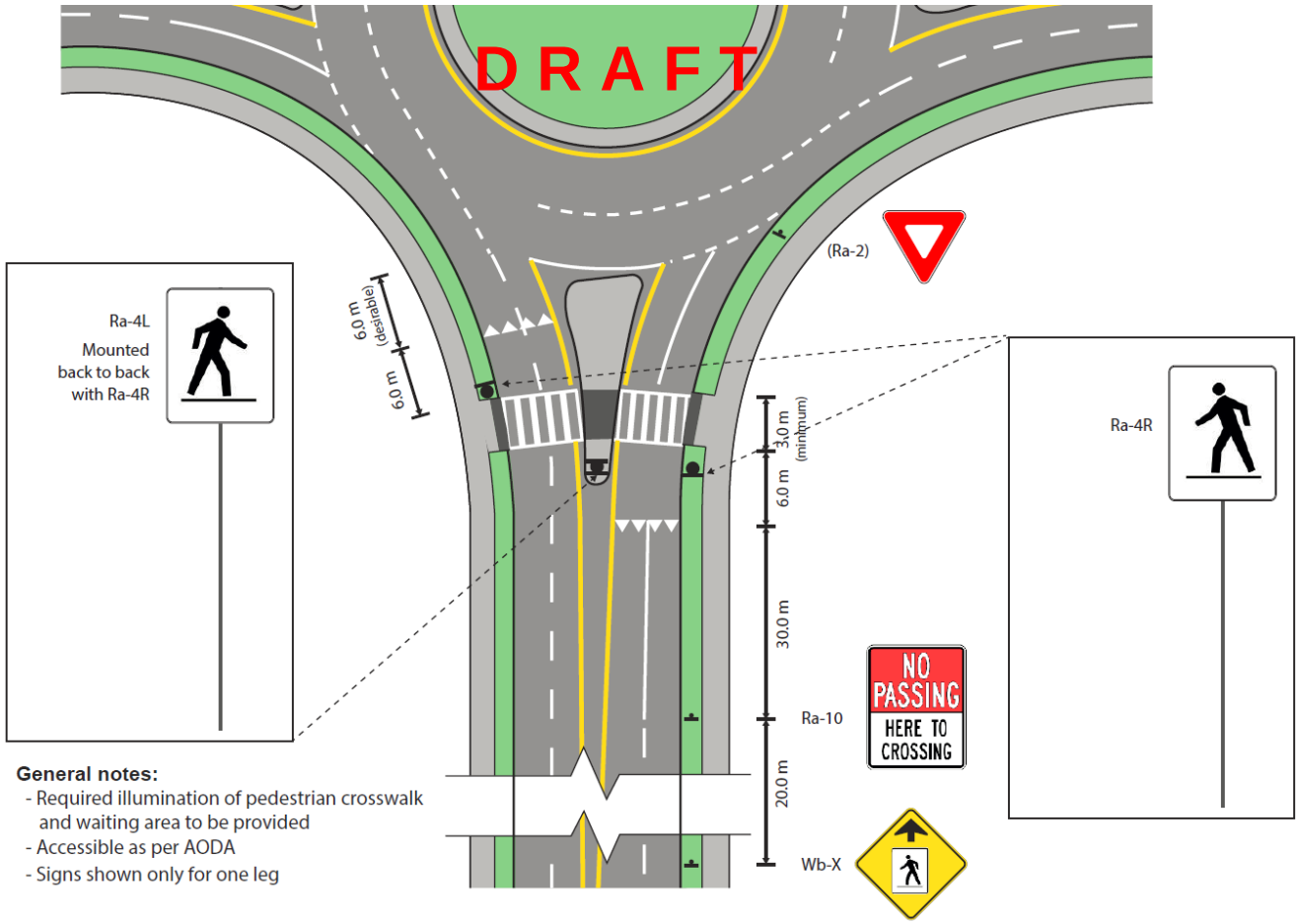
- Gaps large enough to be audibly detected by pedestrians with visual impairments may be infrequent, particularly at multi-lane roundabouts with high traffic volumes where a simultaneous gap in traffic in all lanes is required.

Research continues on geometrics and treatments that will improve the safety of roundabouts even further and address pedestrian access issues. Combined with selective enforcement and education, the long-term safety and capacity benefits of roundabouts can continue to be realized.

Changes to pedestrian crossings are expected with proposed Bill 31 to amend the Highway Traffic Act. This Bill provides a new definition of pedestrian crossover and new duties of drivers to stop for pedestrians in the crossover. How pedestrian crossings at roundabouts are signed and marked will be revised if Bill 31 is passed. The draft revisions are shown in Exhibit 5-16.

[8] Lenters, M., N. Button and T. Knostman, "Improving Pedestrian Performance and Driver Response at Unsignalized Roundabout Crosswalks", 2010 Annual Conference of the Transportation Association of Canada, http://conf.tac-atc.ca/english/resourcecentre/readingroom/conference/conf2010/english/table_of_contents.htm.

Exhibit 5-16: DRAFT Signage and Pavement Marking Layout for Pedestrian Crossover at Double-lane Roundabout (from Ontario Traffic Book 15 Pedestrian Crossing Treatments DRAFT June 2014)



Basic Considerations and Design Criteria for Pedestrian Crossing at Roundabouts

- Pedestrian crossings are provided around the perimeter of the roundabout, on the approaches to the roundabout and set back from the yield line; access to the centre island is strongly discouraged
- The pedestrian crossing should be located one vehicle length, or multiple thereof, back from the yield line
- Align the crossing perpendicular to the direction of traffic to help guide the visually impaired who depart perpendicular to the curb and shorten the crossing
- Provide a raised splitter island with a min. 1.8 m wide pedestrian pathway through the island. The pathway within the refuge island must be long enough to accommodate a wheelchair (1.2 m plus clearance to the travel lane). Include edges or curbing to guide visually impaired pedestrians through the island and perpendicular to the approach crossing.
- All curb ramps at the roadway entry and splitter island must meet accessibility standards and include walking hazard indicators
- Ensure adequate lighting of all pedestrian crossings

- Provide signs and pavement markings as per Ontario Traffic Manual Book 15
- Consider alternatives to improve pedestrian safety, comfort and convenience, such as:
  - Raised pedestrian crossing
  - Pedestrian-activated signals on the approach or upstream of the roundabout
- Along a corridor with multi-lane roundabouts, consider mid-block pedestrian crossings away from the roundabouts
- Include selective enforcement and education to motorists and pedestrians to encourage appropriate behaviour

6 Bikeways

The design toolbox for bikeways contains best practices for providing boulevard multi-use trails, bike lanes, buffered bike lanes, segregated bike lanes and paved shoulders on Regional roads, and intersection treatments. These will contribute to improved safety, convenience and comfort for cycling in Halton Region.

6.1 Types of Bikeways

Bikeways to accommodate the travel of cyclists can be divided into three main categories as described below and illustrated in Exhibit 6-1:

- **Shared space** on roadways or streets where cyclists and motorists use the same road space. Thus these routes typically have lower motor vehicle volumes or lower motorists' speeds, making it possible for cyclists to comfortably share them with motorists. Such bikeways include signed routes, traffic-calmed local streets (or what are known as "bicycle boulevards", local cycling streets or bicycle priority streets), marked shared-use lanes ("sharrows"), and advisory lanes.

  Wide travel lanes, although used for High Occupancy Vehicle (HOV) lanes or Reserved Bus Lanes (RBL) on arterials, are not recommended as bikeways for Regional roads. They do not provide sufficient lateral clearance when motorists are passing cyclists within the lane, especially on roads with moderate to high volumes where opportunities to change lanes are limited and when there are heavy vehicles in the mix of traffic using the outside lane. They generally induce higher motorists' travel speeds that have an impact on the cyclists perception of safety and comfort.

- **Separate space** provides space on the road intended for use by cyclists adjacent to motor vehicle lanes and defined by pavement markings. They consist of:

  - Bike lanes on urban roads with curbs and gutters demarcated by a painted line.

  - Buffered bike lanes on urban roads demarcated by a painted line and painted buffer. The buffer can be between the bike lane and the general purpose travel lane, or between the bike lane and on-street parking, if present.

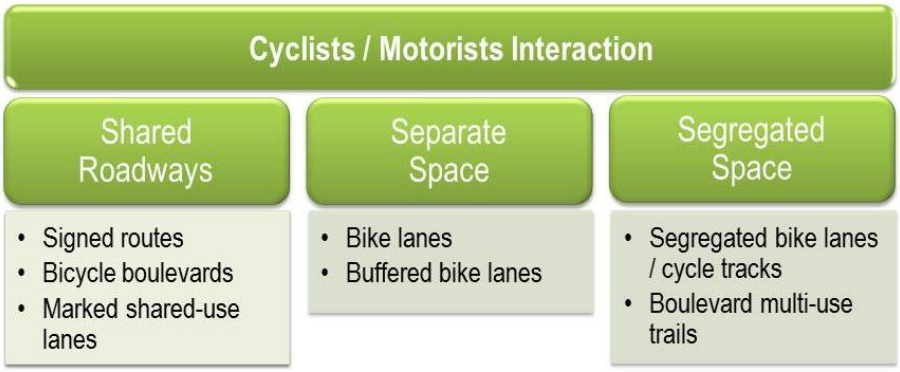
  - Paved shoulders without or with painted buffer for use by cyclists and pedestrians when sidewalks or trails are not present.

- **Segregated space** on roads or in the boulevard is for cyclists and is physically separated from the motor vehicle lanes and on-street parking. These consist of:

    - Segregated bikeways separated from traffic by more than just a painted line. Segregation may consist of bollards or delineators, mountable or barrier curbs, planters, concrete medians, etc. They can be located immediately adjacent to travel lanes, behind on-street parking or in the boulevard adjacent to the sidewalk. Typically segregated bikeways are provided on both sides of two-way streets, but can be two-way on one side of one-way streets. Users are subject to the same rules of the road and similar traffic controls as motor vehicles. Segregated bikeways are sometimes called cycle tracks.

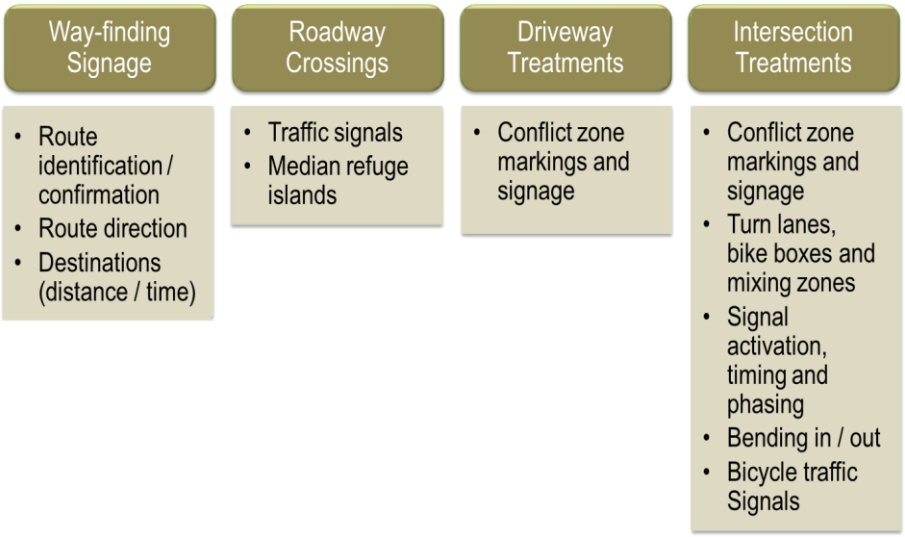
    - Multi-use trails are routes reserved for non-motorized users such as pedestrians, in-line skaters, joggers, boarders, and cyclists. They can be located within the boulevard of roadways on one or both sides of the roadway, or in corridors independent of road rights-of-way, i.e. parks, open space, utility rights-of-way, etc. They are commonly used for two-way travel. Unlike segregated bikeways, they do not come under the rules of the road; right-of-way at driveways and streets is like that of a sidewalk or pedestrian crossing. Some are designated for cyclists use only and may be parallel to a pedestrian-only trail or sidewalk. Unless both the bicycle path and the pedestrian facility are of high quality, and provide the same level of comfort and convenience, bicycle only paths are often used by pedestrians at the frustration of both users.

Exhibit 6-1: Types of Bikeways Classified by interaction between Motorists and Cyclists



A bikeway network consists not only of the above bikeway corridors but also various "enhancements" that address the safety, convenience and comfort of cyclists and other road users of the network. Some of the more common enhancements in use in North America are listed in Exhibit 6-2.

Exhibit 6-2: Bikeway Enhancements in use in North America



6.2 Bikeway Selection Guide

6.2.1 Regional Right-of-way Guidelines

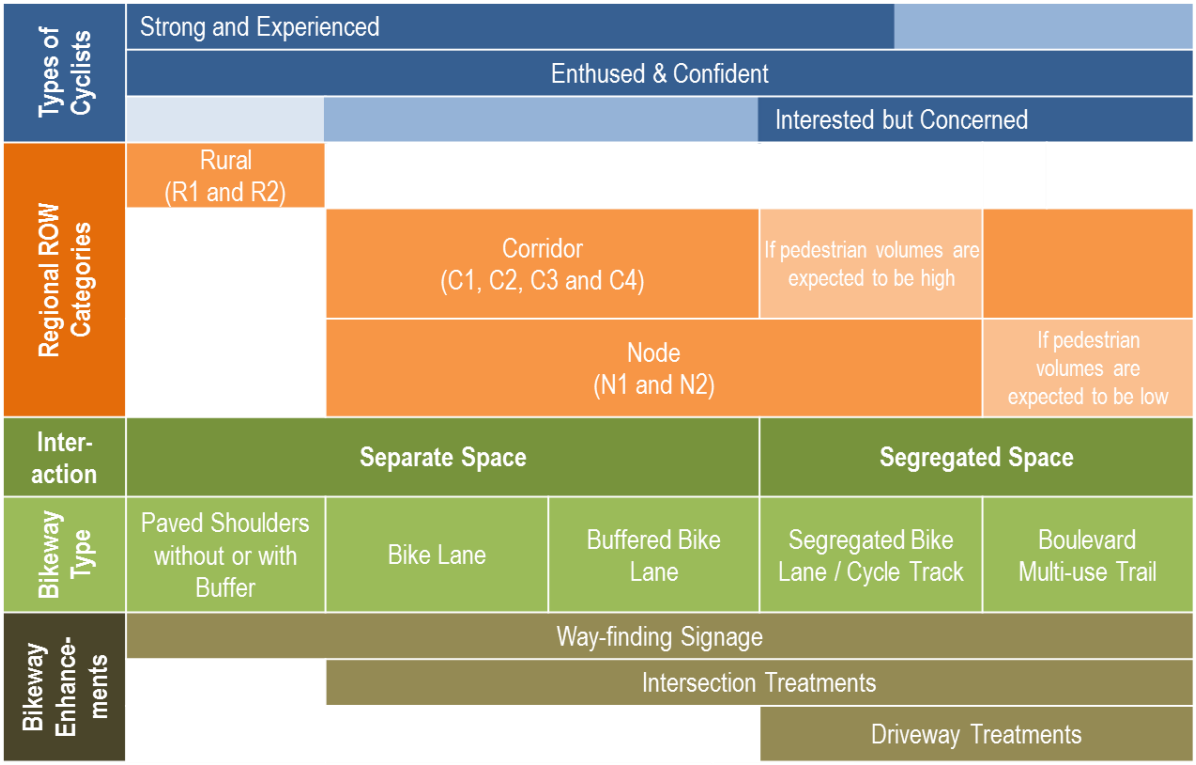
The types of bikeways suitable for different routes or corridors are foremost influenced by the speed and volume of motor vehicle traffic that affects the safety and comfort of cyclists. Although there is no "formula" for matching bikeways with roadways, selection criteria have been developed in many of the design guidelines available generally outside North America. In addition, one must consider the local context: types of users anticipated in the corridor and for the bikeway, the presence of on-street parking, intersection and driveway spacing and use, width of adjacent lanes, slight lines, topography, adjacent development function and form, environmental impacts, costs, maintenance, connecting bikeways, safety, etc.

For bicycle facilities, the *Regional Right-of-way Guidelines* considers the following:

- Provide cycling facilities on all Regional roads: 1.5 m wide paved shoulder; 1.8 m wide bicycle lane; and protecting for 3.0 m wide sidewalk / multi-use path
- Consider special design treatments at high traffic intersections to reduce conflicts for all travel modes; particularly right-turning motorists in conflict with cyclists travelling straight
- Employ standardized street signage for bicycle facilities, including next to parked cars in the "door zone"
- Provide designs that minimize or avoid conflicts at transit stops
- Provide designs that minimize or avoid conflicts between pedestrians and cyclists on multi-use paths

In order for Halton Region to reach its vision and targets for active transportation, a variety of different types of bikeways and enhancements suitable for different users (experienced, confident and casual / interested cyclists) and fitting the local context are necessary. **Expanding on the *Regional Right-of-way Guidelines*, the types of bikeways and enhancements recommended for the various right-of-way classifications are illustrated in** Exhibit 6-3.

Exhibit 6-3: Bikeway Selection Guide for Regional Rights-of-way



This selection guide should be read in conjunction with the Pedestrian Accommodation Selection Guide for Regional Road Rights-of-way, Exhibit 5-5, page 28.

6.3 Bikeway Design Criteria

- All bikeway widths are clear widths and do not include curb and gutter.

6.3.1 Paved Shoulders for Cycling

Ontario's Highway Traffic Act (HTA) defines "roadway" as "that part of the highway that is improved, designed or ordinarily used for vehicular traffic, but does not include the shoulder" (Section 1). Thus any regulation that refers to driving, overtaking or turning on the "roadway" exclude the use of the shoulder to do so.

HTA Section 185 permits the Ministry to regulate the use of any highway or part thereof by pedestrians or any class of vehicle including bicycles. HTA Section 151 permits by regulation designating the use of a paved shoulder under prescribed conditions and circumstances, including prescribing the classes or types of vehicles or drivers. Such a regulation is to include the types of signs and pavement markings. Section 151 also requires the signs to be in place before the designation of the use of the paved shoulder is effective. Section 152 indicates that the use of the paved shoulder can be designated by by-law of a municipality. Thus, Halton Region may designate the use of paved shoulders on Regional roads that are wide enough to comfortably accommodate cyclists as bike lanes by municipal by-law. The by-law would allow Halton Police to enforce the legal use of the paved shoulder; however, the appropriate regulatory bike lane signs must be erected before the by-law is in effect.

There are two options for designating paved shoulders for cycling:

- Permit cyclists to ride in the paved shoulder along a bicycle route signed with the Bicycle Route Marker" sign (OTM Book 18 M511), or

- Designate the existing or retrofitted paved shoulder as a bicycle lane and sign with the regulatory "Reserved Bicycle Lane" sign (OTM Book 18 Rb-84A). The signage can be supplemented with bicycle lane pavement markings (white bicycle lane lines, bicycle symbol, diamond and optional arrow). As noted above, a by-law is required for the designation. It can include exceptions to the regulation, such as allowing emergency stopping in the paved shoulder, use by emergency, maintenance or slow-moving vehicles, pedestrians where there is no sidewalk, etc.

It is recommended that Halton Region designate paved shoulders meeting the recommended widths to accommodate cyclists as bike lanes, and erect the corresponding Reserved Bike Lane regulatory signs with bicycle pavement markings. This will send a clear message to the public that the paved shoulder is part of the cycling network, intended for cyclists to use (with exceptions, as noted) and cycling is explicitly encouraged.

The Highway Traffic Act (Section 179) requires pedestrians walking along a highway where there are no sidewalks to walk on the left side facing on-coming traffic and walk as close to the left edge as possible. Along a Regional road with paved shoulders and no sidewalks, especially in the winter when the roadway is cleared to the edge of pavement, pedestrians will use the paved shoulder. The volume of pedestrians in rural areas is expected to be low. Cyclists should slow and pass on-coming pedestrians with care.

Example of a paved shoulder in Halton Region (left) and a paved shoulder designated as a bike lane in Grey County (right)

Basic Design Criteria for Paved Shoulders for Cycling

- Width of Paved Shoulder along a bicycle route or designated as a bike lane:
  - AADT < 4,500 vpd—min. 1.2 m; desirable 1.5 m
  - AADT > 4,500 vpd—min. 1.8 m
- Pavement markings and signs:
  - If cycling is permitted on the paved shoulder, use an a 100 mm solid white edge line and Bicycle Route Marker sign (M511)
  - If the paved shoulder is designated by by-law for the use of cyclists (with exceptions for emergency stopping, etc.), use 100 to 200 mm bike lane lines, bicycle symbol and diamond pavement markings and regulatory Reserved Bike Lane Signs (Rb-84A) installed after every intersection and every 300 m

- Optionally, paint a buffer 0.5 m to 1.0 m wide to separate cyclists from high volume, mix of traffic in the adjacent travel lane:
  - Buffer lane line (white 100 mm wide) placed at the edge and within the travel lane adjacent the buffer
  - Bike lane line (white 100 mm wide) placed at the edge and within the buffer adjacent the paved shoulder
- If rumble strips are used, provide min. 0.5 m wide buffer and install 300 mm wide rumble strips at the edge and within the buffer adjacent the paved shoulder (MTOD 503.070)

6.3.2 Bike Lanes

Bike lanes on urban roadways provide space for cyclists to ride in their own reserved lane, increasing their comfort particularly on higher speed and higher volume roads with truck and transit traffic. A wider, painted buffer can be applied on major roadways with higher traffic volumes, speeds, truck or transit volumes, or high-turnover on-street parking to increase the separation of the cyclists from parked cars and / or travel lanes.

Regulations, signs and accompanying by-laws are used to reserve the lane for use by cyclists only. Motorists travelling, parking and stopping in the lane must be strictly prohibited (currently by by-law until such time Ontario Regulation 615 is updated to include the designated bike lane sign), with the exception of emergency vehicles, authorized maintenance vehicles and public transit buses.

Example of a bike lane in Halton Region (upper and lower left) and a buffered bike lane in York Region (upper right) and Halton Region (lower right)

Basic Design Criteria for Bike Lanes

- Bicycle lane width (width does not include curb and gutter):
  - Where there is no on-street parking—minimum width of 1.2 m for roads with posted speeds of 50 km/h or less; preferred width for Regional roads of 1.5 to 1.8 m (does not include gutter width)
  - Where there is on-street parking—minimum width of 1.6 m adjacent to 2.1 to 2.5 m wide parking lane (2.4 m preferred to accommodate opening door of parked car)
- Pavement markings and signs:
  - Bicycle lane line (white 100 mm wide) pavement marking
  - Bicycle symbol, diamond and optional arrow pavement markings, space every 300 m or at the beginning and middle of the block, whichever is less
  - Regulatory Reserved Bike Lane Signs (Rb-84 (overhead) or Rb-84A (ground-mounted)) install after every intersection and every 300 m
- Buffer 0.5 m to 1.0 m wide to separate cyclists from high-turnover on-street parking, or high volume, mix of traffic in the adjacent travel lane:
  - Buffer lane line (white 100 to 200 mm wide) between the travel lane and buffer
  - Bicycle lane line (100 mm wide) between the buffer and the bike lane; colour is white or optional some colour used for branding purposes, but not yellow
  - Diagonal hatched line (white 100 mm wide) pavement markings at 45 degrees angling downstream from the bike lane towards the travel lane and spaced 3 to 12 m (a function of vehicle speed—closer for lower speeds)
  - Double solid white lines (buffer lane line and bike lane line) indicate where crossing is discouraged; dashed lane lines (one or both) indicate where crossing is permitted, i.e. adjacent auxiliary turn lanes or major driveways

6.3.3 Segregated Bike Lanes (Cycle Tracks)

Segregated bike lanes that provide some form of physical segregation between cyclists and motorists encourage non-cyclists or casual cyclists to ride because they increase their sense of comfort and safety. They can also reduce the stress of cyclists generally when riding in traffic and negotiating for space with motorists. Research in North America shows that the overwhelming majority of people who would like to cycle but are afraid to do so on urban streets, as well as many current cyclists, would prefer to be segregated from vehicular traffic. The provision of segregated bicycle lanes can therefore remove an important barrier to bicycle use, especially for less experienced cyclists. If designed properly, cycle tracks can also increase cyclists' safety and convenience.

Type of Segregation

Cycle tracks can take many forms:

- Raised bicycle lane elevated several centimetres above the adjacent traffic lanes; preferable at a different level than adjacent sidewalk so pedestrians do not use it and cyclists are not tempted to use the sidewalk. A mountable curb (maximum 4:1 slope) allows faster cyclists to pass slower cyclists using the adjacent lane if the cycle track is not wide enough for passing or becomes congested.

- Segregated on-street bicycle lane, separated from other traffic lanes by a physical barrier such as a median, delineators / flexible posts / bollards, planters or parked cars

Greater separation or barriers increase the level of comfort, separation from traffic, and also reduce the possibility of stopping/parking cars and delivery trucks encroaching into the bikeway. For bikeways without physical barriers, this type of encroachment is frequent on busy commercial streets or high-rise residential areas, where drivers are likely to stop on-street or double-park to save a few minutes. Simpler barriers, such as flexible posts / bollards or raised cycle tracks, will limit this illegal stopping and parking, while stronger physical separators can completely eliminate it. Stronger barriers, however, will require more space not only for the barrier itself, but also to allow for cyclists to pass one another and avoid sudden obstacles as they will no longer be able to easily ride across the margins of the segregated bike lane. They may also introduce complications with drainage and access at intersections.

The effectiveness of separation from encroachment depends on the type of separator used:

- A painted median with delineator posts is likely the least effective, because cars and small trucks can sneak between posts to park. Delineators spaced 20 m apart are effective at keeping moving cars out of the cycle track. However, the delineators require maintenance: those that are hit near intersections or driveways need replacement, and they may need to be removed in winter and reinstalled in the spring to allow for snow removal operations.

- Separation by on-street parking is very effective provided that the parking is well used

- A concrete median, mountable curb or elevated curb can be effective but, while they are unlikely to straddle it, cars and trucks can still park with two wheels on top of the median or curb. A mountable curb (maximum slope of 4:1 for cyclists to be able to traverse it) is easy for motorists to drive onto so they should only be used where there is good compliance to no parking/stopping, strict enforcement or very little parking demand.

- A higher barrier or planters completely prevent encroachment into the path

Intersections are the critical point when designing segregated facilities and the design should take into account the many different possible movements of cyclists. The segregation means that cyclists are positioned in a fixed location; they typically cannot merge across barriers to turn left, and motorists cannot merge to the right of through cyclists to make a right-turn. Specific treatments are presented in Section 6.4.3, page 77.

Examples of various types of segregation for cycle tracks.
Grass boulevard, Vancouver BC

Flexible delineators, Washington DC

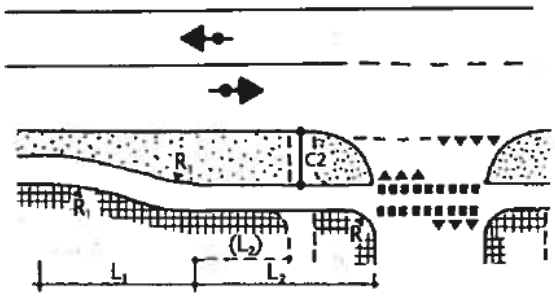
Raised median concrete median, Montreal PQ

Mountable curb and gutter created by saw-cutting existing barrier curb and constructing bike lane behind the curb, Guelph ON

Concrete curb stop with intermittent bollards, Ottawa ON
(photo by cycleseven.com)

Painted buffer, curb and parking, Long Beach CA

Examples of the segregated bike lane/cycle track "bending in" at an intersection (Carroll Street, Vancouver) and Dutch concept of "bending out" at driveways.



Separator / Barrier Design

The design of the separator or barrier must take into account local conditions or needs for:

- Transit stops and passenger boarding and alighting, including those with mobility devices—The separator can sometimes be designed as the passenger waiting area with the cycle track traversing behind it; or must permit transit vehicles to cross it to the curb-side waiting area. Low-floor buses in Canada typically require a barrier curb for passengers to board / alight.

- Street cleaning and winter control equipment and practices—Segregated cycling facilities may have to be removed if the separator is removable, or left unmaintained or closed during the winter season if current equipment cannot clear them of snow and ice. Maintenance may require specialized equipment.

Bus stop integrated with segregated bike lanes in Vancouver BC

Streetcar stop integrated with cycle track in the Netherlands

Bus crossing mountable curb and gutter at bus stop in Guelph ON

Segregated bike lane (mountable curb and gutter) condition after snow event in March with snow piled adjacent boulevard in Guelph ON

Example of bicycle logo, diamond and Reserved Bike Lane sign Guelph ON; and TAC's Turning Vehicles Yield to Bicycles sign (sign should be modified to reflect the type of cyclist facility present in the conflcit zone)

Basic Considerations and Design Criteria for Segregated Bike Lanes (Cycle Tracks)

- Segregated bike lane width:
  - Basic "clear width" minimum 1.8 m; 2.0 m preferred to allow cyclists to pass each other within the segregated lane; 1.5 m allowable at pinch points and at intersections if necessary
  - Width of segregation adjacent travel lane: min. 0.5 m
- Location:
  - Adjacent travel lane; min. buffer width of 0.5 m recommended between segregated bike lane and travel lane
  - Between parking and sidewalk/boulevard; min. buffer width of 1.0 m required to allow for opening parked car doors

- In the boulevard between road and sidewalk, preferably at a different elevation from the sidewalk when pedestrian volumes are moderate to high to discourage pedestrians walking in the bikeway and cycling on the sidewalk. Sidewalks or other pedestrian facilities should not be narrowed or eliminated to provide cycle tracks as pedestrians will likely walk on the cycle track if sidewalk capacity is reduced or if sidewalk conditions are poor.

- Pavement markings and signs:
  - Bicycle symbol, diamond and optional arrow pavement markings: After every intersection and major driveway. Arrows reinforce the correct direction of travel of cyclists
  - Reserved Bike Lane Signs ((Rb-84 (overhead) or Rb-84A (ground-mounted)) installed after every intersection
- In conflict zones Turning Vehicles Yield to Bicycles sign (TAC RB-37)
- Separator / barrier types—select based on debris sweeping and winter control equipment and practices, and transit stop location and transit vehicle operation (accessible (low floor) buses require a barrier curb for passenger pick-up):
  - Painted buffer/median with delineator posts or bollards
  - On-street parking (segregated bike lane is located between parking and sidewalk / boulevard); min. buffer width of 1.0 m required to allow for opening parked car doors
  - Mountable, semi-mountable or barrier curb; min. buffer width to curb if not mountable of 0.5 m
  - Raised concrete median
  - Planters; planter and vegetation height less than 0.75 m; and lower within 30 m of intersections
  - If separator is traversable, max. 4:1 sloped concrete curb, then no buffer is needed between the separator and the bike lane
  - If the separation is raised, no buffer is needed if below pedal height of 60 mm
- Cross-fall towards street for drainage in adjacent roadway
- Because of the difficulty and danger of allowing other traffic to cross the cycle track, not recommended on streets where there are many major and closely spaced intersections or driveways
- Two-way cycle tracks or segregated bike lanes on one side of two-way streets are not recommended unless distances between intersections / major driveways are long (more than 300 m), they link other two-way facilities, or other local conditions reduce or eliminate the volume and speed of traffic turning left across the bikeway. Minimum width 3.0 m; 2.0 m allowable at pinch points if necessary
- Major intersection / driveway treatments:
  - If speeds are greater than 50 km/h, provide intersection treatments to limit motor vehicle speeds
  - Provide two-stage queue boxes to accommodate cyclists' left-turns from the segregated bikeway
  - Bend the segregated bikeway "in" towards the travel lane approaching major intersections to improve motorists and cyclists visibility of each other

- Mark approach and/or departure at intersection with green colour or “sharrows”; green on the approach has been found to improve safety
- Mark path through intersection with green colour, “sharrows”, dashed guidelines, sharrow, or combination of these in the conflict areas
- Consider banning right-turns on red signal phase to reduce potential conflicts
- Consider restricting left-turns from the parallel main road to a protected signal phase only
- Consider providing a leading bicycle and pedestrian phase to reduce the conflicts with turning motorists

➢ Minor intersection / driveway treatments:

- Consider raising the bikeway and sidewalk through driveways creating an incline that serves as a speed hump for motorists
- Mark with green colour, “sharrows”, dashed guidelines, yield symbols, sharrow, or combination of these in the conflict area

➢ Bend the segregated bikeway “out” towards the sidewalk and crosswalk approaching minor intersections and driveways so that motorists cross the crosswalk and bikeway in a separate action from entering or exiting the major street traffic. Space is provided between the bikeway crossing and the crosswalk for motorists to yield without blocking the crossing. This recommended distance between the edge of the roadway and the trail is 4 to 6 m.

6.3.4 Boulevard Multi-Use Trails

A multi-use trail located within the boulevard of a roadway and generally parallel to the road is separated by a grassed or landscaped buffer. Children often are encouraged to ride on boulevard trails and they are sometimes preferred by casual cyclists and non-cyclists because they provide separation from motor vehicles. When the number of users is reasonable for the width of the facility (i.e. conflicts between users is low), and there are few driveways and intersections, a boulevard multi-use trail can provide a comfortable place to travel without being in traffic.

Example of boulevard multi-use trail in Milton

There are various elements to be wary of when placing multi-use trails in roadway boulevards that reduce their function and safety:

- The lack of traffic control at intersections does not give cyclists the right-of-way and decreases their comfort, and the directness or functionality of the path compared to on-road bikeways. On-road bikeways are governed by the intersection traffic control provided to motorists (or separate bicycle signals). The Highway Traffic Act prohibits cyclists from riding in crosswalks so a cyclists involved in a collision in the crosswalk will typically be at fault even though the motorist may have failed to yield the right-of-way.

- The fact that the multi-use trails are usually built on only one side of the street reduces their accessibility to residents and destinations on the opposite side of the street. The idea of riding along the trails gives a sense of comfort. Trying to access the trail or leave

the trail from across the street is problematic, leading to mid-block crossings, cycling the wrong way on the road, and cycling on the sidewalk.

- The risk to the cyclist going unnoticed by motorists turning in and out of side streets and driveways is a real safety concern particularly as the number of cyclists (exposure) increases (similar safety concerns apply to a bi-directional bike lane or two-way segregated bike lane on one side of a two-way street). For example, a motorist turning left or right out of a driveway or side street may notice the cyclist coming towards them on their left, but will generally not notice the cyclist approaching from the right (the motorists is generally looking forward or left to find a gap in traffic). The motorist turning left from the main street into the side street or driveway is looking forward to accept a gap in opposing traffic. As they accelerate to cross opposing traffic, a motorist will not see cyclists, particularly ones on their left approaching from behind. The speed at which the motorist is trying to cross opposing traffic increases risk. This is further complicated by the lack of experience and understanding of the risk by less experienced cyclists who choose to ride on these multi-use trails.

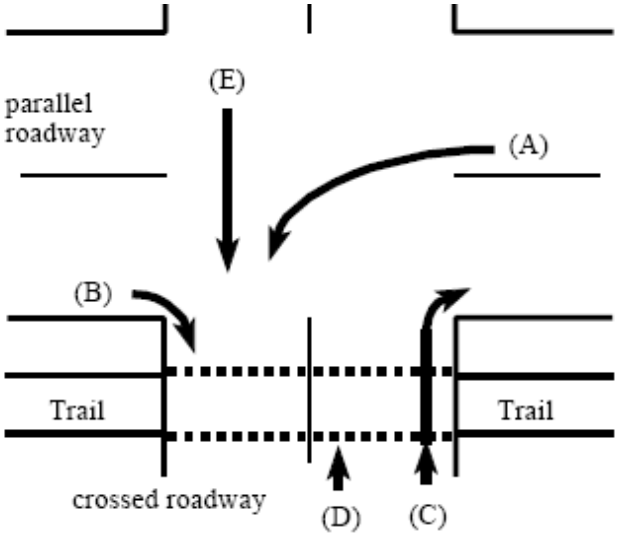
- The beginning / end of the trail needs to be designed to allow users to transition to other bikeways and pedestrian facilities such that cyclists do not end up riding on sidewalks or riding the wrong-way on the road against traffic.

- In areas with moderate to high pedestrian volumes, the higher speed cyclists will decrease their comfort and safety. U.S. Federal Highway Administration's Shared-use Path LOS (SUPLOS) calculator[9] suggests that a 3.0 m wide, multi-use, asphalt trail without a centreline can accommodate about 20 persons/hour at level of service (LOS) A; about 70 persons per hour at LOS C, and about 130 persons/hour at LOS C. This particular calculation assumes a mix of users consisting of 55% adult cyclists, 20% pedestrians, 10% runners, 10% in-line skaters, and 10% child cyclists.

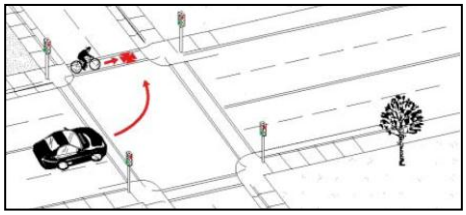
Risks at intersections are further explained in Exhibit 6-4.

[9] U.S. Department of Transportation, Federal Highway Administration, Shared-Use Path Level of Service Calculator, http://www.fhwa.dot.gov/publications/research/safety/pedbike/05138/ (July 2011).

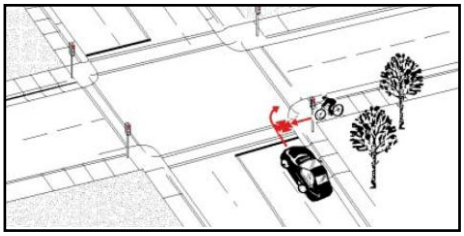
Exhibit 6-4: Crossing Dangers at Multi-use Boulevard Trails and Intersections / Driveways



(A)



(C)



(A) Left-turning motorist is focused on gap selection. Accelerating through the turn, the driver is then faced with the unexpected trail crossing. While the driver was waiting to make the turn, a fast-moving right-to-left cyclist outside the driver's field of view may overtake arriving in the crossing. Slowing or stopping for trail users, this left turning motorist may interfere with through traffic on the parallel roadway.

(B) Left-to-right trail users are out of the field of view of higher speed right-turning motorists

(C) Right-turning motorists are looking left while turning right; right-to-left trail users are out of their field of view. They may also obstruct the trail crossing.

(D) Through motorists may obstruct the trail crossing or obscure the view of right-turning motorists and of left-to-right trail users.

(E) Motorists crossing the road at a signal need a clearance interval that is long enough to allow them to cross the trail before the signal changes providing the trail right-of-way.

Trail Pavement Markings and Signage

When conflicts occur between users on multi-use trails, it is typically an indication that the width of the trail is inadequate for the mix and volume of users it attracts. Striping a centreline is one way to separate opposing directions of travel to reduce conflicts when the width of the trail cannot be modified. Research has found that the presence of a centerline stripe results in a significant reduction in the level of service of a path[10]. It appears that cyclists may feel less comfortable making a same-direction passing movement when a centerline stripe is present. While this finding might appear initially to mean that a centerline stripe should not be used, it is important to note that there may be other valid safety reasons for providing a centerline stripe, particularly on crowded trails, on curves with limited sight distance, and in other appropriate circumstances.

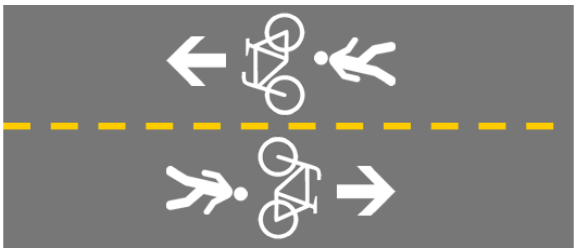
The centreline strip should be yellow; dashed where passing is allowed and solid where passing is discouraged. A solid centreline stripe is typically applied where there is heavy use, on curves with restricted sight distance or design speeds of less than 25 km/h, and approaching intersections.

[10] Ibid.

Segregating 3.0 m wide multi-use trails into one half for pedestrians and one half for cyclists does not provide sufficient width for cyclists or wheelchair users to remain on their side and pass each other travelling in the same direction. This can result in both sets of users being frustrated as others encroach on their space. The shared-use of the trail can be reinforced instead with logos of pedestrians and cyclists with arrows in the "lanes" showing the direction of travel. Signs can also be added messaging "keep right, pass left", "cyclists yield to pedestrians", and "give warning before passing". Pavement marking and signage examples are illustrated in Exhibit 6-5.

Exhibit 6-5: Pavement Marking and Sign Examples for Boulevard Multi-use Trails

Example of yellow centreline striping (1 m solid, 1 m gap) with bicycle and pedestrian logos and arrows reinforcing shared-use and the direction of travel.



Examples of sign options that encourage courteous sharing of multi-use trails. The "Yield to Pedestrians" sign (RB-39) is included in TAC's *Bikeway Traffic Control Guidelines for Canada* (2012).

Side Street Intersection Pavement Markings and Signage

As previously discussed, operational and safety issues associated with multi-use boulevard trails include the lack of traffic control for users at side street intersection crossings, the law prohibiting cyclists to ride through crosswalks, and cyclists going unnoticed by motorists turning in and out of side streets. Where a multi-use boulevard trail is being proposed in place of on-road cycling facilities, there is a need to address these issues.

At intersections, the greatest concern is for trail users being in conflict with right and left-turning vehicles. At signalized intersections, trail users should have the right-of-way when crossing with the pedestrian and green phase for that direction. At unsignalized intersections, they should also have right-of-way over side street vehicles at stop signs and motorists turning from the main street as long as they enter the crossing in time for the motorist to yield. However, Ontario's Highway Traffic Act (HTA) only covers these situations for pedestrians on a sidewalk at a crosswalk (marked or unmarked). In absence of clear rules of the road, it is prudent to consider a "pilot project" defined under the HTA as a project for research into or the testing or evaluation of any matter governed by the Act or relevant to highway traffic, including matters that are prohibited or regulated by the Act. Alternatively, the municipality can create a by-law to address the situation as long as the by-law does not contradict anything in the HTA. Then appropriate signage and pavement markings recognized in national or provincial guidelines can be installed to communicate to all users the rules and expectations

Two signs are included in TAC's *Bikeway Traffic Control Guidelines for Canada* (2012) that can be applied to this situation: "Yield to Bicycles and Pedestrians" sign (RB-38) and "Bicycle Trail Crossing Side Street Sign" (WC-44R or L and WC-44T). The former is used in exceptional cases when the basic right-of-way rule does not provide for safe and efficient movement of vehicles, cyclists and pedestrians. The latter is used when the distance between the intersection and the trail

crossing is insufficient to erect a "Bicycle Crossing Ahead" sign. Examples of these signs are shown in Exhibit 6-6.

The situation is further complicated by the prohibition of cyclists riding in crosswalks at traffic control signals in Ontario's Highway Traffic Act:

> ***Riding in crosswalks prohibited:*** *No person shall ride a bicycle across a roadway within or along a crosswalk at an intersection or at a location other than an intersection which location is controlled by a traffic control signal system. R.S.O. 1990, c. H.8, s. 144 (29).*

In recognition of this, TAC developed the "elephant's feet" pavement marking published in the *Bikeway Traffic Control Guidelines for Canada* (2012) to mark the bicycle crossing. The City of Mississauga requested permission from the Ministry of Transportation, Ontario to test elephant's feet, or "crossrides", first at unsignalized and then at signalized boulevard multi-use trail crossings. An example of the markings is provided in Exhibit 6-6. Elephant's feet are being implemented elsewhere in Canada in association with other types of cycling facilities to mark where they cross through intersections.

Note that is it unreasonable to expect cyclists to dismount to walk through crosswalks. It takes energy to dismount, the cyclists can become de-stabilized during dismounting, and it is more difficult to control the bicycle while walking beside it especially if it is loaded or heavy.

Bicycle / pedestrian symbols and/or green pavement markings are being used to mark driveway crossings, as illustrated in Exhibit 6-6. These are intended to increase the motorist's awareness of the trail users so that they will give them the right-of-way.

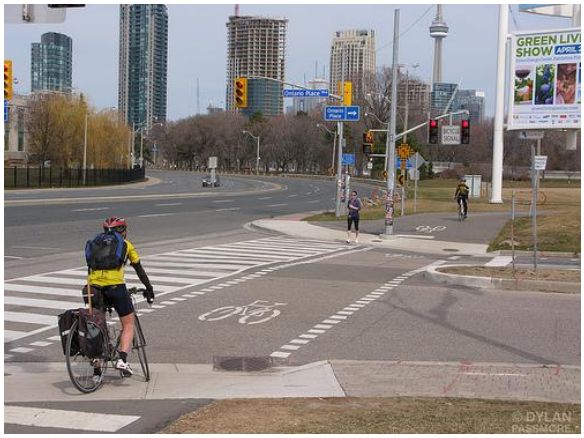
Exhibit 6-6: Examples of Signage and Pavement Markings are Side Street Intersections and Driveways at Boulevard Multi-use Trails

Examples of sign options regarding the operation of boulevard multi-use trails at side street intersections. Both are included in the Ontario Traffic Manual Book 18: Cycling Facilities.

"Yield to Bicycles and Pedestrians" sign (RB-38)

"Bicycle Trail Crossing Side Street Sign" (WC-44L and WC-44T)

Bicycle crossing markings, often referred to as Elephant's feet, are shown below at boulevard multi-use trails in Mississauga ON and Toronto ON



Mid-block Trail Crossings of Regional Roads

There are two options for multi-use trail crossing of Regional roads at mid-block or non-intersection locations:

- Provide pedestrian signals if located within an urban area or built-up area and safety and operational conditions can be satisfied—the warrant and treatment of pedestrian signals are provided in OTM Book 15: Pedestrian Crossing Facilities.

- Provide a mid-block cross-ride, with a median refuge island on multi-lane roadways (see section 5.7.3, page 50). Trail users will have to select a gap in traffic to cross; motorists are not required to yield or stop for them at crossings not controlled by yield or stop signs, or signals. Gap studies should be undertaken to determine if sufficient gaps in traffic exist. Warning signs are installed on the roadway approaching the crossing.

Basic Considerations and Design Criteria Boulevard Multi-use Trails

- Not recommended along roadways unless distances between intersections / major driveways are long (more than 300 m), or other local conditions reduce or eliminate the volume and speed of traffic turning left across the trail
- Intersection treatments to reduce risks:
  - Pilot the use of pavement markings in the road crossings to highlight the presence of the bicycle and pedestrian crossing ("cross-rides")
  - Restrict left turns from the parallel main road at traffic signals to a protected signal phase only if possible
  - Eliminate parking near the intersection / driveways to improve sightlines
  - Incorporate protected traffic signal phasing for trail users to cross major intersections
  - Design the intersection for low-speed right-turns
  - Eliminate right-turn only lanes if volumes do not warrant them

  - Setback stop lines on the side streets/driveways so traffic does not block the trail crossing

- Minimum width of 3.0 m allows:
  - Three pedestrians to walk side-by-side
  - Two cyclist to ride side-by-side
  - A cyclist to pass two pedestrians walking side-by-side
  - An in-line skater in motion to pass a pedestrian but cannot pass a cyclist without slowing down
- Enhanced width of 4.0 m allows:
  - Four pedestrians to walk side-by-side
  - Three cyclist to ride side-by-side
  - Two in-line skaters to skate side-by-side
  - Two cyclists riding side-by-side to pass two pedestrians walking side-by-side
  - An in-line skater in motion to pass two pedestrians walking side-by-side or one cyclist
- Provide minimum 0.6 m wide shoulder or graded area (flatter than 1:6) on both sides of the trail
- Provide a clear zone of 0.9 m wide on both sides of the trail to provide adequate clearance to trees, abutments, poles, guiderails and other hazards
- Consider piloting side street crossing treatments so cyclists do not have to ride illegally in crosswalks:
- Cross-rides (white 200 to 400 mm squares spaced 200 to 400 mm) bordering the pedestrian crosswalk markings both sides and placed min. 0.4 m on either side of the crosswalk markings. Consider centreline pavement marking (yellow 100 mm wide):
  - Broken line where passing is permitted, 1 m solid by 1 m gap
  - Solid centreline where passing is discouraged such as where sightlines are limited, approaching intersections or other locations where there are potential conflicts between users or the number of users exceeds the capacity of the trail
- Consider piloting regulatory and warning signs:
  - In conflict zones Yield to Bicycles and Pedestrians (TAC RB-38)
  - On main road in advance of side street crossing Bicycle Trail Crossing Side Street Sign (TAC WC-44L or R and WC-44T)
- When pedestrian and cyclists use exceeds the capacity of the trail and there are conflicts among users, consider one or all of the following:
  - Yield to Pedestrians (Rb-73)
  - “Keep Right, Pass Left”
  - “Give Warning Before Passing” signs
  - Alternate materials to encourage users to travel at lower speeds. Concrete, which will have a longer life cycle than asphalt, is perceived as more conducive to slower modes. Reduce bumps in concrete surface by providing expansion joints every 30 m and saw-cut contraction joints every 2.5 m with no tooling
- For mid-block crossings determine if there are sufficient gaps in traffic to have an uncontrolled crossing (a median refuge island is recommended it the crossing is more than two lanes wide) or pedestrian signals can be installed

6.4 Intersection Treatments for Cyclists

The planning and design of cycling facilities has focused in the past on what type of facility should be implemented on which roads. A cycling facility will serve many origins and destinations. Some cyclists will ride the entire route, while others will get on and off at many mid-point locations. As with roadway design for motorists, thoughtful consideration is needed to plan and design intersections for cyclists. Various designs are being implemented in North America to improve cyclists' comfort, safety and accessibility at intersections.

Some of the more popular intersection treatments are listed below. Examples are shown in Exhibit 6-7. The NACTO guide is the most recent publication in North America with information on the more innovative intersection treatments; some of these treatments are included in the Ontario Traffic Manual Book 18: Cycling Facilities.

- **Bicycle detection:** pavement markings at the "sweet spot", push-buttons within reach to trigger actuated traffic signals or other active cyclists' detection (video, infrared, etc.)
- **Bike lane markings approaching and departing intersections:** green colour, "sharrow", and / or chevrons approaching and / or departing intersections to raise the awareness of motorists who may be merging or crossing the cyclists' path. Green colour in the bike lane on the approach has been found to improve safety
- **Bicycle routing marked through intersections:** green colour, bicycle symbols, chevrons, and / or dashed guide lines in part or all of the route within the intersection where motorists may be crossing the cyclists' path
- **Bicycle left-turn pocket:** adjacent motorists left-turn lanes or on its own at a trail access
- **Bicycle lay-by for left-turns** at T-intersections
- **Bike box or advance stop bar (one-stage bike box):** set-back stop bar and bicycle symbol, with or without green colour to reduce "right-hook" incidents or provide cyclists access to the left lane on a two-lane approach at a traffic signal. Requires bike lane on the approach to the intersection to provide access to the bike box
- **Left-turn queue box:** waiting area with bicycle symbol with or without green colour for cyclists making a "pedestrian-type", two-stage left-turn at a traffic signal

Exhibit 6-7: Examples of Intersection Treatments for Cyclists

Bicycle detection: push-button in reach, Vancouver BC

Bicycle detection: pavement marking in “sweet spot” of loop detector, Vancouver BC (photo credit: Richard Drdul)

Bicycle lay-by at signalized T-intersection with push-button within reach, Vancouver BC

Bike lane marking approaching and through a signalized intersection: green on the approach, bike box for reducing ”right-hook” incidents, and green with guide lines through the intersection, Portland OR

Bicycle route marked through intersections: “sharrow” bicycle symbol and chevrons, Montreal PQ

Bicycle route marked through intersections: “sharrow” bicycle symbol and chevrons, Chicago IL (photo credit: www.NACTO.org)

Bicycle left-turn pocket: adjacent motorists’ left-turn lane, Vancouver BC

Bicycle left-turn pocket: at trail access, Victoria BC

Bicycle scramble or Barnes Dance phase connecting multi-use trail to street, Portland OR

6.4.1 Advanced Stop Bike Box

An advanced stop bike box consists of a set-back stop bar and bicycle symbol, with or without green colour to provide cyclists access to the left lane on a two-lane approach at a traffic signal. Bike boxes require an ingress bike lane on the approach to the intersection to provide access to the bike box. The left-turn by the cyclist is completed in one stage: moving into the bike box and progressing left through the intersection on the appropriate signal indication (green or green left-turn arrow).

Advanced stop bike box: to allow cyclists to turn left on two-lane, signalized approach, Guelph ON

Advanced stop bike box: to allow cyclists to turn left on two-lane, signalized approach, Waterloo ON

Basic Considerations and Design Criteria for Advanced Stop Bike Boxes

- Applicable to signalized intersections; suitable for not more than two-lanes on the approach to the intersections
- Bicycle detection required if signal is actuated
- Prohibition of right-turns on red recommended (install OTM Book 5 No Right on Red sign, Rb-79R)
- Depth of bike box (separation space between crosswalk and vehicle stop bar): min. 2.75 m; 4.0 m recommended, max. 7 m
- Provide ingress bicycle lane (if bicycle lane not present) to guarantee cyclists' access to bike box, min. 7 m long or as long as the through traffic queue length
- Pavement markings and signs:
  - One bicycle symbol for each approach lane centred in bike box and in front of approach lane
  - Install Stop Here on Red Signal sign (Rb-78) with Except Bicycles Tab sign (TAC RB-9S) at stop bar for motorists
  - Optional green colour in box and ingress bicycle lane
  - Optional "Wait Here" pavement marking behind stop bar for motorists

6.4.2 Two-stage Left-turn Bike Box

A two-stage left-turn bike box is a waiting area with bicycle symbol with or without green colour for cyclists making a "pedestrian-type", two-stage left-turn at a traffic signal. Cyclists make the left turn by progressing straight through the intersection on the green phase, wait in the bike box on the far side of the intersection during the cross street red phase, and then progress straight through on the cross street during the green phase, completing their turn in two stages. Various locations are possible for the bike box depending on the configuration of the intersection, i.e., location of the crosswalk, curb radii, presence or absence of on-street parking and right-turn lane, configuration of the bikeways on each leg of the intersection, etc. Two-stage left-turn boxes may increase cyclists comfort in making left-turns, but also increase their delay due to the need to receive two green signals before proceeding.

Two-stage left-turn bike box: for cyclists making "pedestrian-type" left turn at a traffic signal, Toronto, ON. A green bike lane marking through the intersection is also shown (not related to the green bike box)

Basic Considerations and Design Criteria for Two-Stage Left-turn Bike Box

- Applicable to signalized intersections; suitable or multi-lane approaches to the intersection
- Highly recommended for use with segregated bike lanes to facilitate left-turns when merging into adjacent travel lanes prevented by the segregation
- Locate in a protected area such as shadowed by downstream on-street parking, between the bike lane and crosswalk, etc. Not recommended on far side of parallel crosswalk requiring cyclists to ride across crosswalk to access bike box
- Bicycle detection required if signal is actuated
- Prohibition of right-turns on red recommended (install No Right on Red sign, Rb-79R)
- Size of bike box preferably 1.2 m wide by 3.0 m long
- Pavement markings and signs:
  - One bicycle symbol and left-turn arrow pavement marking centred in bike box outlined by 100 to 200 mm wide white line
  - Optional green colour in box

6.4.3 Bike Lanes at Roundabouts

Roundabouts are used to control traffic and assign right-of-way at intersections. In Halton Region they are an alternative to installing traffic control signals. The advantages of roundabouts over signals are that they reduce speeds, reduce some types of vehicle collisions and, in particular, their severity, and can increase the vehicle capacity of the intersection.

From a cyclist's perspective, areas of concern with roundabouts are:

- Where roundabouts have more than one circulatory lane, there is a greater risk of motor vehicles colliding with cyclists than for single-lane roundabouts

- Generally motorists do not yield to cyclists at an in-boulevard bypass facility because this crossing is not signal controlled

Bike lanes are terminated on the approach to roundabouts and are not continued around the circulatory roadway. This is to prevent the cyclist riding in such a bike lane from being overtaken on the circulatory roadway and then being cut-off by vehicles exiting the roundabout, i.e. turning right immediately in front of them.

Guidance on terminating and beginning the bike lane on the entry and exit approaches to the roundabout is provided in OTM Book 18: Bicycle Facilities. It recommends cyclists and motorists navigate through a single-lane roundabout in single file, sharing the circulatory roadway. For multi-lane roundabouts, it recommends that cyclists should be given a choice between sharing the roadway with motorist and transitioning to an in-boulevard bypass facility.

Basic Considerations for Bike Lanes at Roundabouts

- For all roundabouts, terminate and begin the bike lane on the entry and exit approaches to the roundabout
- For single lane roundabouts, transition to a shared-roadway in advance of the roundabout; install Shared Use Lane sign and Single File tab sign (Wc-19 with Wc-19t) and sharrows pavement markings on the entry and exit approaches.
- For multi-lane roundabouts:
  - Transition to a shared-roadway in advance of the roundabout; install Shared Use Lane sign and Single File tab sign (Wc-19 with Wc-19t) and sharrows pavement markings on the entry and exit approaches
  - Provide an alternate route via a pathway in the boulevard for the cyclist to cross using the splitter islands and the pedestrian crossing. A bicycle ramp connects the bike lane to the pathway. “Cross-bike” pavement markings and signage are recommended.

6.4.4 Bike Lanes at Interchange Ramps

Crossing freeway interchange ramps is a difficult task for cyclists. Cyclists and motorists are travelling somewhat parallel to each other while motorists are merging or diverging while transitioning from high speeds to low or vice versa. This makes it difficult for them to see each other and to judge each other’s speeds. If the ramps operate at lower speeds, 70 km/h or less, then the bicycle lane can be continued through the ramp and the area where the motorist crosses the bicycle lane marked as a conflict zone. The responsibility is on the motorist to merge or diverge across the bicycle lane when it is clear to do so. However, casual or inexperienced cyclists will feel uncomfortable in this situation and may choose to ride on the sidewalk or avoid using a bicycle altogether for a trip that crosses an interchange. Alternatively, cyclists can be routed off-road to cross the ramp perpendicular to traffic. They may be routed onto a sidewalk if it is wide enough to share with pedestrians and appropriate curb cuts are provided. The responsibility is on the cyclist to choose a gap in traffic assuming gaps are available. If traffic is heavy and high speed with few gaps for crossing, then an alternate route or separate structure may need to be considered to accommodate cyclists.

Guidance for treatments at low and high speed merging and diverging ramps is provided in OTM Book 18: Bicycle Facilities.

Effort should be made to design interchanges to accommodate all intended users safely and conveniently. Changes to the interchange configuration to eliminate or reduce the number of free-flow merging and diverging ramps should be considered during re-design and new design projects.

Basic Considerations for Bike Lanes at Interchange

- For bicycle lane crossing treatments of lower speed merging and diverging ramps (70km/h or less) consider continuing the bike lane across the ramp and marking the conflict zone and signs for motorists to yield to cyclists (Ra-2 for merging ramps and RB-37 (TAC) for diverging ramps.
- For all merging and diverging ramps, consider an alternate off-road pathway to allow cyclists to cross the ramp in a gap in traffic; gap studies should be undertaken to determine if this is possible. Shared use of the sidewalk if pedestrian volumes are low and curb ramps are provided is possible. Various configurations, bicycle route signage, regulatory and warning signs are provided in OTM Book 18.

6.4.5 Intersection Design for Segregated Cycling Facilities

Intersections are the critical point when designing segregated cycling facilities and the design should take into account the many different possible movements of cyclists. Those going straight should have priority over turning cars and they should also not be impeded by pedestrians. Cyclists turning right may have to wait for pedestrians. With a 2.0 m wide path, other cyclists can pass them while they wait, but with a narrower path other cyclists will be forced to queue.

With a segregated cycling facility, left-turning cyclists cannot move into a left-turn lane in advance of the intersection (See Exhibit 6-8). Accommodating left-turning cyclists at signalized intersections can be done as follows:

- Provide a separate traffic signal phase that protects left-turning cyclists
- Provide a two-stage left bike box so that cyclists cross to the far-side of the intersection during the main street green signal phase, wait in the designated area (bike box), and then cross to the side street during the side street green signal phase
- Terminate the segregation approaching the intersection and provide a (one-stage) bike box (if the approach is 2-lanes wide or less)

It is strongly recommended that on-street segregation be maintained right up to the stop bar at a signalized intersection if cyclists' left turns can be accommodated as noted above. In terms of cyclist comfort and protection from traffic, the approach to the intersection is where segregation is the most valuable. Designs for mixing zones where there are high volumes of traffic crossing the segregated bike lanes are being tried. Examples are provided in Exhibit 6-8.

Segregated bike lanes or cycle tracks require extra care in design to assure good visibility at intersections. An important measure to this effect is prohibiting parking between the bikeway and the adjacent traffic lanes at intersections. The Vélo Québec design manual suggests that any barriers and planters between the bicycle path and traffic lanes should be less than 75 cm tall so that lights on bicycles remain visible at night. The use of higher vegetation should be restricted to mid-block areas and avoided for at least 30 m before an intersection or driveway entrance.

Exhibit 6-8: Examples of Intersection Treatments for Segregated Bike Lanes (Cycle Tracks)

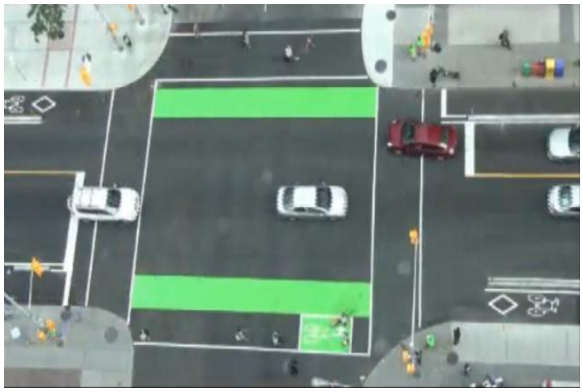
Conventional bike lane transition to segregated bike lane far side of intersection, Richmond BC

Segregated bike lane "bending in" at intersection with red bike box, Vancouver BC

Green pavement in segregated bike lane across driveway, Long Beach CA

Green pavement in segregated bike lane across driveway, Vancouver BC

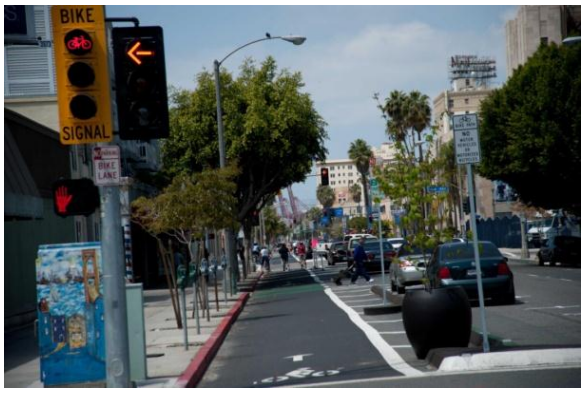
Left-turn queue box: for cyclists making "pedestrian-type" left turn at a traffic signal, and green bike lane through intersection on segregated bike lane, Ottawa ON (photo credit: Citizen Cycle by Ottawa Citizen)



Green pavement, bicycle symbols, elephant's feet and bicycle signals at signalized intersection on a two-way segregated bike lane on a one-way street, Vancouver BC

Signailzed intersection with left-turn lane, bicycle signals, and segregated bike lane on a one-way street, Long Beach CA

Bicycle signal phase on one-way segregated bike lane / street, Long Beach CA



"Begin right-turn lane, yield to bikes" sign at beginning of segregated bike lane / left-turn lane weave on a one-way street, Long Beach CA

Green segregated bike lane at weave to left-turn lane at an unsignalized intersection on a one-way street, Long Beach CA

Buffered bike lane adjacent left-turn lane at unsignalized intersection on a one-way street, Long Beach CA

Bicycle signal head at signalized intersection on a two-way segregated bike lane on a one-way street, Vancouver BC

Mixing zone for right-turning traffic and cyclists, NYC

Left-side buffered bike lane approaching a mixing zone for left-turning traffic / cyclists, NYC

APPENDIX G1

SELECTED BIBLIOGRAPHY OF ACTIVE TRANSPORTATION DESIGN GUIDELINES

SELECTED BIBLIOGRAPHY OF ACTIVE TRANSPORTATION DESIGN GUIDELINES

Active transportation infrastructure includes a number of different types of facilities to accommodate the wide range of abilities, skills and experience of pedestrians, in-line skaters, cyclists, pedestrians with mobility devices, visual, hearing or cognitive impairments, skateboarders, etc. The basic facilities on which they travel consist of: sidewalks for pedestrians including those with mobility aids or devices (i.e., wheelchairs, guide dogs, canes, etc.), child cyclists and small-wheeled users like in-line skaters and skate-boarders; multi-use trails that essentially accommodate all active transportation modes; and bikeways such as bike lanes for cyclists only. General design guidance is provided below and is based on current design guidelines available in North America. Every corridor is unique and the design for each corridor should be custom-made to fit the context of the social, environmental and economic conditions.

Pedestrians and Cyclists

Planning and Design for Pedestrians and Cyclists: A Technical Guide, Vélo Québec Association (2010)

This is the 3rd edition of Vélo Québec's design handbook expanded to include pedestrian design issues. It is a primary source for cycling and pedestrian planning and design guidance in the Canadian context. This manual summarizes the main characteristics of active transportation, discusses the design characteristics of pedestrians and cyclists, presents ideas on creating walkable and bikable environments, and has a section on planning for active transportation. The design sections cover paths and trails, walkways and bikeways in roadway corridors, ancillary elements such as lighting, signs and pavement markings, street furniture and parking, integration with transit, and maintenance and operation of pedestrian facilities and bikeways.

Designing Walkable Urban Thoroughfares: A Context Sensitive Approach, Institute of Transportation Engineers (ITE), 2010

This recommended design practice of the Institute of Transportation Engineers (Washington DC) is a comprehensive guide to the planning and design of major streets in urban areas. It is comprehensive in that it includes all elements of the roadway, whether they are for motorists, pedestrians or cyclists, as they interact to influence the walkability of the corridor. Chapters in the design section include: design controls, and street-side, travel way, and intersection design guidance.

Promoting Sustainable Transportation Through Site Design: An ITE Recommended Practice, Institute of Transportation Engineers (ITE), 2010

This report recommends site design practices that can be applied through the site development process to promote the use of more sustainable modes of transportation, such as walking, cycling and transit. Its primary purpose is to assist policymakers and professionals involved in the preparation, review and approval of non-residential or mixed-use development proposals to identify and incorporate features that make sites more accessible to travel modes other than the single-occupant vehicle (SOV).

Urban Street Design Guide, National Association of City Transportation Officials (NACTO), 2013

This guide covers a broad scope of best practices for designing city streets in North America from the perspective as corridors for conveying people, goods and services, and as public spaces for social, leisure and businesses activities. It presents best practices around street design principles, design elements, and interim design strategies; intersection design principles and design elements, and design controls and performance monitoring.

Canadian Guide to Neighbourhood Traffic Calming, Transportation Association of Canada (TAC), 1998

A common reference for guidance on traffic calming elements such as curb extensions, refuge islands, and other devices that slow traffic and advantage pedestrians and cyclists. Although generally not applicable to arterial roadways, some of the design ideas such as curb extensions and median refuge islands have broader applications in moderate speed environments.

Pedestrians

Ontario Regulation 413/12: Integrated Accessibility Standards made under the Accessibility for Ontarians with Disabilities Act, 2005.

The amendement to this Ontario Regulation under the AODA regulates accessiblity standards for public spaces (built environment) including Recreational Trails and Beach Access Routes, Outdoor Public Use Eating Areas, Outdoor Play Spaces, Exterior Paths of Travel (outdoor sidewalks or walkways), Accessible Parking, Obtaining Services, and Maintenance. The standards for public spaces will only apply to new construction and planned redevelopment. Public sector organizations will have to meet the requirements by January 1, 2016.

Guide for the Planning, Design and Operation of Pedestrian Facilities, American Association of State Highway and Transportation Officials (AASHTO), 2004

This particular AASHTO guide covers characteristics of pedestrians, planning strategies, and facility design, operation, and maintenance. It is a reputable source, with a broad discussion of both planning and design issues around streets and street crossings.

Accessible Sidewalks and Street Crossings—An Informational Guide, Federal Highway Administration (FHWA), 2003

The design details for U.S. accessibility legislation are contained in the Public Rights-of-Way Accessibility Guidelines (PROWAG) and this FHWA manual acts as an abridged version. Until such time that Ontario publishes thier own standards, this guide provides a succinct summary on making sidewalk and street crossings accessible. It covers understanding users, sidewalk corridors, sidewalk grades and cross slopes, sidewalk surfaces, protruding objects, driveway crossings, curb ramps, providing information to pedestrians, accessible pedestrian signals, and pedestrian crossings. A checklist is also provided.

Alternative Treatments for At-Grade Pedestrian Crossings, Institute of Transportation Engineers (ITE), 2001

The report summarizes studies on pedestrian crossings and assembles in a single document the various treatments currently in use by local agencies in the U.S., Canada, Europe, New Zealand and Australia to improve crossing safety for pedestrians at locations where at-grade, marked crosswalks are provided. The report also summarizes the results of various studies conducted by public agencies on pedestrian-related collisions, including those documenting the results of

removing crosswalk markings at uncontrolled locations. The appendix includes policies of specific agencies on where crosswalks are provided as well as typical crosswalk signing and striping plans.

Bikeways

Guide for the Development of Bicycle Facilities, 4th Edition, American Association of State Highway and Transportation Officials (AASHTO), 2012

This AASHTO guide spans planning, design, operation and maintenance of bikeways and bicycle parking facilities for the US. Sections include guidance for on-road faiclities and shared-use paths. This edition updates earlier versions with details on shared roadways, rumble strips, cautionary use of wide outside lanes due to the higher speeds they induce, strategies for retrofitting bicycle facilities to streets, bicycle boulevards, traffic signal considerations, bicycle travel through interchanges and roundabouts, and addressing conflicts associated with shared-use paths along roadways.

Urban Bikeway Design Guide, National Association of City Transportation Officials (NACTO), 2013

NACTO developed this guide as part of their Cities for Cycling initiative to provide cities with state-of-the-practice solutions to create complete streets that are safe and enjoyable for cyclists. It includes descriptions, benefits, applications, design guidance, renderings, images and case studies for bike lanes, cycle tracks (segregated bike lanes), intersections, bicycle signals, and signing and markings. Most of the treatments are not directly referenced in the AASHTO guide or the U.S. Manual for Uniform Traffic Control Devices.

Chapter 3.4—Bikeways, Geometric Design Guide for Canadian Roads, Transportation Association of Canada (TAC), September 1999

The TAC *Geometric Design Guide* provides guidance for the planning and design of roads in Canadian; however, the chapter on bikeways has not changed significantly since initial publication in 1995. Vélo Québec's *Planning and Design for Pedestrians and Cyclists,* noted in Section 3.1, page 8, is the preferred guideline since it is more recently updated and comprehensive.

Ontario Traffic Manual Book 18: Bicycle Facilities, Ontario Traffic Council, December 2013

Ontario Traffic Manual Book 18 is included under *bikeways* and *traffic control*. The Ontario Traffic Council has developed OTM Book 18 within the series of Ministry of Transportation of Ontario publications to provide information and guidance to transportation practitioners in the design, application and operation of traffic control systems in Ontario. Book 18 provides guidance on the planning, design and implementation of bikeways. It outlines the first ever bicycle facility selection process published in a North American guideline, including a "pre-selection nomograph" for the type of bikeway (shared, separated or segregated) based on the volume and speed of traffic on a two-lane roadway.

Traffic Control

Ontario Traffic Manual Book 15: Pedestrian Crossing Facilities, Queen's Printer for Ontario, 2010

The Ministry of Transportation of Ontario publishes a series of *Ontario Traffic Manuals* to provide information and guidance to transportation practitioners in the design, application and operation of traffic control systems in Ontario. Book 15 provides guidance on the planning, design and operation of pedestrian roadway crossings. It outlines the legal requirements, specifically the rules of the road that govern motorists' and pedestrians' movements at controlled and uncontrolled

crossings, and presents the devices, physically separated facilities, and accessibility considerations. An update is expected to respond to proposed amendments to the Highway Traffic Act (Bill 31, 2014), e.g. providing a wide range of pedestrian crossover designs.

Ontario Traffic Manual Book 18: Bicycle Facilities, Ontario Traffic Council, December 2013

The Ontario Traffic Council has developed OTM Book 18 within the series of Ministry of Transportation of Ontario publications to provide information and guidance to transportation practitioners in the design, application and operation of traffic control systems in Ontario. Book 18 provides guidance on the planning, design and implementation of bikeways.

Bikeway Traffic Control Guidelines for Canada (2nd edition), Transportation Association of Canada (TAC), 2012

This guide covers regulatory, warning and information signage, and pavement markings for on-road bikeways and where trails intersect a roadway. It was recently updated to include innovative pavement markings such as shared lane markings ("sharrows"), bicycle boxes and bike lanes at roundabouts.

Guidelines for Understanding Use and Implementation of Accessible Pedestrian Signals, Transportation Association of Canada, 2008

These national guidelines are intended to provide deploying agencies with practical information on public liaison, accessible pedestrian signals installation prioritization and design, installation, operations and maintenance.

Volume V - Traffic Control Devices, ministère des Transports Québec

The Province of Quebec's traffic control device manual includes Chapter 7 on bicycle facilities. Quebec allows the use of the bicycle traffic signals and also includes a section on bikeway way-finding destination / distance signage that is currently not included in the Ontario Traffic Books.

Green Lights for Bikes: Providing for bike riders at traffic signals, Sinclair/Knight/Merz (2010)

Prepared for the State of Victoria, Australia, this report deals with material directly related to traffic signals implemented in Australia and New Zealand. It is an excellent summary of innovative approaches to signals to accommodate cyclists, including detection; start, during and clearance phasing; and other techniques such as the "green wave" synchronization for cyclists. Each traffic signal technique is described along with potential applications, benefits and disadvantages.

Bicycle Parking

Bicycle Parking Guidelines, 2nd edition, Association of Pedestrian and Bicycle Professionals (APBP), 2010

In Spring 2002, the APBP published Bicycle Parking Guidelines, a basic guide to the selection and placement of bicycle racks specifically for short-term parking. This second edition updates the original guide and adds material on long-term and sheltered parking, as well as event parking, in-street bicycle parking, and bicycle transit centres. It includes sample site plans and diagrams to help avoid blunders in rack and locker placement, sample quantity requirements for bicycle parking to meet need by land use, and a worksheet for programming bicycle parking for a building or cluster of buildings.

Bicycle End-of-Trip Facilities: A guide for Canadian municipalities and employers, Transport Canada, 2010

This guide is intended to help municipalities create appropriate and attractive bicycle parking and related facilities that will encourage bicycle use; and determine where, how much, and what type of bicycle parking and related facilities to provide, and how to best design them; and create incentives and regulations that will encourage the provision of bicycle parking and related facilities in the private realm. For employers, it is a useful resource for designing attractive long-term bicycle parking facilities that will encourage employees to commute by bicycle; and designing accessible short-term bicycle parking facilities that will attract cyclist clients.

Guidelines for the Design and Management of Bicycle Parking Facilities, City of Toronto, 2008

This is an excellent resource intended to improve the quality of bicycle parking that is secured through the development approval process. The guidelines provide planners, developers, and property managers with information to support the design, construction and management of high quality bicycle parking facilities. Although aimed at new developments, the Bicycle Parking Guidelines can also be applied to existing developments looking to improve bicycle parking facilities.

How-to Guide: Bicycle Parking, Vélo Québec

A concise four-page leaflet on bicycle parking including six good reasons to provide bicycle parking facilities; and five simple steps to set up parking facilities.

Multi-Use Trails

Trail Intersection Design Handbook, University of North Carolina's Highway Safety Research Center (HSRC) for Florida Department of Transportation (FDOT)

This handbook discusses design processes and principles of designing trail/roadway intersections. A discussion of risks at trail instersections is provided. It includes information on various crossing types, regulating traffic and site design. It also reviews some European trail crossing guidelines. Guidelines from the Netherlands and development of a bicycle crossing time equation are included in the appendices.

Designing Trail Termini, University of North Carolina's Highway Safety Research Center (HSRC) for Florida Department of Transportation (FDOT)

When a trail ends at a roadway junction, trail users must be transitioned back onto the roadway and sidewalk system. This document discusses how to accomplish this transition and provide case studies.

Ontario's Best Trails: Guidelines and Best Practices for the Design, Construction and Maintenance of Sustainable Trails for All Ontarians, Trails for All Ontarians Collaborative (TAOC), 2006

The objective of the TAOC guide is to provide design guidelines for trails that protect and preserve outdoor environments that are universally designed to include people of diverse abilities. The guide provides information about trail design, construction, user amenities, signage and maintenance.

Trail Planning, Design and Development Guidelines, Minnesota Department of Natural Resources (MN DNR), 2006

This manual contains guidelines for creating both motorized and non-motorized trails. It is a best practices guide for government agencies or private organizations and includes sections on planning, design principles, ecological sustainability, trail classifications, shared-use paved trails, and sustainable natural trails.

European Bikeways (includes Segregated Bike Lanes)

The following guidelines are referenced in particular for the planning and design of segregated bike lanes, or cycle tracks, including cross-sectional criteria, side street / driveway layouts, and strategies for intersections.

Design Manual for Bicycle Traffic, Record 25, Centre for Research and Standardisation in Civil and Traffic Engineering (CROW), 2007

London Cycling Design Standards, Transport for London (TFL), 2010

Collection of Cycle Concepts, Danish Road Directorate, 2000

Other References

There is a considerable body of pedestrian and bikeway design guidance in related literature such as neo-traditional development; transit-oriented development (TOD); traffic calming; roundabouts; streetscaping; urban design; and documentation on specific case studies such as road diets, or pedestrian crossings. Many of these can be found through the Pedestrian and Bicycle Information Center (PBIC), the US national clearinghouse for information about health and safety, engineering, advocacy, education, enforcement, access, and mobility for pedestrians (including transit users) and bicyclists; see www.pedbikeinfo.org, www.walkinginfo.org, www.bicyclinginfo.org and www.saferoutesinfo.org (information on safe routes to school policy and programs) (January 2011). Another good source for documents on worldwide cycling policy is Fietsberaad with a web site in Dutch, German, French, English and Spanish, see www.fietsberaad.nl.