NOVEMBER 2019

BC Parkway Intersection Design Guidelines

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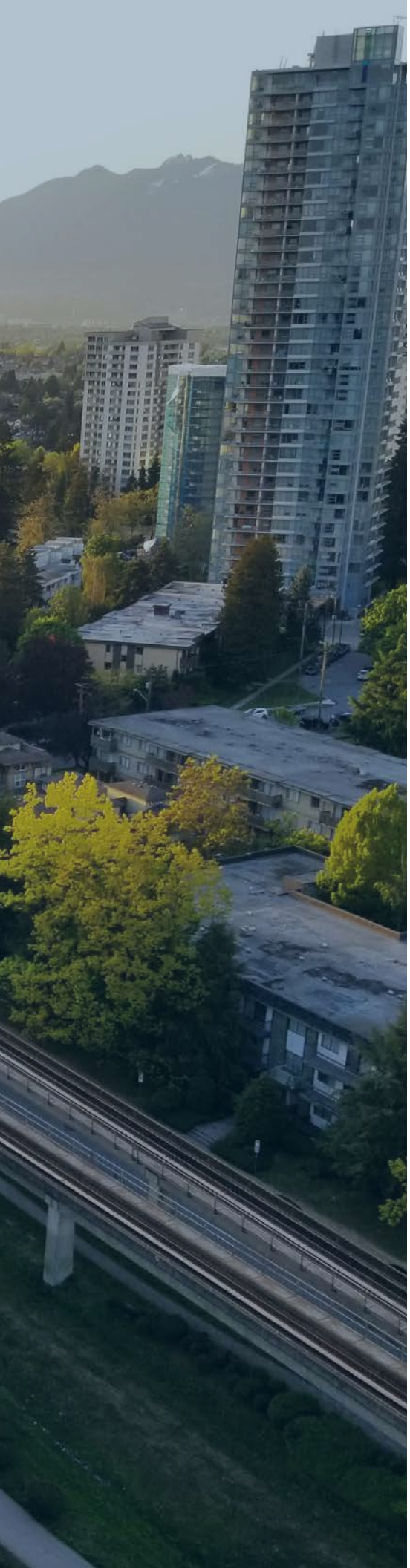

TransLink recognizes that intersection crossings of BC Parkway are under municipal jurisdiction and each municipality has their own design practices, standards, and guidelines for design. The intent of the BC Parkway Intersection Guide is to provide a consolidated document with current best practice examples for pathway crossings at intersections. The Guide is intended to help promote a consistent design approach at BC Parkway intersections and can be used as a support document for municipalities in addition to their own guidelines and standards.

A yellow square on the top corner of the page indicates that detailed design guidance with examples is provided.

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1 INTRODUCTION

1.0 INTRODUCTION

The BC Parkway is an important regional multi-use pathway that extends for approximately 26 kilometres between Vancouver and Surrey along an alignment that roughly parallels the Expo SkyTrain Line. The corridor runs through four municipalities in Metro Vancouver – the City of Vancouver, City of Burnaby, City of New Westminster, and City of Surrey.

TransLink currently has a licensing agreement in place with BC Hydro/Southern Rail for the use of the SkyTrain within their property right-of-way. As a result of this licensing agreement, TransLink also has jurisdiction over portions of the BC Parkway alignment itself. However, the intersection crossings of the BC Parkway fall under the jurisdiction of the municipalities.

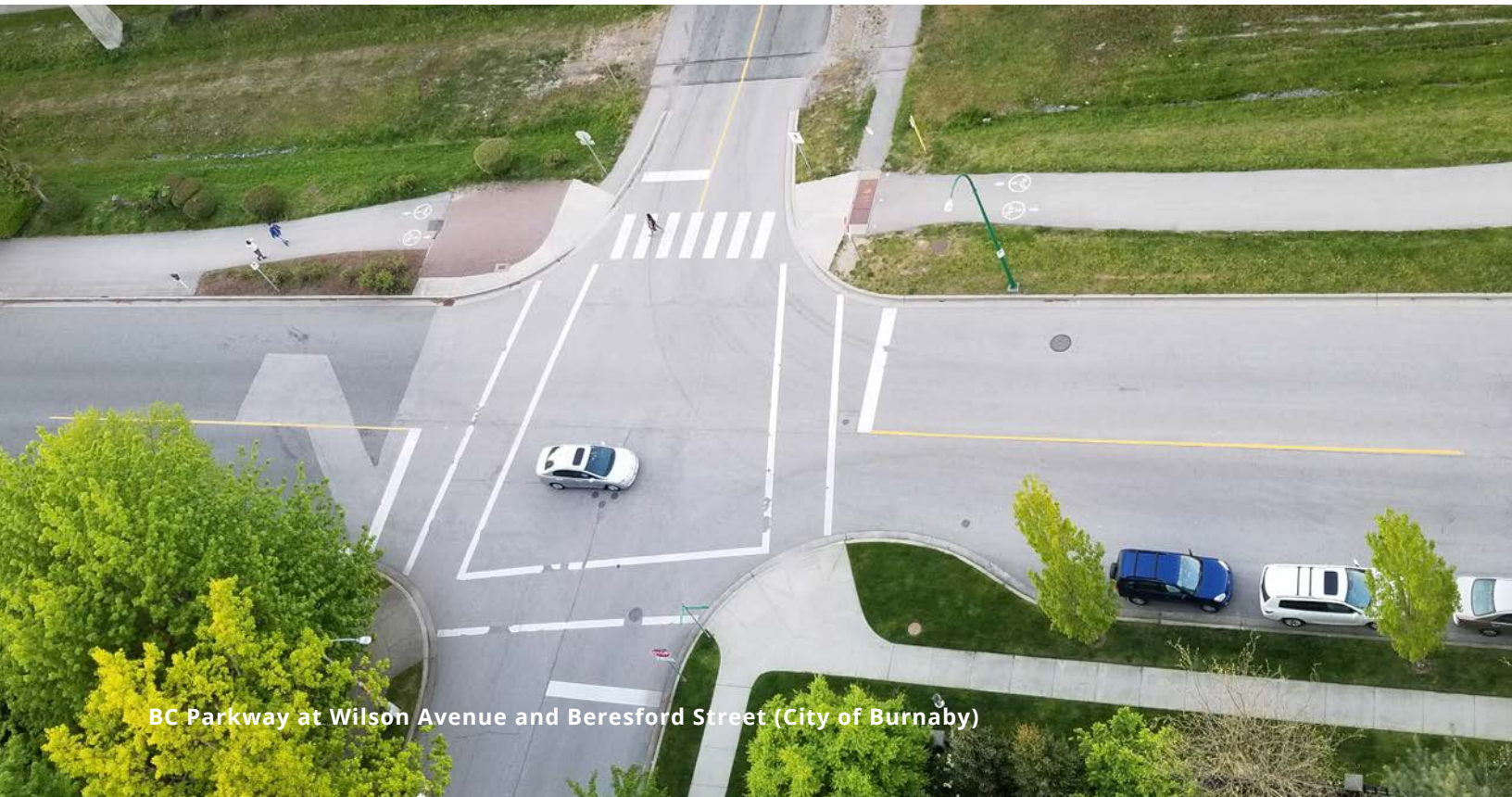
The BC Parkway is an important component of TransLink's bicycle program and the regional major bikeway cycling network. This includes ensuring that the BC Parkway is a continuous active transportation corridor that is comfortable for people of all ages and abilities and that it serves both recreational and utilitarian users. TransLink is particularly interested in ensuring that users travelling along the BC Parkway find it to be an intuitive and low stress experience, particularly when approaching and crossing intersections. As the general design of the BC Parkway is an off-street pathway, the greatest potential for conflict with motor vehicles occurs at intersections.

In recent years, growth and development has impacted the way people use the BC Parkway. There has been a significant amount of residential and commercial development occurring adjacent to and within proximity to the BC Parkway. Additionally, TransLink has recently undertaken several SkyTrain station improvement projects (including the Joyce and Metrotown SkyTrain stations), which impact the way users interact and travel between the BC Parkway and these stations.

In 2009, TransLink developed a Conceptual Design Report for the BC Parkway that recommended significant upgrades to the off-street pathway alignment and at intersections. TransLink is currently working to update the 2009 report and is now developing the BC Parkway Intersection Design Guide to ensure safe and consistent intersection treatments that reflect local, national, and international best practices.

1.1 PURPOSE OF THE BC PARKWAY INTERSECTION DESIGN GUIDE

TransLink is committed to making walking and cycling safe, comfortable, and convenient mobility choices for people of all ages and abilities for all trip purposes, including both transportation and recreation. Improving and maintaining the BC Parkway is an important step for TransLink to achieve the long-term cycling and walking goals identified in the both the Regional Cycling Strategy and the Regional Transportation Strategy. Developing this Intersection Design Guide will help to ensure that a consistent design approach is taken at intersections where the BC Parkway crosses streets in each of the four municipalities. BC Parkway is intended to be used by all modes of active transportation, this includes any human powered travel mode and typically includes cycling, walking, rollerblading, skateboarding, and people using mobility aids. It is important to consider the different travel speeds and operating space of each mode. Developing guidelines that create a consistent design for both pathway users and motor vehicle drivers will lead to a safer and more comfortable facility for all users.



BC Parkway at Wilson Avenue and Beresford Street (City of Burnaby)

The Intersection Design Guide have been developed through consultation with each of the municipalities located along the BC Parkway along with an in-depth national and international best practices review. The guide is intended to be shared with the municipalities which the BC Parkway is located in.

The guidelines in this document are based on current research into best practices for the design of pathways at intersections. All designs that reference the Intersection Design Guide must be carefully considered using sound engineering judgment and must consider any potential legislative and site-specific constraints.

This Intersection Design Guide is only intended to provide guidance specific to intersections along the BC Parkway where the pathway that is travelled by all active transportation modes cross motor vehicle travel lanes. Detailed guidance for other vehicle related items in the street such as lane widths and parking lanes are not provided in the guide and can be found in other national and municipal design guides.

1.2 STUDY PROCESS

The Intersection Design Guide was developed over the course of a one-year period based on an extensive review of national and international best practices as well as engagement with municipalities which the BC Parkway is located in. The work associated with each Phase is summarized below:

PHASE 1: PROJECT LAUNCH

The purpose of this Phase was to ensure a successful launch of the project, including a project kick-off meeting and collecting all relevant background information and data needed to complete Phase 2 and 3. The major deliverable of this Phase was a best practice review summary report.

PHASE 2: DEVELOP DRAFT INTERSECTION DESIGN GUIDE

Phase 2 included developing preliminary content for the planning, design, and operation of BC Parkway intersections based on the literature review and input received during the stakeholder meetings. The draft Intersection Design Guide was presented internally at TransLink and to the stakeholder group made up of the municipalities of Vancouver, Burnaby, New Westminster, and Surrey.

PHASE 3: DEVELOP FINAL INTERSECTION DESIGN GUIDE

Phase 3 involved the finalization of the BC Parkway Intersection Design Guide based on the findings of the best practice review and feedback received from the municipalities through which the BC Parkway is located.

1.3 BASIS OF DESIGN GUIDE

The Intersection Design Guide is intended to build upon existing pedestrian, bicycle facility, and,pathway design guidance provided at the national level in Canada by the Transportation Association of Canada (TAC) through a range of documents, including:

- *Pedestrian Crossing Control Guide* (2018)
- *Canadian Guide to Traffic Calming: Second Edition* (2018)
- *Geometric Design Guide for Canadian Roads* (2017)
- *Manual of Uniform Traffic Control Devices for Canada (MUTCDC): Fifth Edition* (2014)
- *Traffic Signal Guidelines for Bicycles* (2014)
- *Bikeway Traffic Control Guidelines* (2012)
- *Guide for the Design of Roadway Lighting* (2006)

The Intersection Design Guide also draws upon experience and lessons learned from other design guidelines and resources from Canada and around the world:

- *Alberta Bicycle Facilities Design Guide* (2019 – DRAFT)
- *B.C. Active Transportation Design Guide* (2019)
- *Netherlands CROW Design Manual for Bicycle Traffic* (2016)
- *Federal Highway Administration (FHWA): Separated Bike Lane Planning and Design Guide* (2015)
- *Massachusetts Department of Transportation: Separated Bike Lane Planning & Design Guide* (2015)
- *Toronto multi-use Trail Design Guidelines* (2015)
- *National Association of City Transportation Officials (NACTO): Urban Bikeway Design Guide* (2014)
- *Ontario Traffic Manual (OTM) Book 18: Cycling Facilities* (2014)
- *BC Ministry of Transportation and Infrastructure (MoTI) Electrical and Traffic Engineering Manual* (2013)
- *American Association of State Highway and Transportation Officials (AASHTO): Guide for the Development of Bicycle Facilities* (2012)
- *BC MoTI – BC Supplement to TAC; Bikeway Traffic Control Guidelines* (draft 2011 – not published)
- *VéloQuebec: Planning and Design for Pedestrians and Cyclists* (2010)
- *Accessible Pedestrian Signals: A Guide to Best Practices* (Workshop Edition 2010)

1.4 REPORT OVERVIEW

The Intersection Design Guide is divided into six sections:

SECTION 1: INTRODUCTION introduces the Intersection Design Guide, outlining its purpose, the process for development, and the basis of the design guidance.

SECTION 2: DESIGN PRINCIPLES AND CONSIDERATIONS describes general off-street pathway intersection design considerations, including safety and comfort, as well as motorist and cyclist operational and behavioural characteristics.

SECTION 3: ACCESSIBILITY provides guidance on accessibility features such as curb ramps, tactile guides, and crossing distances.

SECTION 4: INTERSECTION DESIGN TREATMENTS provides design principles, considerations, and guidance for intersection approaches, components, and geometric design. This section deals with areas of high potential user conflict and provides guidance pertaining to design treatments, signage, pavement markings, and various other elements.

SECTION 5: LIGHTING AND SIGNAL DESIGN provides design considerations and guidance for street lighting, traffic signal placement, and operations.

SECTION 6: SIGNAGE AND PAVEMENT MARKINGS describes the application and design dimensions of signage and pavement markings used along BC Parkway.

BC Parkway at Kingsway (City of Burnaby)

2

DESIGN PRINCIPLES AND CONSIDERATIONS

2.0 DESIGN PRINCIPLES AND CONSIDERATIONS

This section provides an overview of the key considerations for planning and designing BC Parkway at intersections. This includes prioritizing user safety and comfort, understanding the concept of design domain, and reviewing the specific design parameters for off-street pathways. Design parameters include the dimensions and speed potential of the users and vehicles that will be using the facility, as these characteristics will dictate the minimum design requirements for the off-street pathway.

Off-street pathways such as the BC Parkway are physically separated from the street and are typically located at a higher elevation than the street resulting in grade separation. They are generally perceived as comfortable, low-stress, and attractive routes for people walking, cycling, and those partaking in other forms of active transportation. This is especially true for people who prefer to avoid motor vehicle traffic. This separation from motor vehicle traffic – one of the most significant factors influencing the comfort and safety of people walking and cycling – makes off-street pathways feel safer and more attractive for people of all ages and abilities. However, extra care in intersection design needs to be considered to mitigate conflicts at these locations.

There are two types of off-street pathways:

MULTI-USE PATHWAYS, which can be used by several types of users and is also referred to as shared use pathways; and

SEPARATED BICYCLE AND PEDESTRIAN PATHWAYS, which are intended for the exclusive use of bicyclists and pedestrians respectively.

2.1 SAFETY AND COMFORT

Safety and comfort are key considerations when designing off-street pathway facilities at intersections. The lack of safety – whether real or perceived – is a significant barrier to walking and cycling. The research on active transportation safety generally considers two types of safety:

- **SUBSTANTIVE SAFETY**, which refers to the number of walking and cycling injuries and fatalities at locations; and
- **PERCEIVED SAFETY,** or measures of the reported levels of comfort among active transportation users.

While perceived and substantive safety have been found to be closely aligned when it comes to active transportation infrastructure[1] , perceived safety can vary greatly on a person-to-person basis based on existing comfort levels with walking or riding alongside motor vehicle traffic. Intersections that accommodate active modes should be designed to increase both real and perceived safety and comfort, and to serve people of all ages and abilities, offering safe and comfortable crossing options for those who are interested in walking and cycling, but who may not be comfortable crossing uncontrolled busy streets with high traffic volumes and speeds. All Ages and Abilities, or 'AAA' facilities, are designed to be safe, comfortable, and equitable, creating a welcoming transportation experience for a broad array of users, from children to seniors. Where BC Parkway is a designated multi-use pathway, physically separated from motor vehicles, it is generally considered to be a AAA facility, however, not all of the existing intersections currently meet AAA best practices. In addition to being comfortable for people of all ages and abilities, active transportation facilities should be safe and accessible through all seasons and at all times of day.

Off-street pathway intersection design should consider user safety more broadly by utilizing Crime Prevention Through Environmental Design (CPTED) strategies. Relevant CPTED strategies for off-street pathway intersections should focus on natural surveillance, access restriction, and territorial reinforcement. In essence, the environmental design approach should provide a high level of visibility, casual monitoring of activity at the intersection and along the pathway approach and communicate a clear sense of ownership and responsibility for appropriate pathway use.

[1] UBC Cycling in Cities Program, Bicyclists' Injuries & the Cycling Environment study

2.2 OFF-STREET PATHWAY USERS

BC Parkway is designed to be used by a wide range of user types with varying operating speeds and dimensions, including people:

- Walking (including those using mobility aids, pushing strollers, runners, joggers, and people walking dogs);
- Rolling (using manual or motorized wheelchairs and electric mobility devices);
- Cycling (including a range of bicycle types, such as cargo bicycles, recumbent bicycles, and bicycles with trailers);
- In-line skating or roller blading;
- Skateboarding or longboarding; and
- Using other emerging modes, such as hover boards.

Other than maintenance vehicles, the only motorized vehicles allowed on the BC Parkway are:

- Motorized wheelchairs and other electric mobility devices; and
- Electric-assist bicycles (or e-bikes), as long as the electric bicycle meets the definition set out for "motor assisted cycle" in the British Columbia Motor Vehicle Act.

Minor Intersection Crossing (Green Necklace - City of North Vancouver)

2.3 SEPARATING USERS

The potential for collisions at intersections between pathway users and motor vehicles was noted above. However, intersections can also be a location for conflict between various pathway users. There are a wide range of users and existing facility types approaching intersections, including separated walking and cycling facilities and multi-use facilities that need to be considered when designing intersections. Separating pedestrians and cyclists at intersections is the best practice at all crossings regardless of the pathway configuration of the approach. There are some incidences where a multi-use facility approaches an intersection where a multi-use crossing is preferred, such as at locations with low volumes of pathway users and challenging geometry that restricts sightlines of both pathway and roadway users. Throughout this guide, both shared use and separated bicycle or pedestrian crossings are shown in the intersection figures. Separated crossings are preferred when space exists, and the pathway users are separated on the approach to the intersection or are planned to be in future BC Parkway configurations.

Example of Pathway with Separated Walking and Cycling Facilities (City of Portland)

2.4 DESIGN PARAMETERS

Design parameters, sometimes referred to as the "design user" or "design vehicle," are the user dimensions and speed potential that are used to dictate the minimum design requirements for a given facility. When designing intersections along the BC Parkway, a range of design parameters must be considered, such as the volume and type of people using the facility. In addition to the guidance provided in this document, Section 6.2 of the 2017 *TAC Geometric Design Guide for Canadian Roads* outlines the operating characteristics of people walking and using mobility devices and Section 5.2 outlines the operating characteristics of people cycling. This information can also be found in Chapter B.4 of the *B.C. Active Transportation Design Guide*.

The images outlined on the following pages present the operating envelopes of various BC Parkway users.

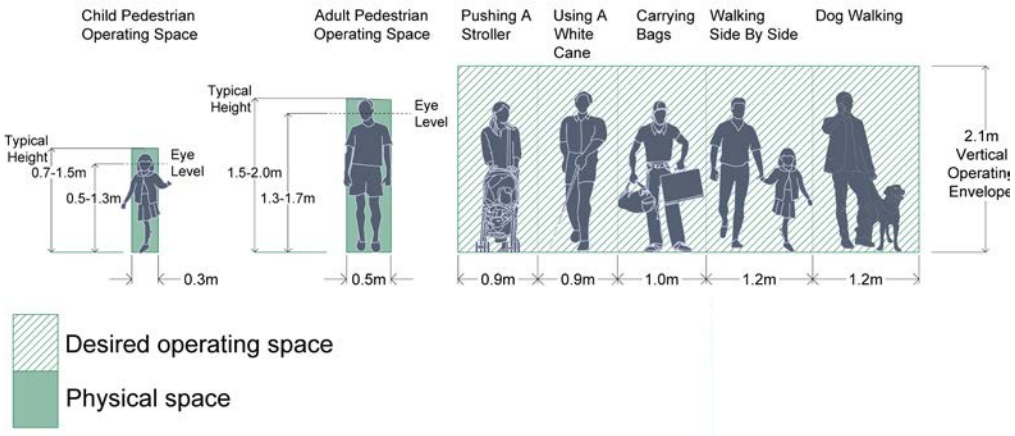


FIGURE 1 - TYPICAL DIMENSIONS FOR PEDESTRIANS

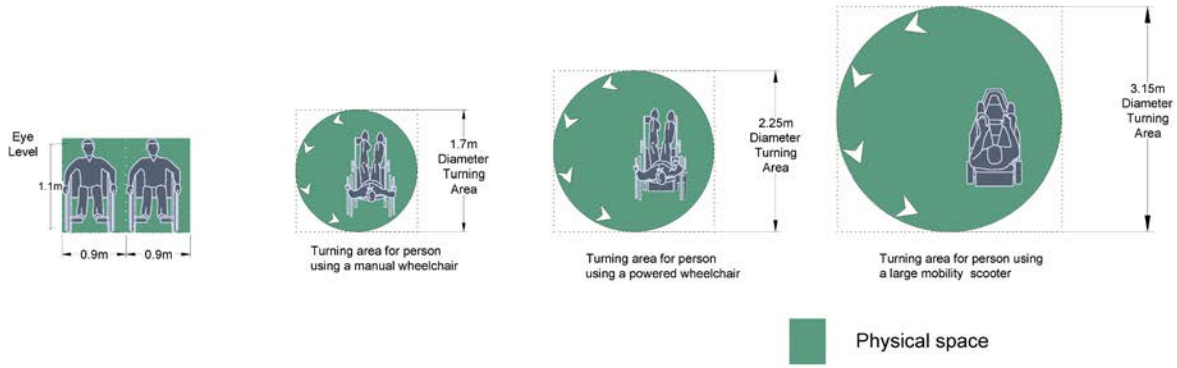


FIGURE 2 - TYPICAL WHEELCHAIR OPERATING SPACE
(SOURCE: ADAPTED FROM B.C. ACTIVE TRANSPORTATION DESIGN GUIDE)

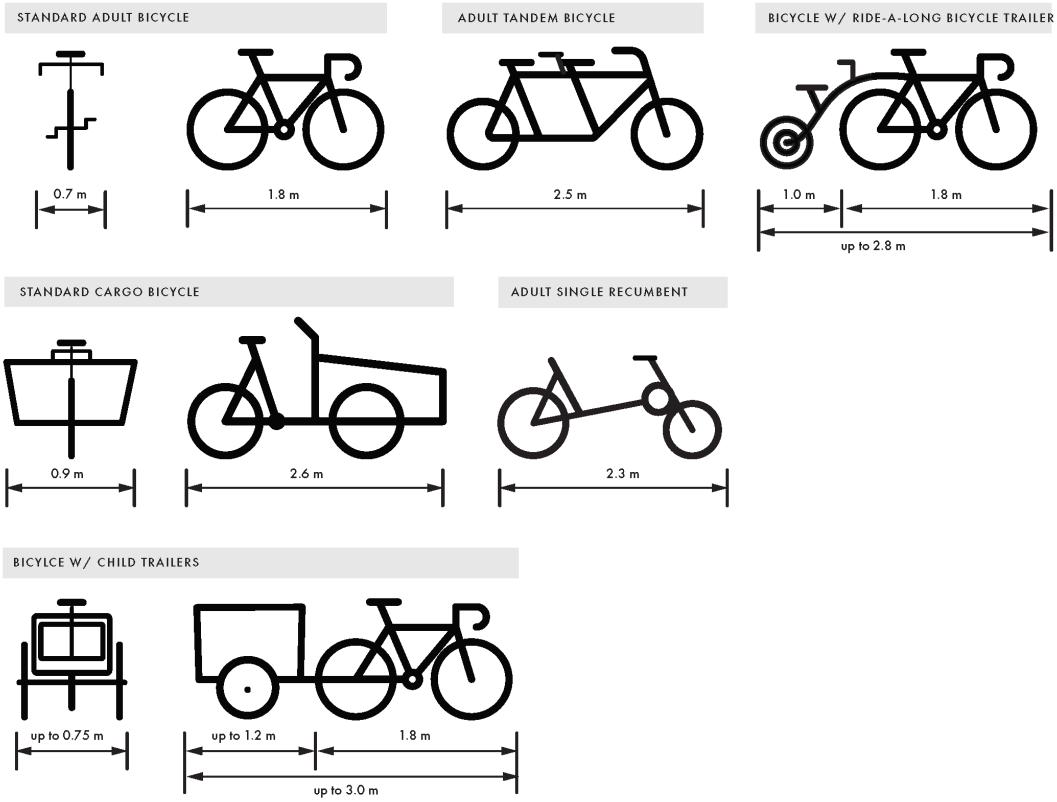


FIGURE 3 - TYPICAL BICYCLE USER DIMENSIONS

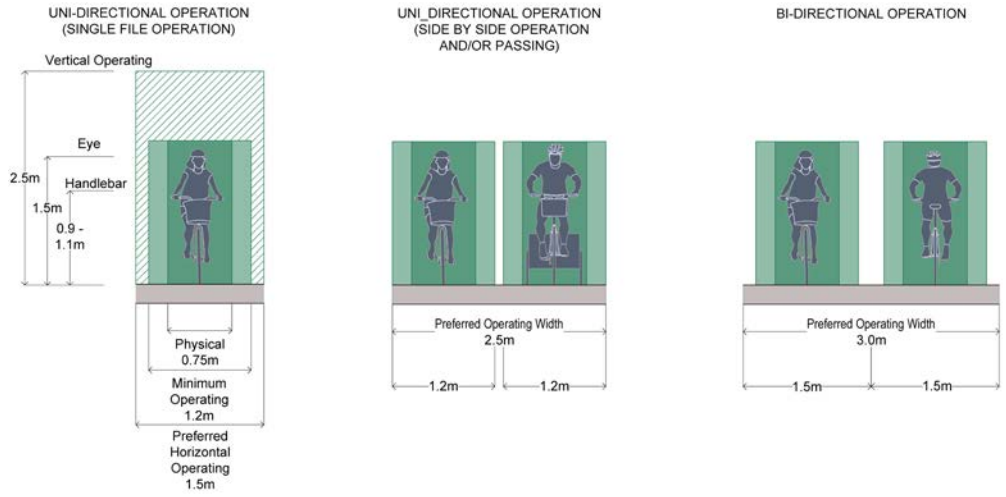


FIGURE 4 - TYPICAL BICYCLE USER OPERATING SPACE
(SOURCE: ADAPTED FROM B.C. ACTIVE TRANSPORTATION DESIGN GUIDE)

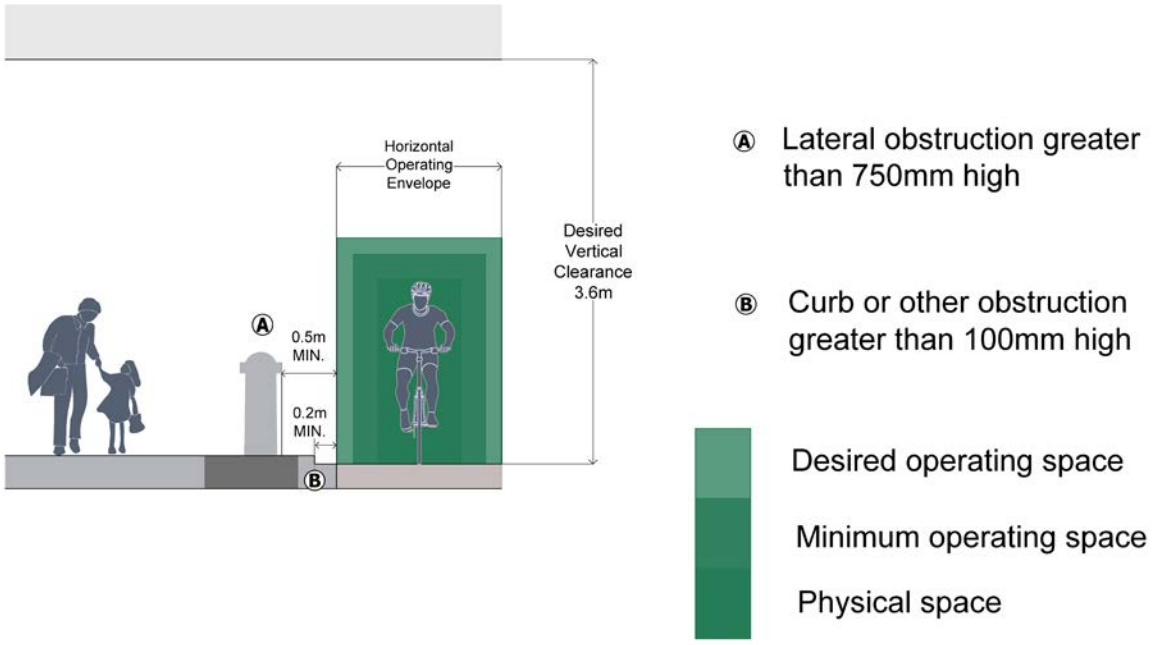


FIGURE 5 - MINIMUM HORIZONTAL AND VERTICAL CLEARANCES
(SOURCE: ADAPTED FROM B.C. ACTIVE TRANSPORTATION DESIGN GUIDE)

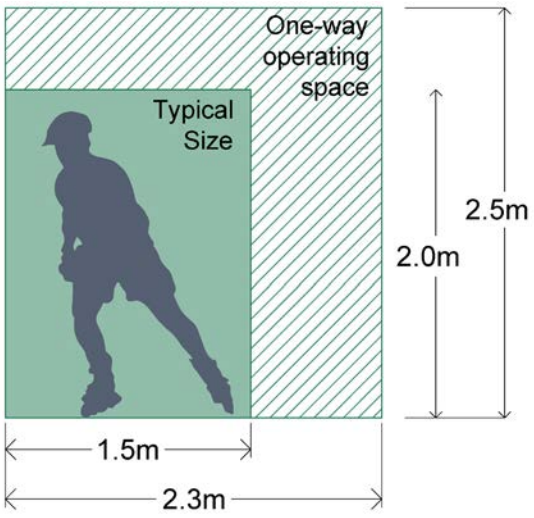


FIGURE 6 - TYPICAL DIMENSIONS FOR OTHER USERS

PEDESTRIAN OPERATING SPACE

Figure 1 shows the typical horizontal and vertical operating envelopes for people walking, including walking single file, two abreast, three abreast, and with a young child. The vertical operating envelope for people walking is 2.1 metres, including lateral sway while walking. The horizontal operating envelope of a person walking is 0.75 metres, while two people walking abreast take up approximately 1.5 to 1.8 metres, with the latter value allowing for 0.8 metres of personal space. The horizontal operating envelope for someone walking with a child, suitcase, or dog is 1.2 metres. **Figure 2** shows the dimensions of a typical wheelchair of 0.8 metres. Two wheelchair users travelling side-by-side or passing one another requires a minimum width of 1.8 metres. **Figure 2** also shows the physical space required for a human powered and motorized wheelchair to turn around.

BICYCLE OPERATING SPACE AND DESIGN VEHICLE

It is important to note that bicycles are not uniform in size or operating style. Standard bicycles, children's bicycles, bicycle-trailers and trail-a-bikes, cargo bicycles, recumbent bicycles, adult tricycles, electric assist bicycles, and other larger cycle-powered bicycles used by vendors and courier companies all have unique characteristics (**Figure 3**). Another crucial consideration is the person riding the bicycle and the wide range of user preferences, physical abilities, level of training or experience that the user may have, as these attributes greatly impact the operation of a bicycle.

Figure 4 shows typical bicycle operating space requirements. A single person cycling requires a horizontal operating envelope of 1.2 to 1.5 metres, which allows for variations in tracking (i.e. lateral movement, which is common when riding uphill and when moving at full speed). A bicycle with a trailer can be up to 3 metres long, which should be factored in to the design of facilities such as median refuge islands.

It is important to note the height of pedals and handlebars, as these can catch lateral objects if insufficient space is provided. **Figure 5** shows the minimum horizontal clearance from curbs and lateral objects. The design of off-street pathway intersections must consider the human element; for example, family members may wish to ride side by side, either for social purposes or when a parent is helping to guide or teach a young child.

OTHER USERS

Additional design users of the BC Parkway may include skateboarders, longboarders, in-line skaters, and roller skaters. **Figure 6** shows the horizontal operating envelope of an in-line skater, which requires 2.3 metres of operating space. Emerging technologies, both human-powered and electric, may require consideration in the future.

Pathway user travel speed is important to consider when designing intersections, since pathway users traveling at high speeds require further stopping sight distance. A pathway user's speed is dependent on a number of factors, including the mode of transportation, the physical condition of the user, the type and condition of the user's equipment, the purpose of the trip, the number of users on the pathway, and the pathway condition and design.

DESIGN SPEED

BC Parkway intersections should be designed to accommodate the preferred speed of the fastest pathway users, while also considering the need to control speeds in a multi-use setting. There is no single design speed that works for all contexts. However, the following guidance can be used to determine the appropriate design speed for each intersection:

- For most off-street pathways in relatively flat areas with grades of less than 2%, a design speed of 30 km/h is generally sufficient for the common user. The minimum design speed should be no lower than 20 km/h, except in rare circumstances where the context and user types support a lower speed.
- In areas of hilly terrain and long steep grades, the design speed of off-street pathways should be based on the anticipated travel speeds of cyclists traveling downhill. Upright cyclists are generally considered the critical users on most off-street pathways with respect to design speed guidelines. In most cases, 50 km/h is the maximum design speed that should be used.

BC Parkway at Nanaimo Street (City of Vancouver)

3 ACCESSIBILITY

3.0 ACCESSIBILITY

TransLink values all residents and visitors and strives to ensure that facilities such as the BC Parkway are accessible for all, regardless of age or ability. As such, the design of BC Parkway intersections must be inclusive and accessible, considering the broad range of users that may use the pathway. "Accessibility" no longer refers only to a narrow scope of remedies for people with mobility impairments; rather, accessibility involves the application of 'barrier-free' or 'universal design' principles that improve safety, convenience, and access for all users (see Chapter B.3 of the 2019 *B.C. Active Transportation Design Guide*).

In the context of the BC Parkway, universal design means considering and meeting the needs of pathway users who may have impaired mobility, vision, hearing, strength and dexterity, and/or comprehension (including cognitive impairments and language barriers). Unique design considerations are often required to provide this universal access and inclusion. The considerations presented in this section are intended to help designers recognize that through careful planning, discreet design, and the application of universal design principals, providing inclusive access to the BC Parkway can be safe, consistent, visually appealing, and cost effective.

The 2017 TAC *Geometric Design Guide for Canadian Roads,* the 2018 *CSA standard B651-18 – Accessible Design for the Built Environment*, and the 2019 *B.C. Active Transportation Design Guide* each contain more detailed guidance about planning and designing accessible walking and cycling facilities. The following are some key design considerations for multi-use pathways. It is recognized that each municipality has their own practices and design guidance for providing facilities that are accessible to all. This Section is intended to provide an overview of current best practices.

3.1 SURFACE CONDITION AND MATERIALS

Providing smooth, firm, and slip-resistance surfaces on all pathways, transitions, and intersection crossings ensures that people with mobility impairments, including those using wheelchairs, canes, walkers, and other mobility devices, can safely navigate the intersection. All sections of the BC Parkway should be clear of any tripping hazards or obstructions. Year-round monitoring and maintenance are important for ensuring that walking and cycling facilities are safe at all times and are cleared of debris, standing water, ice, and snow.

Where the BC Parkway is designed as a multi-use facility that accommodates a wide range of users and trip purposes, asphalt is the preferred surface type. Asphalt surface treatment provides a smooth continuous surface that is accessible for all user groups at a relatively modest cost. Asphalt is a resilient and flexible material that can conform to small changes in the underlying base material without cracking. When properly installed, asphalt can last more than 15 years without replacement. When dedicated facilities are provided for both people walking and cycling, additional measures are needed to ensure both visual and tactile differentiation between facilities. Contrasting paving surfaces such as coloured or stamped asphalt or concrete can be used to provide visual contrast.

Change in Surface Materials (City of Vancouver)

Different Surface Materials for Users (City of Vancouver)

Additionally, a grade separation or tactile warning strip can be used to delineate the two facilities approaching the crossing. A smooth continuous surface made of asphalt or concrete should be maintained through the intersection – pavers are not recommended.

Alleyway and driveway crossings should be designed to support continuity of the pathway material to highlight to motorists that they are crossing a multi-use facility and that the pathway users have the right-of-way. It is also desirable to maintain a consistent pathway elevation rather than ramping people on the pathway up and down. This concept should be applied where permitted by constructibility.

10th Avenue (City of Vancouver)

3.2 DETECTABLE WARNING SURFACES

A detectable warning surface is a surface treatment or material that is detectable by sight, cane, and underfoot, helping to alert and/or guide people who are visually impaired. These surfaces should be slip-resistant, non-glare, and should be made of a contrasting colour or material so that they stand out from the surrounding pavement.

Tactile walking surface indicators, also referred to as tactile guides, are recommended as the standard detectable warning surface treatment. There are two sub-types of tactile walking surface indicators: tactile attention indicators and tactile direction indicators. Tactile attention indicators, also known as truncated domes, alert pedestrians to potential hazards or changes in elevation, such as at the base of a curb ramp or the edge of a transit platform. Tactile direction indicators, also known as directional tiles, indicate travel direction and are used as a wayfinding device to guide pedestrians to key destinations, such as a crosswalk or bus stop. Chapter B.3 of the 2019 *B.C. Active Transportation Design Guide* provides further guidance on the application of tactile walking surface indicators.

Tactile Walking Surface Indicators (City of Winnipeg)

3.3 SCORE LINES

Score lines consist of a series of parallel grooves that are embedded or troweled into curb ramps, laneway crossings, and driveway ramps. They are detectable by cane and underfoot, providing directional wayfinding for people who are visually impaired. The score lines should be aligned with the crosswalk and the receiving curb ramp, helping to guide pedestrians in the correct direction. Score lines may be used in conjunction with detectable warning surface treatments such as tactile attention indicators.

Score Lines and Tactile Surface Indicator on Curb Ramp (City of Vancouver)

Score Lines (City of Vancouver)

3.4 CURB RAMPS

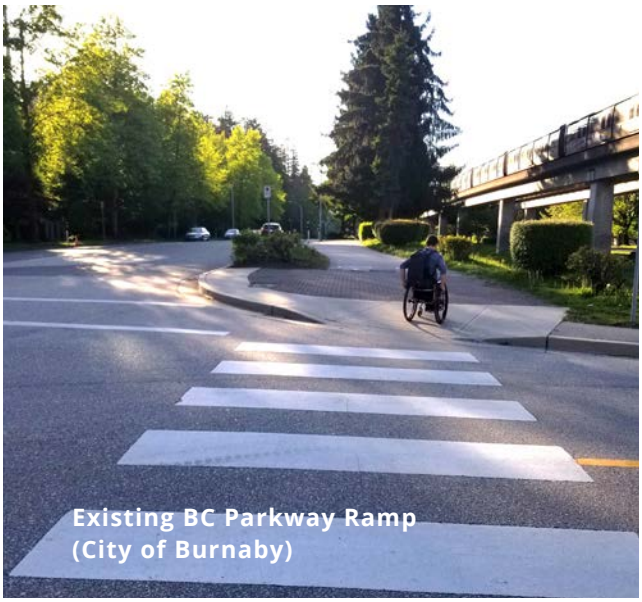
Curb ramps are smooth, graded transitions between the street and the BC Parkway. Curb ramps are critical for enabling people using mobility devices, pushing strollers, riding bicycles or other active devices, to comfortably navigate the BC Parkway. Curb ramps consist of an accessible ramp, flared sides, and clear approach and landing areas at the top and bottom of the ramp that provide manoeuvring space. Some curb ramp design considerations include:

- Both the crosswalk and curb ramp should be at least as wide as the connecting off-street pathway. For combined walking and cycling crossings, the minimum width of the curb ramp (exclusive of flared sides) is 3.0 metres. For separate walking and cycling crossings, the minimum width of the pedestrian curb ramp (exclusive of flared sides) is 1.8 metres. Bicycle curb ramps should be a 2.0 - 3.0 metres wide depending on if they are uni- or bi-directional. The ramps for bicycles should be the same width as the green paint application.
- Ramp surface shall be stable, firm, and slip resistant.
- Curb ramps should have a maximum running slope of 8.3%.
- The maximum counter slope at the bottom of the curb ramp should be 5%. Counter slopes are where the down slope of the curb ramp meets the upwards cross slope of the gutter or road. Steep counter slops can be difficult to navigate for wheelchair users.
- Avoid locating catch basins or drainage inlets in the ramp area to reduce the risk of water pooling. Ensure that the landing areas are well maintained and cleared of debris.
- Provide ramp flares with a maximum slope of 10% to avoid abrupt grade changes and tripping hazards.
- Curb ramps should be equipped with both score lines and tactile attention indicators, as described above, to make the users aware they are entering a hazard area and direct their travel.
- Double curb ramps aligned with the perpendicular crosswalks are preferred to combined curb ramps, as they align the user with the crosswalk and the receiving curb ramp. Where double pedestrian curb ramps are not possible, combined curb ramps may be used. Score lines are particularly important on combined curb ramps to guide visually impaired pedestrians in the correct direction.
- Separate walking and cycling curb ramps are preferred at crossings with separate crosswalks

and cross-rides, with the bicycle crossing preferably located closer to the parallel motor vehicle travel lane. Contrasting surface materials may be used to differentiate the pedestrian and cycling curb ramps. Where separate walking and cycling ramps are used, score lines and tactile attention indicators should only be installed on the pedestrian curb ramps. This ensures that people who are visually impaired are able to correctly identify the designated pedestrian crossing and stay aligned with the receiving pedestrian facility.

Chapter G.3 of the 2019 *B.C. Active Transportation Design Guide* provides further guidance on curb ramps. Additionally, sections 5.7.3 and 6.4.6 of the 2017 *TAC Geometric Design Guide for Canadian Roads* provide design guidance on pedestrian and bicycle curb ramps, respectively.

Crossing with Asphalt Curb Ramp for Cyclists (top) and Concrete Curb Ramp with Score Lines for Pedestrians (bottom) (Arbutus Greenway - City of Vancouver)



Existing BC Parkway Ramp (City of Burnaby)

3.5 VISUAL NAVIGATION AIDS

Visual navigation aids such as signage, pavement markings, wayfinding, and contrasting materials help to ensure that people of all ages and abilities can safely and easily navigate an intersection. Visual aids are especially important for people who are deaf, have impaired hearing, or have cognitive impairments. Providing adequate lighting also enhances accessibility at intersection. Additionally, pedestrian countdown timers at crosswalks can help people walking and cycling to determine whether it is safe to cross the intersection. Providing consistent and clear wayfinding signage throughout the region and along BC Parkway is important to ensure that all users have easy to follow visual cues to guide their way. TransLink has developed the *Wayfinding Guidelines for Utility Cycling in Metro Vancouver*. This document is available online.

Pedestrian Countdown Timer (City of Vancouver)

3.6 AUDIBLE NAVIGATION AIDS

Audible pedestrian signals provide non-visual indications in the form of audible and vibro-tactile indications that confirm when it is legal and safe to make a street crossing. These signals can assist pathway users who are visually impaired, blind, or deaf-blind to independently cross a street. Additionally, they are useful for many other users who may benefit from non-visual prompts, such as children, seniors, and people with cognitive disabilities. By indicating when a crossing interval begins, audible signals allow people walking to begin the crossing before turning cars enter the intersection and to complete the crossing with less delay. These non-visual signals can also provide directional guidance that can assist in the crossing of non-perpendicular intersections and multi-lane crossings.

Audible Pedestrian Signal Speaker (City of Vancouver)

Adjustable Audible Pushbutton (City of North Vancouver)

4 INTERSECTION DESIGN TREATMENTS

4.0 INTERSECTION DESIGN TREATMENTS

Intersections require careful design consideration as they present a location for potential conflict between off-street pathway users and motor vehicles, and tend to be where a higher number of collisions occur. In this Design Guide, the term 'intersection' is used broadly to refer to a range of scenarios where users interact with one another, including locations where the BC Parkway crosses the roadway at a signalized intersection, unsignalized intersection, or at mid-block locations. Additionally, this includes other areas where conflicts between motor vehicles and off-street pathway users may occur, such as where the BC Parkway crosses driveways and alleyways. This section also covers other related areas, including rail crossings, grade-separated crossings, and transitions between different facility types. This section of the guide is organized into eight sub-sections:

SECTION 4.1: INTERSECTION DESIGN PRINCIPLES provides general design considerations to apply throughout the intersection design process.

SECTION 4.2: INTERSECTION COMPONENTS provides an overview of signage, pavement markings, intersection controls (including roadway-facing and off-street pathway-facing), and traffic calming elements.

SECTION 4.3: INTERSECTION APPROACHES includes guidance on designing the roadway and pathway approach to an intersection and provides guidance on intersection sight distances.

SECTION 4.4: SIGNALIZED INTERSECTIONS provides guidance for signalized intersections where the BC Parkway crosses roadways controlled by traffic signals. These intersections often require pathway users to cross three or more travel lanes. Guidance is provided for both intersections with and without channelized turn lanes.

SECTION 4.5: MINOR INTERSECTIONS AND DRIVEWAYS provides guidance for intersections where the BC Parkway crosses roadways and driveways where no traffic signals are present. Typically, minor intersections are stop controlled, while driveways are typically uncontrolled.

SECTION 4.6: **MID-BLOCK CROSSINGS** provides guidance for locations where the BC Parkway crosses a road at a mid-block location between two intersections.

SECTION 4.7: **TRANSITIONS** provides design guidance for intersections when the BC Parkway facility type shifts from one type to another (for example, from an off-street pathway to an on-road bicycle facility).

SECTION 4.8: **GRADE-SEPARATED CROSSINGS** provides design guidance for grade-separated crossings, including consideration of the access and perceived safety of pathway users on grade-separated crossings. Additional guidance is provided on applications where grade separation is preferred to at-grade crossings.

4.1 INTERSECTION DESIGN PRINCIPLES

The following key design principles should be applied in order to provide safe and accessible intersections between the BC Parkway and roadways for all users.

DESIGN FOR ALL USERS AND PEOPLE OF ALL AGES AND ABILITIES to ensure that people of all ages and abilities should be able to safely and comfortably navigate an intersection, crossing, or transition area. Design elements that facilitate access for people with all forms of physical and cognitive impairments should be included. Elements such as detectable surfaces, audible cues, curb ramps, smooth surfaces, and other accessibility features can ensure that all people can safely navigate an intersection or crossing.

ENSURE CLARITY OF RIGHT-OF-WAY by providing clear and consistent traffic control devices and visual cues that indicate which user is expected to yield and/or stop ensures clarity of right-of-way. Priority of right-of-way needs to align with municipal bylaws and provincial laws under the BC MVA and associated regulations. Right-of-way at intersections and crossings should be intuitive for all users.

MINIMIZE CONFLICTS BETWEEN USERS by separating different users in space and/or time. Providing dedicated spaces and/or protected phasing for active modes through intersections and crossings increases the predictability of movements and supports more compliant behaviour. Minimizing exposure between active transportation users and motor vehicle traffic can also help to reduce conflicts.

ENSURE A CLEAR LINE OF SIGHT for the intersection approaches and crossing areas is provided for all users. Providing clear sightlines ensures that street users have sufficient decision and reaction time to stop or yield to conflicting traffic.

REDUCE SPEED AT CONFLICT POINTS FOR ALL USERS by minimizing the differential speeds between the types of users, through separation and speed reduction measures at intersections. This will help reduce the potential for collision and severity of injury when collisions occur.

MAKE INTERSECTIONS AS COMPACT AS POSSIBLE to enhance safety for active transportation users by increasing visibility for all modes, reducing pedestrian and bicyclist exposure to motor vehicles, and slowing motor vehicle speeds at conflict points. Intersections can be made more compact by reducing corner radii, limiting the use of dedicated turn lanes, and removing channelized right turn lanes when possible.

Spirit Trail Intersection Crossing (District of West Vancouver)

4.2 INTERSECTION COMPONENTS

This section outlines the key intersection components that impact off-street pathway crossings, including signage, pavement markings, intersection controls, and traffic calming elements.

4.2.1 INTERSECTION SIGNAGE

Signage is critical at intersections to control right-of-way and to provide warnings and wayfinding as appropriate. At the same time, care must be taken to not place too many signs at intersections; otherwise, they begin to lose their impact. Intersection signage is important for pathway approaches to establish right of way. Additionally, shared pathway (RB-98) or a pathway organization (RB-94) signage should be installed on both sides of the intersection on the pathway approach. The specific application of signage at intersections is discussed throughout **Section 4** as design treatments are explained. A list and description of applicable signage can be found in **Section 6**.

4.2.2 INTERSECTION PAVEMENT MARKINGS

Like signage, pavement markings are a key component of intersections that help to dictate right-of-way while also raising awareness of the BC Parkway crossings. There are two types of pavement markings that are most often used at intersections along the BC Parkway. Pedestrian crosswalks are typically marked with either parallel white painted lines aligned along the crossing direction or zebra pavement markings that are painted perpendicular to the crossing pedestrian crossing direction. Cross-ride pavement markings (also called elephants feet) are used to indicate that people will be cycling their bicycle perpendicular to the motor vehicle travel direction. Cross-ride pavement markings are white broken lines painted along the cycling crossing direction and can either be installed on the outside of a crosswalk or alone.

Enhanced pavement markings inside the crosswalk area may be considered. These markings can increase the visibility of the crossing, beautify the public realm, and add visual continuity along a pathway when used at multiple crossings. They can also be used as a type of facility branding as seen along the Spirit Trail located within the District of West Vancouver, District of North Vancouver, and the City of North Vancouver.

Pathway pavement markings at intersection approaches are also important to consider. It is recommended that a yellow centre is provided along the pathway at intersection approaches to organize pathway users by direction. The specific application of pavement markings at intersections is discussed throughout **Section 4**. A list and description of applicable pavement markings can be found in **Section 6**.

4.2.3 INTERSECTION CONTROLS

Intersection controls help pathway users safely and efficiently cross the roadway by clearly indicating right-of-way and by warning both motor vehicle drivers and pathway users of a potential conflict area. Determining who has right-of-way and selecting which type of control to use (if any) is dependent on the context, including the type of street, crossing location, line of sight, topography and alignment of the street and pathway, land use, and the volumes and speeds of both pathway users and motor vehicles. Both roadway-facing intersection controls (for motor vehicle drivers) and off-street pathway-facing intersection controls (for pathway users) can be provided.

ROADWAY FACING CONTROLS

The 2018 *TAC Pedestrian Crossing Control Guide* provides guidance on when various types of crossings systems are warranted at intersections. If BC Parkway is crossing a roadway that is currently uncontrolled a warrant should be conducted to determine the appropriate intersection control required. Some of the municipalities along the BC Parkway also have their own guidance and warrant process to determine the crossing control that is warranted. Specific roadway facing controls are described in **Section 4.4.1** and **Section 4.5.1** for signalized and unsignalized crossings, respectively and are summarized in **Table 1**.

BC Parkway Crossing a Signalized Intersection (City of Surrey)

TABLE 1 - ADVANTAGES AND DISADVANTAGES OF INTERSECTION CONTROL DEVICES

Type of Control	Description	Advantages	Disadvantages
RFB 	Rapid Flashing Beacons (RFBs) have flashing amber lights that alternate back and forth to attract motorists' attention, increasing yielding behaviour. RFBs or other side mounted flashing beacons can be used to mitigate conflicts at challenging crossings such as slip lanes and roundabouts*.	▪ Less delay for major street (activated on demand only). ▪ Can be implemented when conventional signal warrant is not met or where a conventional traffic signal is not desired. ▪ Requires less infrastructure (side mounted) ▪ Can be activated through inductive loop technology.	▪ Does not provide a 'red/stop' condition for drivers, and may lead to variation in motorist behavior. ▪ Wide streets can make side of street signing more difficult for drivers to see. ▪ No platooning of crossing users so unpredictable for motor vehicle traffic.
Special Crosswalk 	A Special Crosswalk, also referred to as Overhead Pedestrian Flashers, is not a traffic signal but a traffic device installed to enhance warning and awareness for motorists of a crosswalk at intersections and mid-block crosswalks. The system consists of an overhead Pedestrian Crossing sign (MUTCD RA-5) with pedestrian-activated flashing amber beacons**.	▪ Less delay for major street (activated on demand only). ▪ Can be implemented when conventional signal warrant is not met or where a conventional traffic signal is not desired. ▪ Requires less infrastructure than full signals.	▪ Does not provide a 'red/stop' condition for drivers and may lead to variation in motorist behavior. ▪ No platooning of crossing users so unpredictable for motor vehicle traffic. ▪ Less visibility than a traffic signal.

Type of Control	Description	Advantages	Disadvantages
Half Signal 	Half signals, also referred to as pedestrian signals, or pedestrian/cyclist actuated signals, are traffic signals that facilitate pedestrian and cyclist movements while controlling motor vehicle movements on only one street, rather than two or more streets. They can be used at the intersection of major and minor streets, or at major mid-block crossings.	▪ People walking and cycling are given a clear signal when to cross, and drivers on the major street see a conventional signal indicating when to stop. ▪ Suitable for streets with higher volumes and larger cross sections, where crossing opportunities are less frequent and side mounted systems are less effective. At intersections: ▪ Side street motor vehicle traffic access the major street from stop condition, typically with all movements. However, this can create a conflict with bicyclists and pedestrians crossing the minor street.	▪ Higher cost as the system requires more infrastructure than RFB or other side mounted flashing beacons. ▪ Increased delay for major streets compared to RFB system. ▪ If located on bus routes, it could impact the predictability of transit schedules as bicycle activation will slow motor vehicle traffic if a coordination strategy is not developed. At intersections: ▪ Some concerns of potential confusion for road users, including pedestrians, with side street being stop controlled and major street signal controlled.

Type of Control	Description	Advantages	Disadvantages
Full Signal 	Full signals are also known as traffic signals. They control all approaches and regulate which user can enter the intersection safely at a given time. Full traffic signals are used at intersections between a combination of streets that are major and minor in classification.	▪ A full signal assigns right of way for all users. ▪ They are usually installed at higher volume intersections (for all road users alike). ▪ Ability to coordinate/ delay/time the actuations and calls, similarly to a half signal. ▪ May be accessible for all users.	▪ Higher installation costs due to more infrastructure required. ▪ May impact traffic operations and result in delay.

* Several cities are reviewing the use of RFB devices at bicycle crossings. In many municipalities RFBs are only used at pedestrian crossings and on roadways with one motor vehicle lane in each direction.

** The City of Vancouver does not install special crosswalks.

OFF-STREET PATHWAY FACING CONTROLS

Signage and pavement markings are the primary means of communicating to BC Parkway users when they must yield or stop before proceeding through an unsignalized and/or minor intersection or a crossing at a mid-block location. The off-street pathway controls required will depend on which user has the right-of-way: the motor vehicle driver on the roadway or the pathway user.

Typically, the best practice is to provide consistency along the off-street pathway facility and at unsignalized intersections. The preferred treatment is to give the right of way to pathway users by requiring individuals travelling on the roadway to stop. However, there may be some locations where yield or stop control may be used to control the movements of pathway users. These include locations where:

- Appropriate sightlines are not achieved between motorists and people riding bicycles, additional signage for bicyclists to yield or stop and watch for turning motorists should be installed. The presence of stop or yield signs on the pathway does not limit people walking from entering the crosswalk in an appropriate manner. More information about sight distance can be found in **Section 4.3**.
- At locations where a pathway intersects with a roadway that has a designated bicycle facility.

Pathway Users Yield to Roadway Users (Arbutus Greenway - City of Vancouver)

4.2.4 TRAFFIC CALMING

Geometric design can be used to calm traffic at intersections, creating a safer crossing environment for off-street pathway users. Curb extensions and median islands are two examples of treatments that can be used to narrow the roadway for motor vehicles which can help to slow motor vehicle speeds on the approach to intersections. Speed humps can also be used along local streets. These traffic calming devices have additional benefits, as they can also help to alert drivers of the upcoming crossing, create better sightlines, and reduce the crossing distance for pathway users. In addition to median islands and curb extensions, raised crossings, directional closures, or full closures may be considered. Each of these traffic calming features will slow or prohibit vehicles, making people walking and cycling safer and more visible. Considerations for curb extensions and median refuges at intersections and mid-block crossings can be found in throughout **Section 4**. Further design guidance on traffic calming features to be used along roadways and at intersections can be found in the 2018 *TAC Canadian Guide to Traffic Calming*.

Curb Extensions to Reduce Crossing Width (City of Vancouver)

4.3 INTERSECTION APPROACHES

This section outlines the important design considerations for the intersection approaches, from both the perspective of a roadway and pathway user. This section provides guidance on sight distance as well as features that can be used to reduce roadway and pathway user speeds upon approaching the intersection.

4.3.1 SIGHT DISTANCE AT INTERSECTIONS

The overall objective when determining intersection sight distances is to ensure that each user has adequate sight distances to detect a conflicting movement and to react appropriately.

STOPPING SIGHT DISTANCE

Minimum stopping sight distance for bicyclists is the distance required to bring the bicycle to a controlled full stop and is a factor of the bicyclist's speed, the surface material and condition (friction between the tires and surface), bicyclist's perception-reaction time, and grade of the facility. The stopping sight distance can be greater for people cycling than motor vehicle drivers, especially on downgrades, and need to be considered in the design of bikeways. The 2017 *TAC Geometric Design Guide for Canadian Roads*, Chapter 5, Section 5.5 provides detail on how to determine the minimum stopping sight distance.

BC Parkway Intersection at Willingdon (City of Burnaby)

INTERSECTION SIGHT DISTANCE

Two types of clear sight triangles are considered in intersection design: the approach and departure sight triangles. Refer to the 2017 *TAC Geometric Design Guide for Canadian Roads* Section 9.9.2 for details on determining the appropriate sight distances and sight triangles to provide.

- **Approach sight triangle**: The area bounded by the approach sight triangle should be free of obstructions (such as parked vehicles, railings/barriers) to provide users adequate opportunity to anticipate potential conflicts with crossing traffic. Figure 10 from the 2017 *TAC Geometric Design Guide for Canadian Roads* shows the typical clear sight triangles to the left and to the right for a motor vehicle approaching an uncontrolled or yield-controlled intersection. Refer to the TAC guide for details on determining the a1, a2, and b values. The decision point shown is the location where the user on the minor facility should brake in order to stop before conflicting with a user along the major road. This sight triangle can be applied at both an intersection or a mid-block crossing.

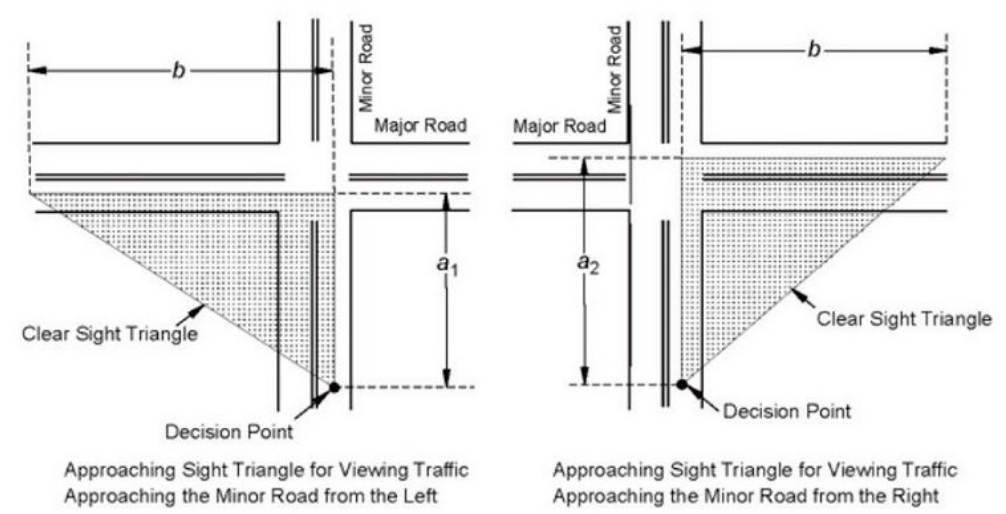


FIGURE 7 - APPROACH SIGHT TRIANGLE (UNCONTROLLED OR YIELD CONTROLLED) (SOURCE: 2017 TAC GEOMETRIC DESIGN GUIDE FOR CANADIAN ROAD, CHAPTER 9, FIGURE 9.9.1, SECTION 9.9, PAGE 61

- **Departure sight triangle**: The departure sight triangle provides sight distance sufficient for a user that is stopped on a minor approach to depart from the intersection and enter or cross the major road. The area bounded by the departure sight triangle should be free of obstructions (such as parked vehicles, railings/barriers) to provide users adequate opportunity to anticipate potential conflicts with crossing traffic. Figure 11 from the 2017 *TAC Geometric Design Guide for Canadian Roads* shows the typical departure sight triangles to the left and to the right of a motor vehicle stopped on the minor road/facility.

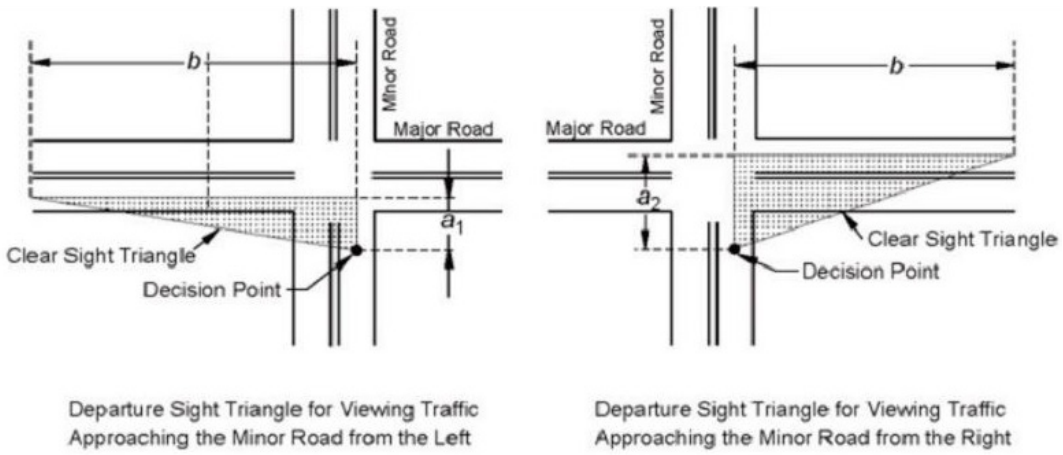


FIGURE 8 - DEPARTURE SIGHT TRIANGLE (STOP CONTROLLED) (SOURCE: 2017 TAC GEOMETRIC DESIGN GUIDE FOR CANADIAN ROADS, CHAPTER 9, FIGURE 9.9.2, SECTION 9.9, PAGE 62)

- **Sightline condition for who has right of way**:
  - Right turn motorist yields to through bicyclists: clear sightlines for the motorist to see the approaching person using BC Parkway.
  - Through bicyclist yields to right turning motorist: clear sightlines for pathway users and motorists to see and react to each other
  - For left turning or crossing motorists (far side) on a two-way road, provision of adequate sightlines will not typically mitigate the risk of motorists looking for gaps in the opposing traffic (not paying attention to a person approaching from the opposite direction). Additional measures need to be implemented to minimize conflict and can include signalization (protected only left turns or pathway phases), conflict markings and/or raised crossing.

- For motorists crossing from a minor street at a stop-controlled approach, the departure sight triangle to the BC Parkway users and motorists on the major street needs to be met. If the stopped motorist must go into the crossing path of the pathway facility in order to achieve the necessary sightline to cross the major road, then signalization should be considered.
- Areas that are more built out and have greater pedestrian presence should use an agreed upon design speed for determining sightlines, and consideration should be made to lower the posted speed limit if the target design speed is lower than posted. Implementing other measures to reduce speed will also support safety at intersections.
- Fixed objects such as tree, signs, street furniture, and buildings, can obstruct clear sightlines at intersections. Consideration should be made to implement other measures to increase awareness of pathway users approaching the intersection and/or install traffic controls to improve safety when fixed objects cannot be removed.

4.3.2 ROADWAY APPROACH

Streets can be designed to ensure that as motorists approach an intersection or mid-block crossing with the BC Parkway, visual cues alert them to the multi-use pathway crossing and motor vehicle speeds are reduced. Vertical elements such as trees and other landscaping can help to alert motorists of the crossing. However, vegetation must be managed so that sightlines are maintained. Signage and pavement markings also help to alert motor vehicle drivers of the pathway crossing. The Pedestrian and Bicycle Crossing Ahead warning sign (WC-46) with a Crossing (WC-7S) tab should be installed on the approach to the intersection to alert motorists of the BC Parkway crossing perpendicularly. The Bicycle Trail Crossing Side Street sign (WC-44) should be installed on the approach to the intersection of any roadway that travels parallel to the BC Parkway. Custom Turning Vehicles Yield to Bicycles signs should be installed at the intersection for all turning movements across the BC Parkway. Further signage and pavement marking design guidance is discussed throughout in **Section 6**.

Geometric design elements such as curb extensions and median islands may be also used to slow motor vehicle traffic approaching intersections and crossings with the BC Parkway. These elements have the added benefit of reducing crossing distances for pathway users.

Median islands also provide a refuge allowing pathway users to cross one direction of motor vehicle traffic at a time. Median islands are especially desirable on higher speed roads and/or roads with multiple travel lanes in each direction. They should include curb ramps or cut-throughs with tactile warning strips. Median islands should be a minimum of 3 metres wide in order to provide adequate protection for all types of users (i.e. bicycles with trailers).

4.3.3 PATHWAY APPROACH

Geometric design may also be used to reduce user speed on the BC Parkway as users approach intersections and mid-block crossings. This can include adding horizontal and vertical curvature to the pathway, including an uphill grade in advance of the crossing. Upon approaching an intersection, the BC Parkway should either bend-in or bend-out, as discussed in **Section 4.4.2**.

Along the route of the parkway there are a number of community plazas that have been maintained by community groups, private companies, and TransLink. Pathway approaches at intersections can be ideal locations for the installation of plazas and other trail amenities.

There are additional considerations at intersection approaches that can be made as part of the intersection design process to help enhance comfort and safety of users at intersections. For example, at intersections where BC Parkway is heavily used, an additional width and queuing space can be provided to ensure pathway users can all cross during one signal phase. It is recommended that a yellow centreline is installed 10 to 15 metres in advance of an intersection to help organize movement through the intersection.

Amenities at Pathway Intersection Approaches (City of Kitchener)

4.3.4 ACCESS RESTRICTION

Access control devices are features that are used at locations where multi-use pathways intersect streets to restrict access by unauthorized motor vehicles while accommodating periodic access (e.g. maintenance vehicles). There are a number of physical features and treatments that are used to both restrict motor vehicle access and visually indicate to bicyclists the need to slow down.

Current best practice is to avoid the use of rigid bollards or maze gates at pathway points of entry unless there is a demonstrated history of motor vehicle encroachment, and/or a collision history. The use of rigid bollards or maze gates (offset gates) for bicycle speed control is also not appropriate. The slowing effect it creates is offset by the safety hazard it creates for bicyclists. Bollards and other obstructions placed within the operating space of a bicycle facility have been shown to present a significant injury risk to bicycle users.

The Bicyclists' Injuries & the Cycling Environment (BICE) study conducted for the Cycling in Cities Program at the University of British Columbia found that 12% of all cycling injury collisions requiring emergency room treatment were a result of impact with infrastructure such as bollards, street furniture, curbs, fences, speed bumps, or stairs. Maze gates can also impact snow clearing as it creates a barrier, which may lead to lower operational standards for people cycling.

Currently, there are several locations along BC Parkway where rigid bollards have been used to restrict vehicle access on BC Parkway. BC Parkway access points should minimize the use of bollards to restrict motor vehicle access. Bollards create a confined operating space and increase the likelihood of conflicts and collisions between other pathway users and the bollards themselves. Existing bollards should be removed unless a history of vehicle access has been observed.

At locations without bollards where motor vehicle access continues to be observed, consider other treatments to minimize vehicle access. Alternative treatments include raised centre medians, flexible delineators, and signage to indicate that motor vehicles are prohibited. Design guidance on these measures are summarized below:

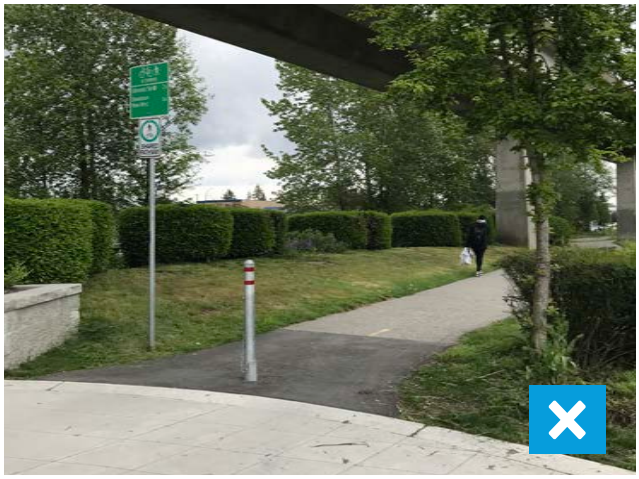
- Add signage at the pathway entry to indicate its intended use as a pathway and its restriction of motor vehicles.
- The physical design of the pathway point of entry should clearly indicate that it is not intended as a motor vehicle access. One method of restricting motor vehicle entry is by using a centre island that splits the point of entry into two pathways separated by low landscaping. The low landscaping allows maintenance and emergency vehicles to straddle the island to access the pathway when needed. The pathway-side approach to the island should include solid lane markings leading to and around the island to guide pathway users around the centre island. The width of the pathway

on either side of the island should be no more than 1.8 metres to emphasize the non-motorized use of the pathway. The pathway entry design also needs to consider winter maintenance and snow clearing equipment.

- If motor vehicle incursion occurs despite the use of the strategies described above, consider targeted surveillance and enforcement which may require policy changes. If motor vehicle incursion continues, evaluate the reasons why such incursion is taking place at this specific location, and determine whether changes to the pathway farther from the point of entry would effectively eliminate the incursion.
- Consider using flexible delineators or spring-mounted bollards in order to reduce potential injuries from crashes.

Multi-Use Pathway with No Access Restrictions (City of Toronto)

EXAMPLES OF EXISTING ACCESS RESTRICTION TREATMENTS



If all other access restriction measures have failed and rigid bollards are installed, it is important to ensure that the rigid bollards are shorter than the height of a typical handlebar. The minimum height of the bollard is 1.0 metres with a minimum diameter of 100 millimeters.. The hardware that is used to hold a bollard should be flush with the pathway surface or recessed into the pathway in order to minimize additional hazards for bicycle tires. Removable bollards should be fully removable and a permanently affixed cap that is flush without collar should cover the open hole when the bollard is removed. Bollards should not restrict access to people with disabilities and should allow passage by all users who are legally permitted to use the pathway. A functional minimum of 1.2 metres of clearance between bollards must be maintained, though this minimum should be reviewed, and pathway widened for other legal users of the pathway if necessary. If bollards are used, a tactile painted diamond should be installed to delineate the safe shy zone from the bollard.

If additional speed-reduction is needed for pathway users, textural surface contrast, transverse pavement markings, and warning signage treatments can be applied to the intersection approach of the pathway.

Further signage and pavement marking design guidance is presented in **Chapter 6**.

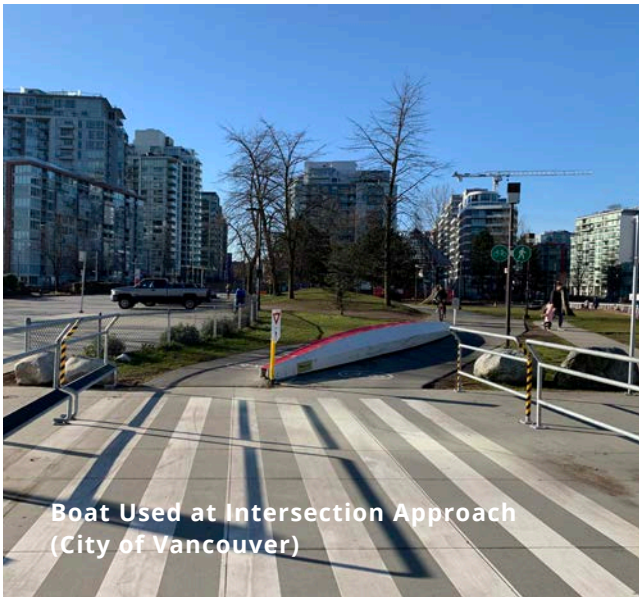
Painted Diamond to Identify Obstruction (City of New Westminster)

4.3.5 OTHER DESIGN CONSIDERATIONS

CURB EXTENSIONS AND A MEDIAN REFUGE: At signalized intersections with three or more motor vehicle travel lanes, enhanced treatments such as a median refuge island or curb extensions could be provided to reduce the crossing distance. Curb extensions can also help improve sightlines by restricting parking or other obstructions approach the crossing location. For design guidance for traffic calming treatments refer to the 2018 *TAC Canadian Guide to Traffic Calming* or existing municipal design guidelines. It is worth noting that the implementation of refuge areas is not considered best practice in the City of Vancouver.

Median Refuge
(City of North Vancouver)

ART, CREATIVE SIGNAGE, OR OTHER OBJECTS: There are opportunities to add other features such as art, creative signage, or other objects at the approach to an intersection crossing or plazas that can draw people's attention and allow them to understand and recognize that they are transitioning to a shared space.



Boat Used at Intersection Approach
(City of Vancouver)

SPEED REDUCTION AT PATHWAY APPROACH: Geometric design may be used to reduce user speed on bicycle pathways and multi-use pathways as they approach mid-block crossings. This can include adding horizontal and vertical curvature to the pathway or an uphill grade in advance of the crossing. Additional speed-reducing elements that can be applied to the pathway approach include textural surface contrast, transverse paint lines, yield markings, and warning signage along the pathway.

Crossing Ahead Pavement Pathway Pavement Markings (City of Portland)

Slow Pavement Markings (Green Necklace - City of North Vancouver)

4.4 SIGNALIZED INTERSECTIONS

Signalized intersections are defined as locations where the BC Parkway crosses a street that is controlled by a traffic signal. This can include locations where all movements are controlled by a full traffic signal or locations where a half signal is actuated by BC Parkway users. At signalized intersections design treatments such as dedicated phasing, pavement markings, and signage are required to provide safe and comfortable crossings for all pathway users. These treatments highlight the pathway user's presence and inform motorists that the crossing is not only for people walking, but for multiple types of users.

At signalized intersections with high volumes of turning motor vehicles or with complex intersection geometry, it is recommended that a separate signal phase is provided to allow pathway users to cross the intersection separate from turning motor vehicles (additional information on signal phasing can be found in **Section 5.2**). At larger intersections where there are channelized turn lanes, where feasible, it is recommended that channelized slip lanes be removed from all major intersections and replaced with dedicated or shared right turn lanes. This section provides design guidance to create safe and comfortable crossings for BC Parkway users at signalized intersections.

Multi-use Crossing at a Signalized Intersection (City of Toronto)

4.4.1 INTERSECTION CONTROL

Signalized intersections requires all users to follow traffic control devices to ensure safe operations and movement through the intersection act as both roadway and pathway facing controls. Two types of signalized traffic control device are considered for this design guide: full signals and half signals.

FULL SIGNALS are conventional traffic signals for all approaches and regulate which user can enter the intersection safely at a given time. Full traffic signals are used at intersections between a combination of streets that are major and minor in importance. If full traffic signals are installed when not warranted, it may result in long delays to users of the intersection and non-compliance with the traffic signal. If full signalization is unwarranted, there are a number of other controls that may be used to enhance the off-street pathway crossing visibility and the yielding behaviour of motorists, such as half signals and unsignalized controls.

HALF SIGNALS are traffic signals that control movements on only one street, rather than two or more streets. They can be used at the intersection of major and minor streets, or they can be used at mid-block crossings. Half signals give very clear directions to motorists facing the signals and at mid-block crossings; however, they can be misunderstood by motorists on the cross street. This is due to the requirement to control one traffic movement with traffic lights while other movements are controlled by signage (stop sign). This can create confusion between people walking or cycling across the street and motorists proceeding from a stop-controlled condition, leading to the potential for conflicts.

Both half signals and full signals along off-street pathways, as described above, are typically activated by pedestrian and/or bicycle push buttons, but may also be triggered by motion detectors, in-pavement loop detectors, video, or other technologies. When pushbuttons are used, care should be taken to ensure they are located in a convenient and accessible location. For additional information on these intersection controls, refer to the 2018 *TAC Pedestrian Crossing Control Guide*.

Separate bicycle signals may be installed and protected signal phasing can be used to reduce conflicts between people cycling/walking and motorists. Protected signal phasing may be provided if warranted; alternatively, a leading signal phase may be provided for people walking and cycling. More information about traffic signals can be found in **Section 5.2**. It is important to note that the Motor Vehicle Act (MVA) currently does not recognized bicycle signals as a traffic control device and as such, they have no legal meaning under current legislation. Municipalities should only consider the installation of bicycle signals based on sound engineering and legislative review.

4.4.2 SIGNALIZED INTERSECTIONS WITHOUT CHANNELIZATION

This section provides guidance on the treatment of BC Parkway crossings at signalized intersections without channelized right turn lanes.

DESIGN GUIDANCE

When designing the off-street pathway approach, there are generally two options for designing the alignment of the pathway as it approaches a signalized intersection.

1. Bending the pathway towards the parallel roadway (bend-in).
2. Bending the pathway away from the parallel roadway (bend-out).

For both bend-in (**Figure 9** and **10**) and bend-out designs (**Figure 11** and **12**), reduce the ① corner radii to as small as possible for the design vehicle and circumstance. An effective turning radius is based on the typical travel path used by motorists to travel around a corner. By identifying the effective turning radius allows the designer to select a corner radius that best suits the design vehicle. The taper ratio of the pathway alignment shift should be between 3:1 to 10:1, with a 10 to 15 metre tangent ②.Both designs must ensure good sightlines ③ are provided for pathway users Sightline obstructions can include trees, guideway columns, signals, and utility poles.

For the bend-in design (**Figures 9** and **10**), intuitive sharing of existing traffic signals at signalized intersections can be achieved ④. For the bend-out design (**Figures 11** and **12**), the pathway crossing is set back a minimum of 6 metres to provide space for one vehicle to stop in advance of the crossing ④. This provides some additional reaction time to drivers turning across the path.

> *Bending the pathway away (bend-out design) from the parallel roadway is generally recommended as it yields more benefits; however, bending the pathway towards (bend-in) the roadway tends to require less space. Both bend-in and bend-out intersections can be configured with separated or combined crossings for pedestrians and cyclists. Separated crossings are preferred, when space permits, and should include separated ramps or contrasting pavement for cyclists and pedestrians. The following provides a summary of the benefits and disadvantages of both bend-in and bend-out alignments.*

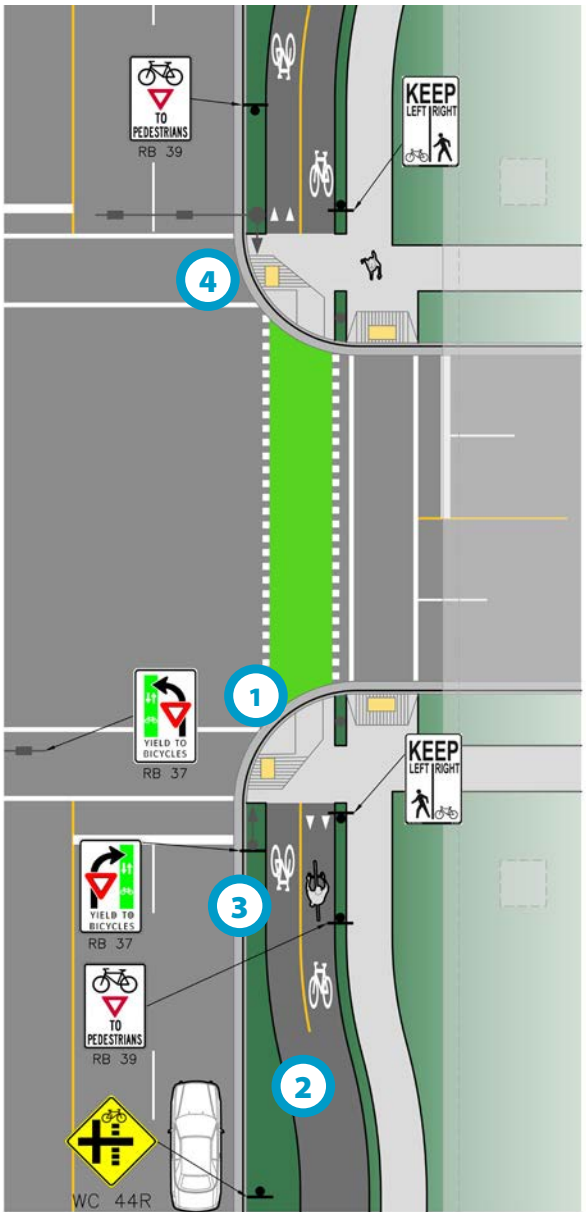


FIGURE 9 - BEND-IN SEPARATED CROSSINGS

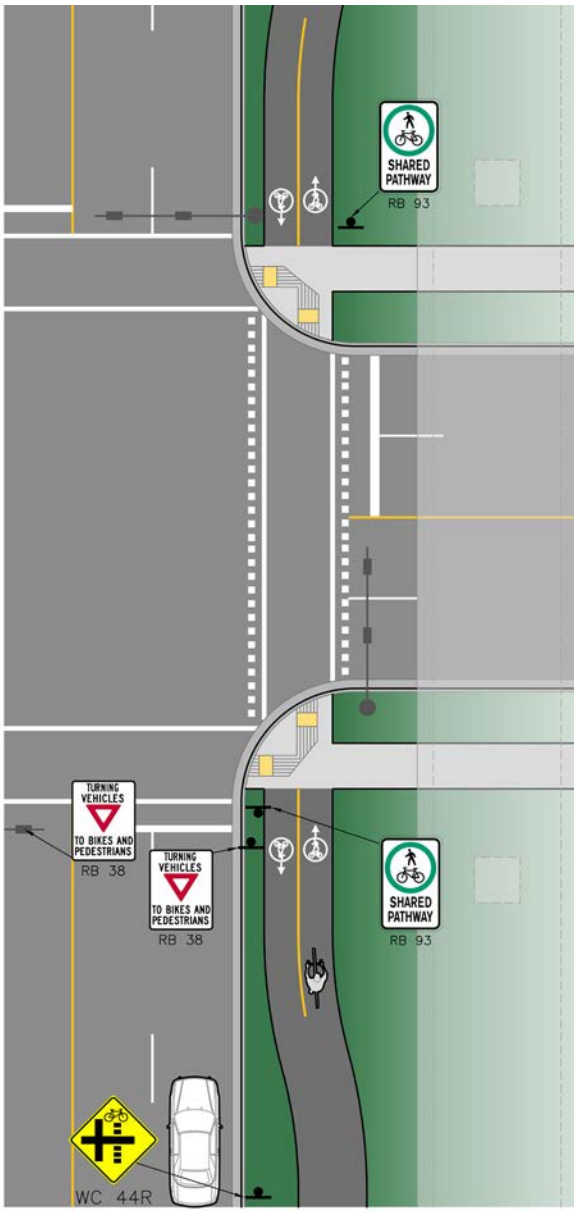


FIGURE 10 - BEND-IN MULTI-USE CROSSINGS

1. Reduce corner radii
2. 3:1 to 10:1 taper ratio alignment, with a 10 to 15 metre tangent
3. Provide good sightlines for motorists to see people using the pathway
4. Intuitive sharing of existing traffic signals at signalized intersections with optional bicycle activated signal

BEND-IN CROSSING (See **Figures 9** and **10**)

+ Improves sightlines for motorists to see people using the pathway;
+ Allows for intuitive sharing of existing traffic signals at signalized intersections;
+ Tends to require less space; and
- Less space for pedestrian queuing and turning vehicle stacking.

BEND-OUT CROSSING (See **Figures 11** and **12**)

+ Provides additional reaction time for motorists turning onto the crossing street. For vehicles turning right, this is dependent on having clear sightlines to the pathway on the approach;
+ Allows motorists from the parallel street to orient their motor vehicles perpendicular to the pathway before crossing it, facilitating better sightlines for both pathway users and motorists;
+ Provides stacking space for motorists turning from the parallel street, so that they are out of the through traffic path when waiting for people to cross the intersection;
+ Provides more room for bicycle box placement to facilitate bicyclists turning off the pathway;
+ Provides more space for people walking to queue between the pathway and curb when crossing the parallel roadway, and is thus preferred at intersections with high volumes of people crossing the roadway;
- There may be reduced sightlines for motorists approaching the intersection on the crossing street, as the stop bar is set back. It may also cause some motorists to queue onto the crosswalk as they advance towards the intersection for better sightlines; and
- Tends to require more space at intersections.

Signage and pavement markings are similar in each treatment (as seen in **Figure 9, 10, 11**, and **12**). The Bicycle Trail Crossing Side Street Sign (WC-44), is used for the parallel street in advance of the intersection. A combined crosswalk and cross-ride are used to bring awareness to the multi-use pathway crossing and separated cross-ride and crosswalk markings are applicable for separated facilities. Turning Vehicle Yield to Bicycles signs (RB-37) or Turning Vehicles Yield to Bikes and Pedestrians signs (RB-38) should be placed in advance of where motorists could cross a cycling or multi-use pathway facility and are required to yield to the cyclists and pedestrians. A second, complementary sign can also be added on the receiving (far) side of the intersection. Shared pathway (RB-98) or a pathway organization (RB-94) signage should be installed on both sides of the intersection on the pathway approach. Curb ramps should be provided in all cases. At intersections where bicyclists are separated from other users two ramps should be provided. The ramp intended for pedestrians should include tactile walking surface indicators, more information about these treatments can be found in **Section 3.**

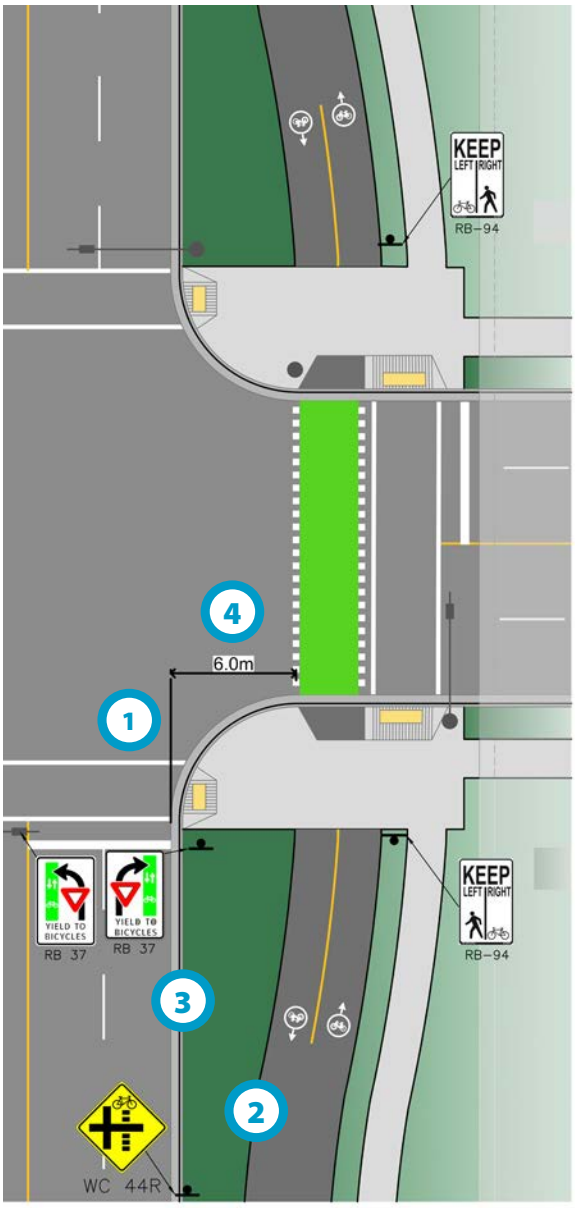


FIGURE 11 - BEND-OUT SEPARATED CROSSINGS

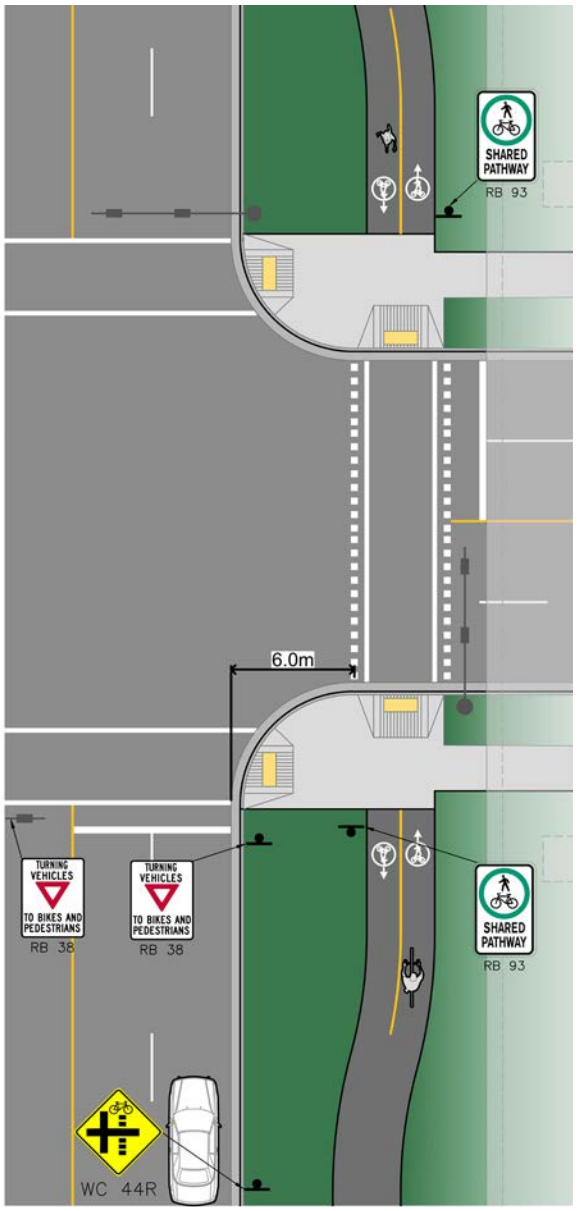


FIGURE 12 - BEND-OUT MULTI-USE CROSSINGS

1. Reduce corner radii
2. 3:1 to 10:1 taper ratio alignment, with a 10 to 15 metre tangent
3. Provide good sightlines for motorists to see people using the pathway
4. Setback crosswalk to provide space for one vehicle

4.4.3 SIGNALIZED INTERSECTIONS WITH CHANNELIZATION

Design guidance is included for both un-channelized and channelized signalized intersections, understanding that circumstances exist where removing channelized turn lanes is not possible or desirable due to increased crossing distances for the pathway users. Intersections where BC Parkway pathway users are required to cross a channelized right turn lane requires special attention, as motor vehicles may maintain a relatively high speed when turning. Higher speeds increase the safety risk and potential collision severity for pathway users crossing the intersection. Due to the additional safety concerns, channelized right turn lanes should be avoided where possible at BC Parkway crossing locations.

Roads with channelized right turn lanes may be retrofitted to remove the channelization and reduce the corner radii, as seen in **Figure 13**. Removing channelized turning lanes is preferred at most intersections where the geometry allows for the required vehicle turning movements. Removal of channelization is desirable for many reasons including:

- Reducing the number of crossings and potential conflict locations for BC Parkway users;
- Reducing the speed of turning vehicles;
- Improving sightlines for turning motorists; and
- Reclaiming space to be used by people traveling on the BC Parkway.

The benefits of removing channelization all contribute to improving safety and comfort for pathway users. Where removal of the channelized right turn lane is not feasible, a second option is to redesign the channel as a 'high entry angle' or 'smart channel.' The difference between a conventional channelized right turn lane and a high entry angle right turn lane. High entry angle channels increase the entry angle to the cross road and decreases the turning speed to be more consistent with a yield condition. The high entry angle reduces the motorist viewing requirement and requires less neck rotation for motorists.

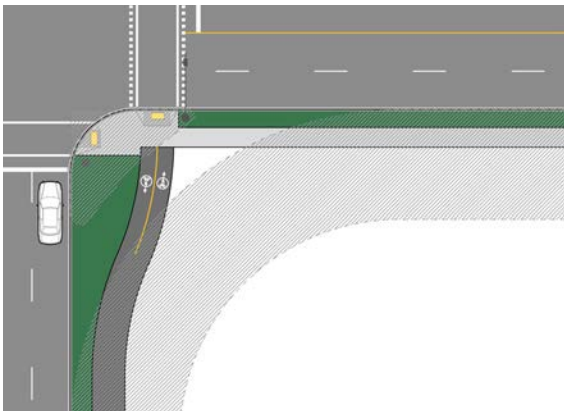


FIGURE 13 - RECONFIGURED CHANNELIZED INTERSECTION

High entry angle approaches also make pedestrians and bicycle users more visible at the crossing. **Figure 14** illustrates the difference between conventional channelized right turn lanes compared to a 'smart channel' right turn lane.

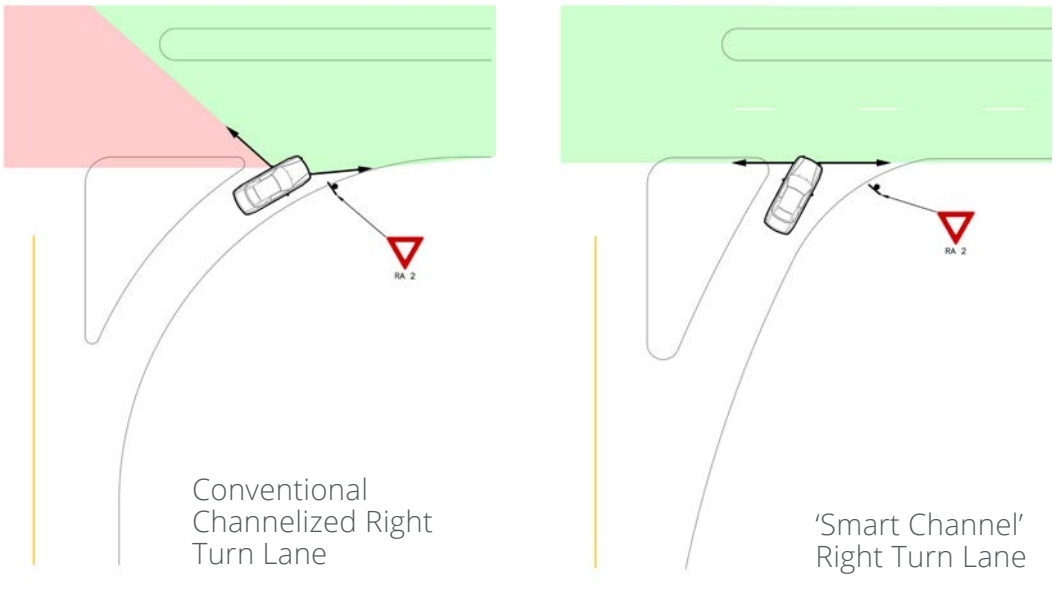


FIGURE 14 - CONVENTIONAL VERSUS SMART CHANNELIZED RIGHT TURN LANES

BC Parkway Crossing at a Channelized Right Turn (City of Burnaby)

DESIGN GUIDANCE

Geometric design, signage, and pavement markings can help to reduce the speed of turning motor vehicles using channelized turn lanes and make BC Parkway users more visible. The design (**Figure 15**) should ensure adequate motor vehicle decision sight distance is achieved for the crossing. ① Turning motor vehicle speeds can be reduced by providing a low-angle right turn 'smart channel' configuration ②. The curb radius can be compounded to accommodate larger vehicles such as trucks and buses ③, while a painted radius can mark off where smaller motor vehicles should turn ④. A minimum of 6 metres should be provided to allow for a motor vehicle to queue after the crossing without obstructing the pathway while waiting for a gap to turn right ⑤. The pathway should be oriented perpendicular to the roadway at the approach, which improves sightlines and gives pathway users the shortest possible crossing distance ⑥. A combined crosswalk and cross-ride should be painted across both the channelized right turn lane and across the main intersection. Curb ramps should be provided in all cases. The pathway centerline may be striped near the intersection. Pathway facing signage can be yield or stop control, this is required because the current MVA only prescribes right of way for pedestrians but not bicycles in a crosswalk. ⑦ Pathway facing signage should be installed to confirm right of way. An optional mountable curb apron can be installed to enable larger vehicles to the turn wide turn while visually creating a smaller space.

The Pedestrian and Bicycle Crossing Ahead Sign (WC-46) should be installed on the main roadway for both directions of the roadway in advance of the intersection, along with the Crossing supplementary tab sign (WC-7S). Multi-Use Crossing signs (CUSTOM) should be installed on each side of the slip lane prior to the combined crosswalk and cross-ride. A yield sign (RA-2) should be installed for motor vehicles exiting the right turn lane. A yield sign for pathway users (RA2 (BICYCLE)) should be installed to confirm right of way. Shared pathway (RB-98) or a pathway organization (RB-94) signage should be installed on both sides of the intersection on the pathway approach, depending on pathway configuration. Curb ramps should be provided in all cases.

At signalized intersections where separate pedestrian and bicycle pathways are provided, as seen in **Figure 15**, it is desirable to keep the walking and cycling pathways separated across the intersection when the channelization island is large enough to accommodate this. Separate curb let downs are preferred, although contrasting paving materials can alternatively be used in constrained locations.

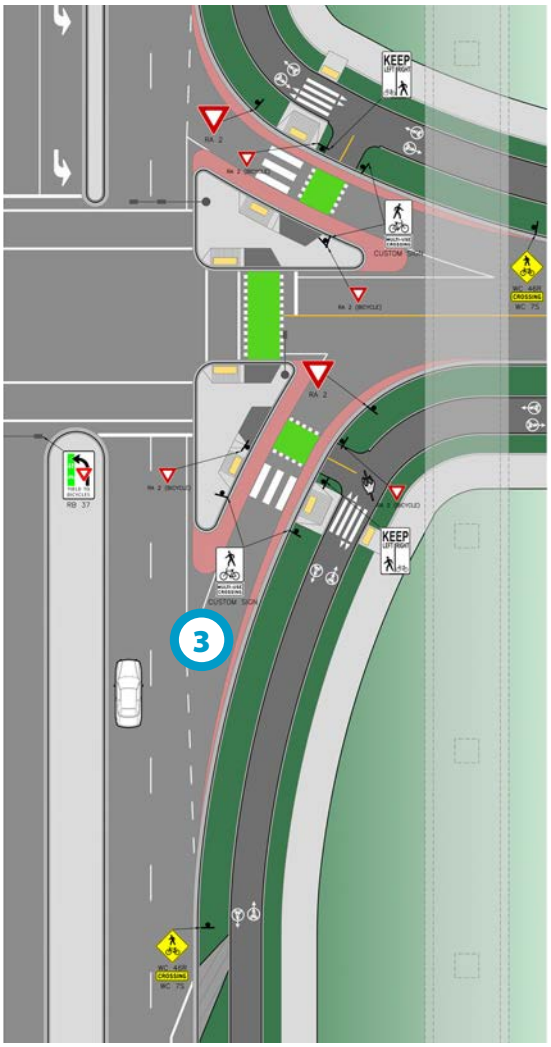


FIGURE 15 - CHANNELIZED INTERSECTION WITH SEPARATED CROSSINGS

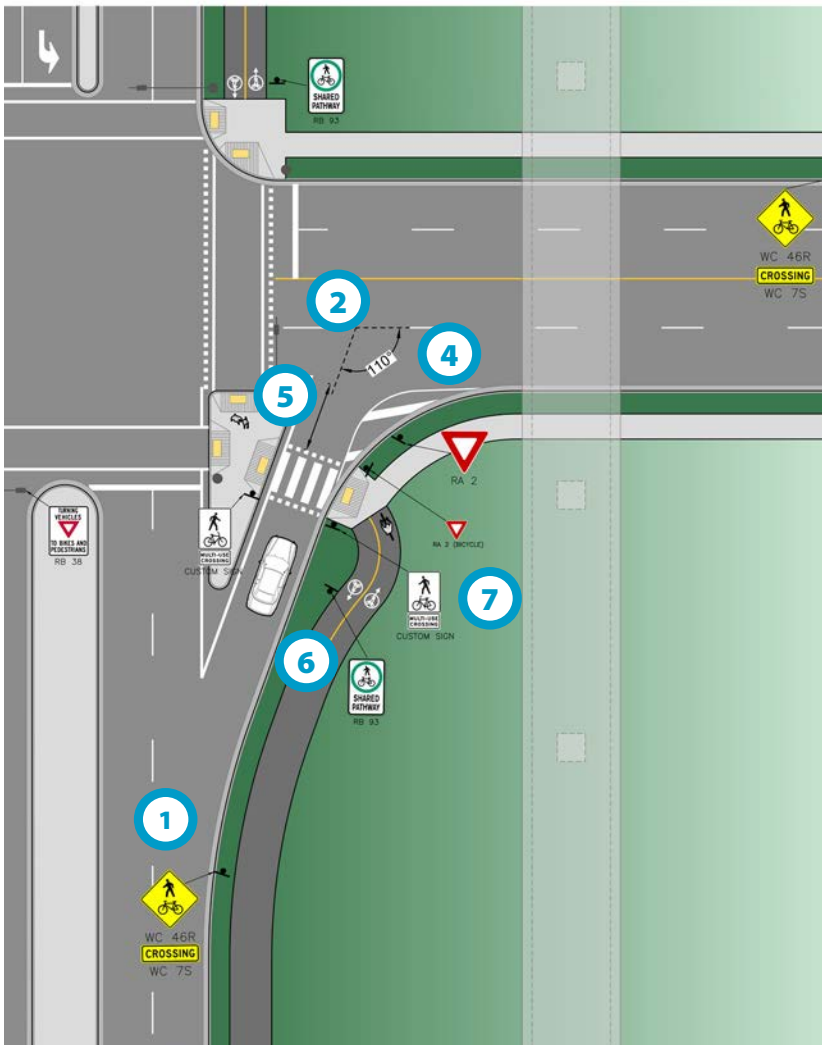


FIGURE 16 - CHANNELIZED INTERSECTION WITH A MULTI-USE CROSSING

1. Ensure adequate motor vehicle decision sight distance is achieved for the multi-use crossing
2. Consider a low-angle right turn 'smart channel' configuration to reduce turning speed
3. Compound curb radius to accommodate the largest design vehicle
4. Painted radius for passenger car turn
5. Minimum 6m to provide space for one vehicle
6. Orient trail perpendicular to the roadway at approach
7. Pathway facing signage

4.5 MINOR INTERSECTIONS AND DRIVEWAYS

Minor intersections are typically locations where the BC Parkway intersects local and minor collector roadways. Typically, these intersections are controlled by stop signs on at least two of the four legs, with a preference to stop control the roadway that crosses the pathway, which then assigns the right-of-way to the BC Parkway.

Driveways are locations where motor vehicles cross BC Parkway to access local access roadways or parking lots. In both of these locations, motorists might not be expecting pathway users, which highlights the importance of design features to highlight and/or control the conflict point. Additionally, considerations should be made at minor intersections and driveways to restrict certain movements to improve the safety and comfort of the pathway users.

4.5.1 INTERSECTION CONTROL

Minor intersections are typically low volume intersections where both motor vehicles and BC Parkway users' movements are controlled by a number of different control devices. Unsignalized intersections often rely on both motorists and pathway users to yield the right of way depending on the context of the intersection. At unsignalized intersections, pathway users may be given right-of-way through stop control for the side street. Where this is the case, no intersection controls are required for the pathway user, although signage, pavement markings, and geometric design may be used to alert BC Parkway users of the upcoming intersection. Other types of roadway facing controls that can be installed at minor intersections include: Rapid Flashing Beacons and Special Crosswalks which are summarized below. More detail about both can be found in **Section 4.2.3**.

There may be some locations where yield or stop control may be used to control the movements of pathway users:

- Where sightlines are not achieved between motorists and people riding bicycles, additional signage for bicyclists to yield or stop and watch for turning motorists should be installed. The presence of stop or yield signs on the pathway does not limit people walking from entering the crosswalk in an appropriate manner.
- At locations where a pathway intersects with a roadway that has a designated bicycle facility yield or stop control for pathway users can be installed.

Consistent use of traffic control for pathway users and motorists is essential to ensure pathway users' safety and compliance. Pathway user compliance at intersections with pathway stop control and should only be used when geometric or sightline issues increase the risk of a conflict.

RAPID FLASHING BEACON:

When activated by a pathway user that is waiting to cross, Rapid Flashing Beacons (RFBs) have flashing yellow lights that alternate back and forth to attract motorists' attention, increasing yielding behaviour. RFBs can be rectangular or circular and can be installed to 'gate' a crossing with one on either side of the street. A two-sided RFB can be included in the median island, if a median exists.

Rapid Flashing Beacon
(Stanley Park Causeway)

SPECIAL CROSSWALKS:

Special Crosswalks, also known as Overhead Pedestrian Flashers, Pedestrian Corridors, and Pedestrian Crossovers, is a traffic control system installed to aid people in walking across the street. The system consists of an Overhead Pedestrian Crossing sign (RA-5) with flashing amber beacons that are activated by the pathway user. Advanced warning signs and flashers can be installed where sightlines are constrained. Pavement markings and ground mounted signs also supplement the overhead flashers. At intersections, the flashers are typically only installed on one side. When used in conjunction with a bicycle crossing, a custom combined Pedestrian and Bicyclist Crossing sign can be used.


Special Crosswalks
(City of Burnaby)

4.5.2 MINOR INTERSECTIONS

DESIGN GUIDANCE

An example of BC Parkway crossing a minor, unsignalized street can be seen in **Figure 17** and **18**. This treatment includes reduced corner radii (preferably 5 metres) that helps to slow motor vehicle turning speeds (1). The pathway bends out, away from the parallel roadway (2). A minimum of 6 metres of space should be provided between the face of the curb and the start of the combined crosswalk and cross-ride to provide stacking space for turning motor vehicles so that they are out of the through traffic path when waiting for people crossing (3).

Unsignalized crossings at minor intersections should be stop controlled for motor vehicles crossing the BC Parkway (4). However, as outlined previously, where sightlines are not achieved between motorists and off-street pathway users, signage for pathway users to yield or stop and watch for turning motorists should be installed (for more information about sightlines, see **Section 4.3**). If pathway users are required to stop, stop signs should be installed on the pathway and oriented to indicate to pathway users riding bicycles that they must stop before proceeding across the crossing. The presence of stop signs on the pathway does not limit people walking from entering the crosswalk in an appropriate manner, nor does it relieve motorists of the responsibility to yield to people in the crosswalk. An additional measure to bring awareness of the crossing to motorists is to install enhanced crossing treatments such as Rapid Flashing Beacons or Special Crosswalks.

Raised crossings or fully raised intersections are the preferred design treatments at unsignalized intersections and driveways to help define right-of-way, slow approaching vehicles, and create a comfortable level crossing for pathway users (5). Raised crossings increase crossing visibility and yielding behaviour with vertical deflection. Raised crosswalks are most appropriate in areas with high volumes of pathway users, such as near parks, schools, transit stations and other major destinations.

Raised intersections are full intersections that are constructed at a higher elevation than the adjacent approach streets. The purpose of a raised intersection is to reduce motor vehicle speeds and reduce conflicts, as they often are provided in conjunction with a stop control on one or both intersecting streets. A raised intersection should be raised by the same amount as any adjacent raised sidewalks (typically 80 millimetres). When raised crossings or intersections are not possible, pathway users are crossing at the same grade as the street. In this case, separate ramps for people walking and cycling are preferred but contrasting pavement can be used to define the space for constrained locations.

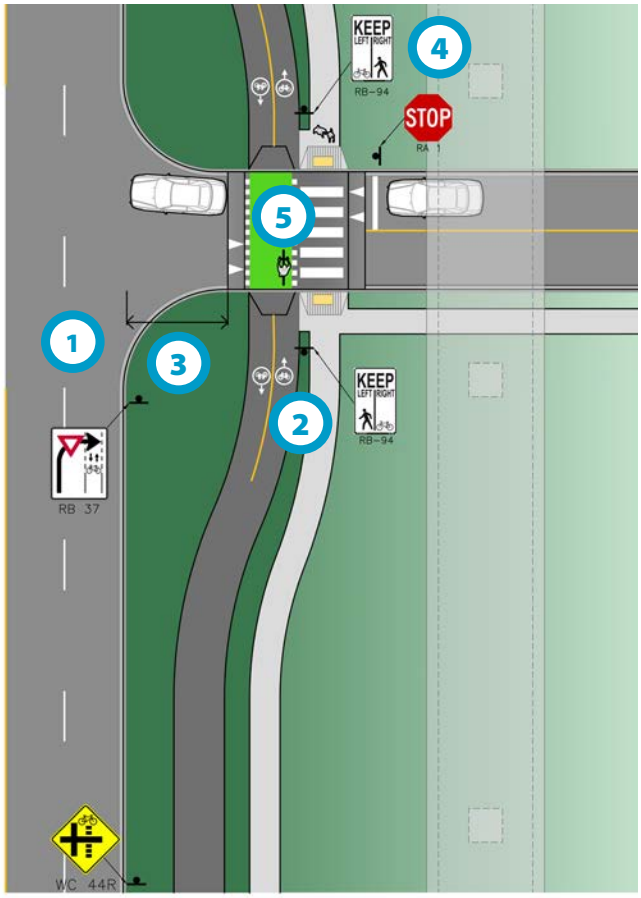


FIGURE 17 - MINOR SEPARATED CROSSING INTERSECTION

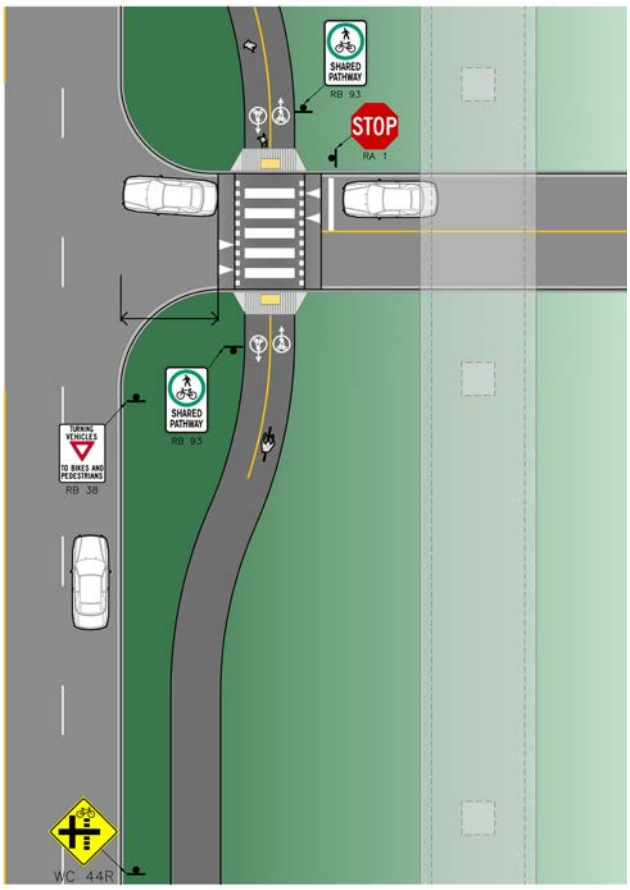


FIGURE 18 - MINOR MULTI-USE CROSSING INTERSECTION

1. Reduce corner radii
2. Bend-out deflection of pathway at intersection
3. Minimum 6 metres to provide space for one vehicle
4. Stop control at minor street crossings
5. Optional raised crossing

Signage and pavement markings are similar for both the multi-use and separated crosswalk scenarios. The Bicycle Trail Crossing Side Street Sign (WC-44) is used for the parallel street in advance of the intersection. Combined zebra and elephant's feet marking are used to bring awareness to the multi-use pathway crossing, and separated cross-ride and crosswalk markings are applicable for separated facilities. Turning Vehicle Yield to Bicycles signs (RB-37) should be placed in advance of where motorists could cross a cycling facility and are required to yield to the cyclist. A second, complementary sign can also be added on the receiving (far) side of the intersection. The Pedestrian and Bicycle Crossing Ahead sign (WC-46), along with the Crossing supplementary tab sign (WC-7S), may be installed on the cross street approach in advance of the crossing. Shared pathway (RB-98) or a pathway organization (RB-94) signage should be installed on both sides of the intersection on the pathway approach.

Raised Crossing at a Minor Intersection (City of Vancouver)

4.5.3 DRIVEWAYS

While the BC Parkway provides protection for users from adjacent through traffic, there is the potential for conflicts at locations where there are driveway or alleyway crossings present. Design considerations need to be made to increase motorists' and pathway users' awareness of the crossings and potential conflicts to ensure safety. **Figure 17** shows design options for driveway crossings.

DESIGN GUIDANCE

An example of BC Parkway crossing a driveway can be seen in **Figures 19** and **20**. Provide sufficient sight distance for motorists and pathway users to see each other ahead of the point of conflict. If there is on-street parking near the driveway, a sightline analysis should be completed to determine the extent of parking restrictions required on either side of the access/driveway.

Where space permits, a 'bend out' alignment can be used from the driveway intersection with the roadway in order to provide additional stopping distance and a space for turning or exiting motor vehicles to wait for crossing people on bicycles. These bends can also serve to reduce bicycle speeds on higher speed sections of the BC Parkway (1). A minimum of 6 metres of space should be provided between the face of the curb and the start of the combined crosswalk and cross-ride to provide stacking space for turning motor vehicles so that they are out of the through traffic path when waiting for people crossing (2). Design alleyway and driveway crossings to support continuity of pathway material to highlight to motorists that they are crossing a bicycle and walking facility, and that the pathway users have right-of-way (3). It is also desirable to maintain a consistent pathway elevation rather than ramping people on the pathway up and down. This concept should be applied where adjacent grading permits construction. Motorists entering the roadway from driveways, alleys and accesses are legally required to stop prior to entering the roadway. However, additional traffic control signage can be installed to reinforce this in locations where motorists encroachment on the sidewalk and/or pathway is an issue (4) .

Signage can also be provided to alert motorists both entering and exiting the driveway or alleyway to the presence of people walking and on bicycles and the direction(s) they are approaching from.

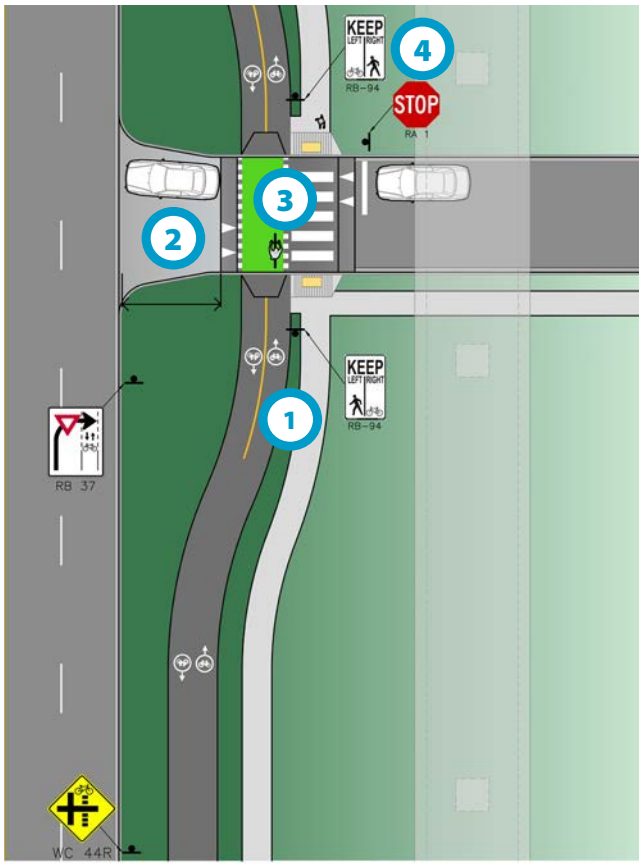


FIGURE 19 - DRIVEWAY SEPARATED CROSSING

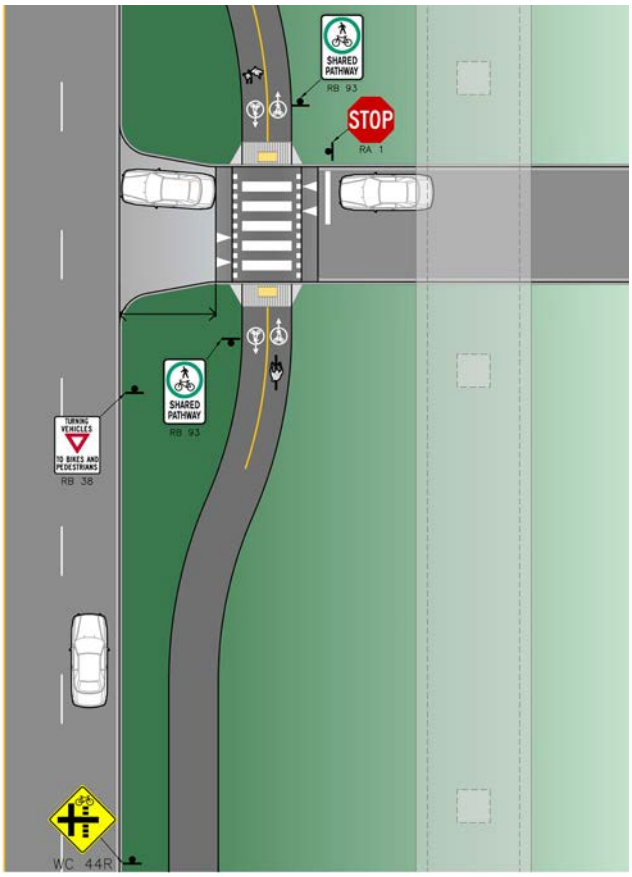


FIGURE 20 - DRIVEWAY MULTI-USE CROSSING

1. Bend-out deflection of pathway at intersection
2. Minimum 6 metres to provide space for one vehicle
3. Raised crossing / continuity of pathway materials and elevation
4. Stop control may be provided at commercial or high volume driveways

The Bicycle Trail Crossing Side Street Sign (WC-44) is not required at all driveway locations, but can be used for the parallel street in advance of major driveway crossings. Combined zebra and elephant's feet marking are used to bring awareness to the multi-use pathway crossing, and separated cross-ride and crosswalk markings are applicable for separated facilities. Turning Vehicle Yield to Bicycles signs (RB-37) should be placed in advance of where motorists could cross a cycling facility and are required to yield to the cyclist. A second, complementary sign can also be added on the receiving (far) side of the intersection. Shared pathway (RB-98) or a pathway organization (RB-94) signage should be installed on both sides of the intersection on the pathway approach.

Separated Crossing and a Minor Street (City of Kelowna)

4.6 MID-BLOCK CROSSINGS

This section provides guidance on the treatment of off-street pathways at mid-block crossings. Mid-block crossings, as the name indicates, are not located at intersections and need to be designed appropriately to consider that motorists are expected to yield to users at the crossing location. Typically, mid-block crossings are preferred when the nearest intersection is more than 75 metres from the crossing location. When an intersection is less than 75 metres from the crossing location consider rerouting the BC Parkway crossing to the nearest intersection.

In some circumstances, it may be appropriate to provide a midblock crossing with an additional signal if it follows the desire line of the parkway. There is an example of this at Joyce Station where a second pedestrian activated signalized crossing is located within less than 30 metres from another signalized intersection. This type of treatment may by suitable where pathway volumes are high and enhances the directness of the pathway.

DESIGN GUIDANCE

PATHWAY ALIGNMENT

At a mid-block crossing, the off-street pathway should be as close to perpendicular as possible to the road that is being crossed. The pathways on each end of the crossing should be aligned with one another. Therefore, pathway alignments may need to shift before crossing the road. Additionally, as noted earlier in this chapter, prior to the crossing the roadway, the pathway alignment should be adjusted geometrically to slow the pathway users' approach speeds to the crossing.

ADEQUATE SIGHTLINES (OF BICYCLISTS AND MOTORISTS)

Mid-block crossings should be installed only where adequate sight distance for both motor vehicle drivers and pathway users is available. **Figure 21** and **Table 2** show the calculation required for determining the appropriate sightlines required for mid-block crossings and resulting values for some roadway widths and speeds. These tables come from the 2017 *TAC Geometric Design Guide for Canadian Roads.* For any widths or speeds not shown in **Table 2**, the formula shown in the **Figure 21** may be used to calculate the required sight distance.

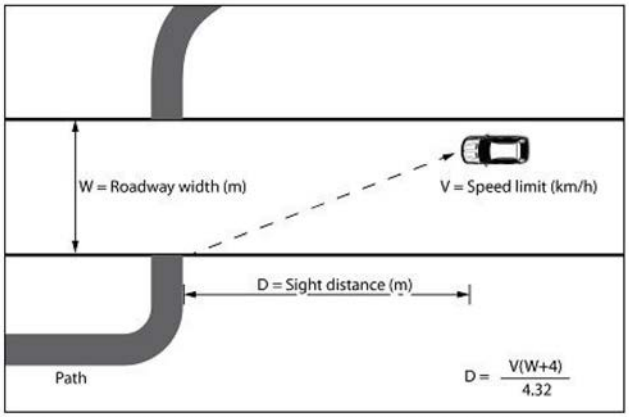


FIGURE 21 - MINIMUM SIGHT DISTANCE FOR MID-BLOCK CROSSING

TABLE 2 - MINIMUM SIGHT DISTANCE FOR MULTI-USE PATHWAY CROSSING

Roadway Design Speed (km/h)				
Width of Roadway - W (m)	**50**	**60**	**70**	**80**
7.0	130	150	180	200
10.5	170	200	230	270
14.0	210	250	290	330
17.5	250	300	350	400
21.0	290	350	410	460

Sightlines can be enhanced by 'daylighting' in advance of the mid-block crossing, which refers to improving sightlines of the crossing by removing obstructions and/or bringing pathways users further out into the motorists' line of vision. This can be accomplished by installing a curb extension to bring pathway users out into the view of motor vehicle drivers and to provide better sightlines for pathway users of motor vehicles on the road as they approach the crossing. On-street parking may also need to be removed in advance of the crossing on both sides of the road to enhance sightlines. The extent of parking removal to ensure adequate stopping sight distance will be dependent on the design speed of the pathway and the roadway, and the location and width of the crossing. Curb extensions are also advantageous in that they shorten the crossing distance while creating a break in on-street parking that impedes motorists from driving down the parking lane.

UNSIGNALIZED CROSSING

Figure 22 and **Figure 23** show two options for designing a mid-block multi-use pathway crossing of an unsignalized street.

In **Figure 22**, a median island has been added to provide refuge for crossing pathway users. The median island should have a desired width of 3.5 metres (minimum 2.5 metres) ① . A minimum travel lane width of 3.5 metres should be provided on either side of the island ②. For higher volume multi-use pathways or streets, the motor vehicle traffic may be stop controlled when the off-street pathway is crossing minor roads ③. RFBs can be implemented with midblock crossings dependent on site conditions. Stop lines should be set back 6 to 15 metres from the mid-block crossing for multi-lane cross sections to ensure that a person crossing the street is visible to the second driver when the first driver is stopped at the stop line. Stop lines should only be used when the crossing is signalized or stop sign controlled ④. A separated bicycle and pedestrian crossing can also be installed.

BC Parkway Mid-block Crossing (City of Burnaby)

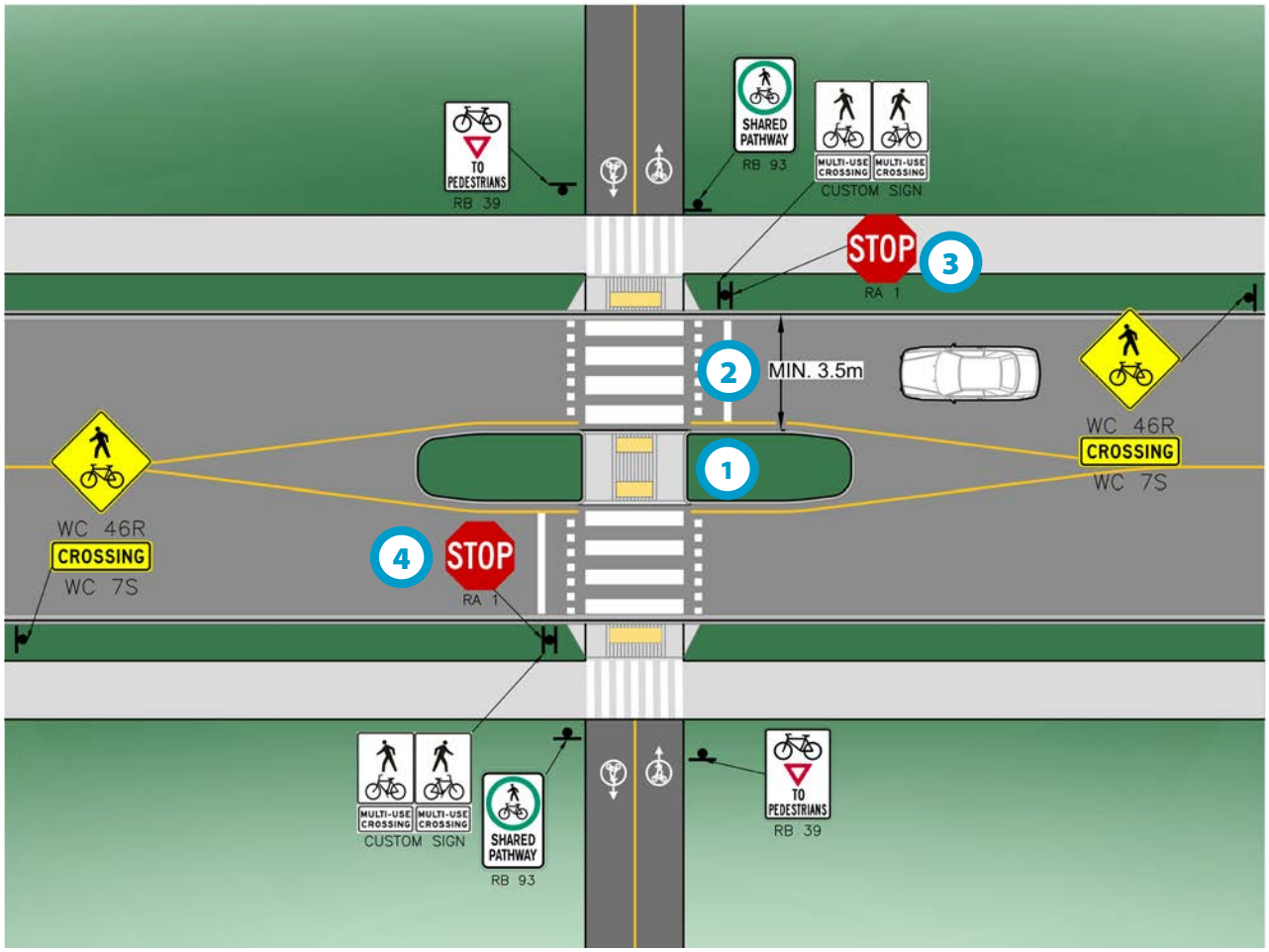


FIGURE 22 - MIDBLOCK UNSIGNALIZED CROSSING - MEDIAN ISLAND

1. Median island (minimum width 2.5 metres / desired 3.5 metres)
2. Minimum vehicle lane width 3.5 metres
3. Stop control for roadway users can be implemented at midblock crossings dependent on site conditions
4. Place the stop line back 6 to 15 metres for multi-lane cross sections

In **Figure 23**, guidance is provided for designing a mid-block crossing at an unsignalized intersection where a curb extension has been installed to narrow the crossing to 6 to 7 metres ①. This example shows how the pathway is adjusted geometrically to slow the users approach speed prior to crossing ②. For higher volume multi-use pathways or streets, the motor vehicle traffic may be stop controlled when the off-street pathway is crossing minor roads ③. Stop lines should be set back 6 to 15 metres from the mid-block crossing either on the roadway when pathway users have right-of-way ④. A raised crossing can be considered as an optional treatment ⑤.

Signage and pavement markings are similar in each treatment. The Pedestrian and Bicycle Crossing Ahead Sign (WC-46), along with the Crossing supplementary tab sign (WC-7S), is used for the approach on the cross street, while double-sided Pedestrian Crossing signs (RA-4R/L) should be installed on each side of the cross street. Combined zebra and elephant's feet marking and yield lines are used to bring awareness to the multi-use pathway crossing. Bicycle Yield to Pedestrian (RB-39) signs should be placed in advance of where a separated bicycle pathway crosses a pedestrian facility. Shared Pathway (RB-98) or a Pathway Organization (RB-94) sign should be installed on both sides of the intersection on the pathway approach. Curb ramps should be provided in all cases.

Along minor streets, another measure to bring awareness of to motorists is to install enhanced crossing treatments such as Rapid Flashing Beacons or Crosswalks, as described in **Section 4.5.1**. For additional awareness of crossing locations, reflective post inserts or sleeves for applicable signage can be added at all crossings.

BC Parkway Mid-block Crossing (City of Burnaby)

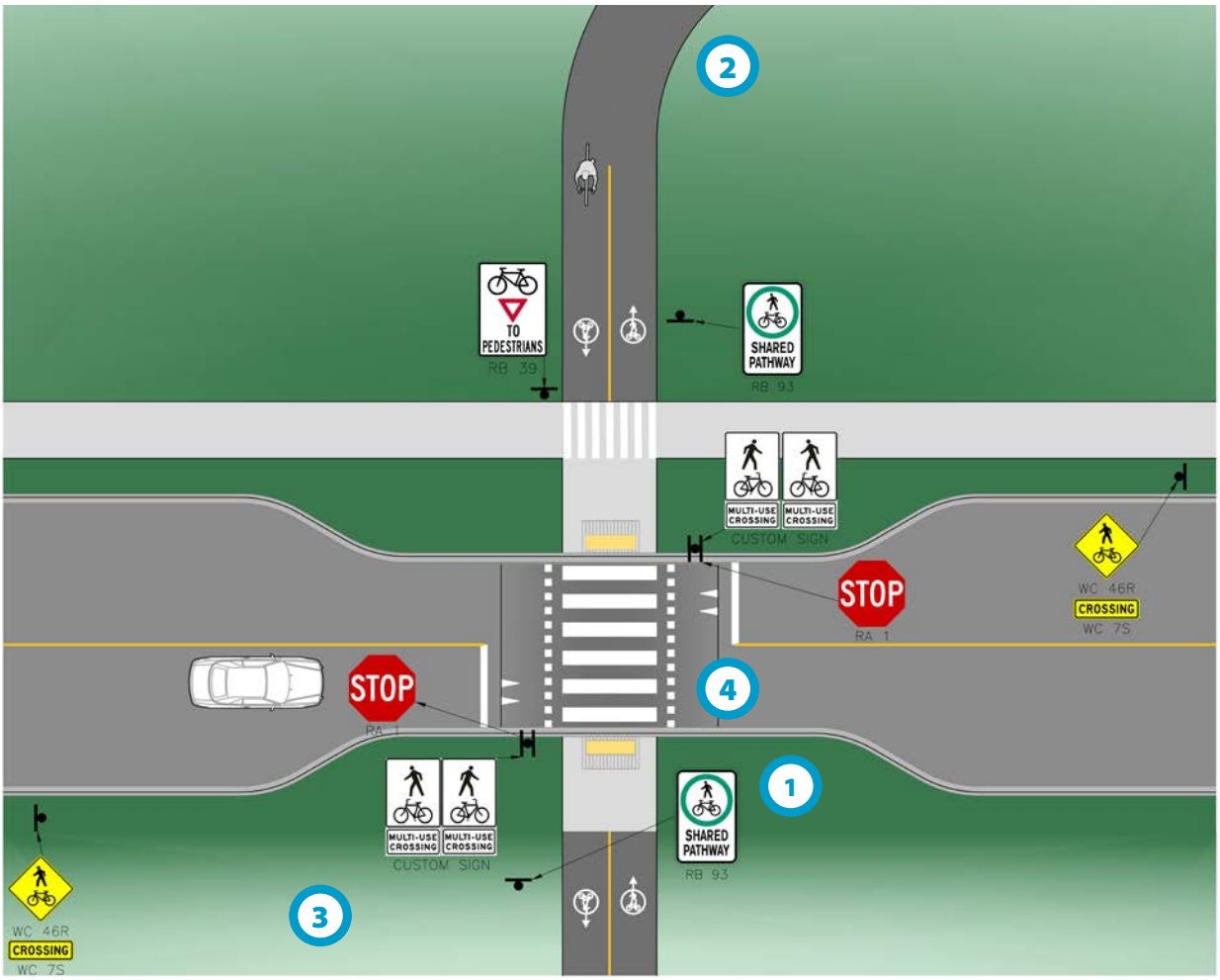


FIGURE 23 - MID-BLOCK UNSIGNALIZED MULTI-USE CROSSING - CURB EXTENSIONS

1. Curb extensions to reduce crossing distance
2. On approach to the mid-block crossing the pathway can be adjusted geometrically to slow the users approach speed prior to crossing
3. Stop control for roadway users can be implemented at midblock crossings dependent on site conditions
4. Optional Raised Crossing

There may be some locations where yield or stop control may be used to control the movements of pathway users, including locations where sightlines are not achieved and where BC Parkway intersects with a roadway that has a designated bicycle facility. **Figure 24** is an example of a mid-block crossing that is stop controlled for pathway users. A stop or yield sign can be installed with optional RFBs (1). This example also shows a mid-block crossing with a separated bicycle and pedestrian crossing.

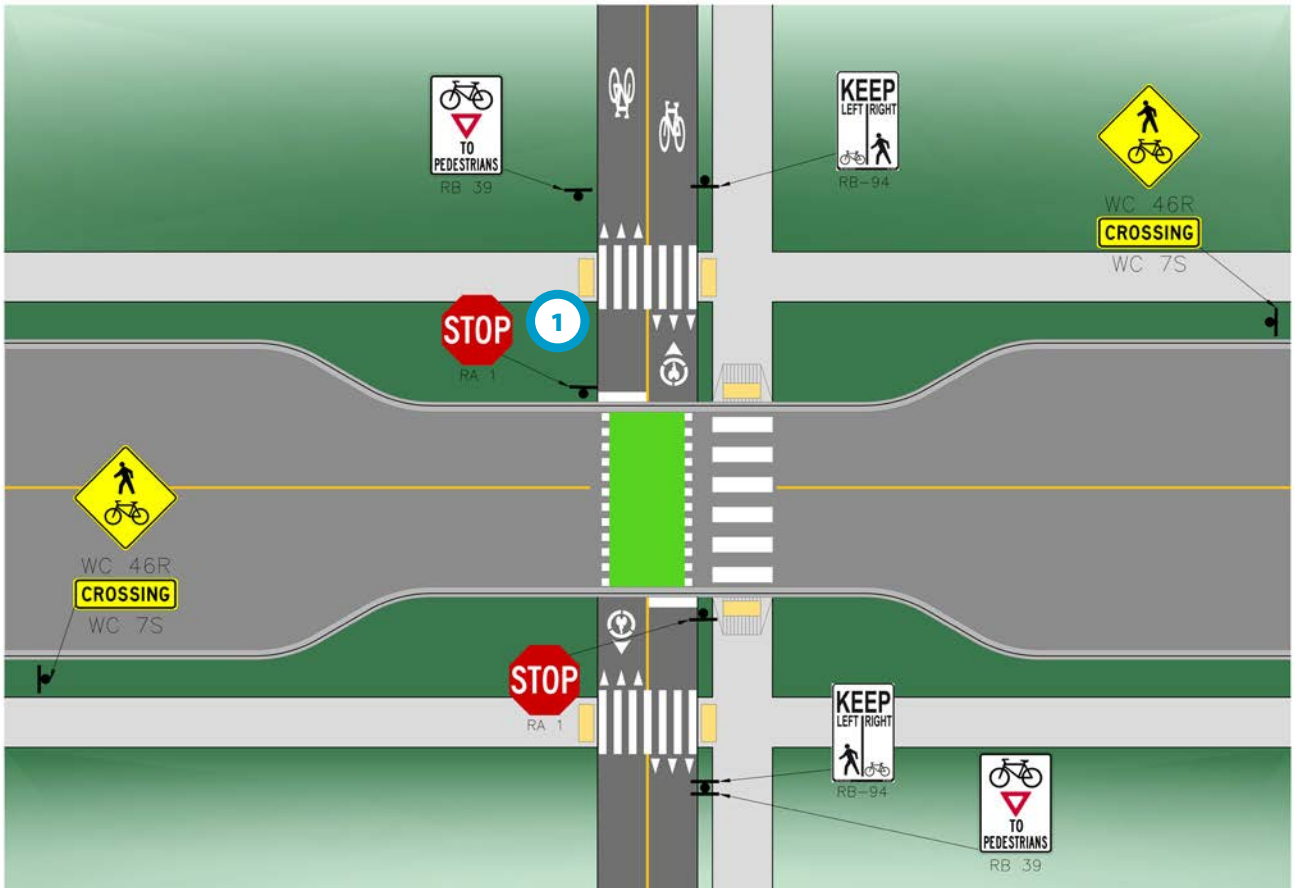


FIGURE 24 - MID-BLOCK UNSIGNALIZED SEPARATED

(1) Stop control for pathway users can be implemented where required. RFBs can also be installed.

MID-BLOCK SIGNALIZED CROSSING

Figure 25 shows a signalized mid-block crossing at a divided major roadway. In this example, a traffic signal is installed for roadway users and a bicycle and/or a pedestrian signal is installed with automatic detection or a push button must be provided for activation (1). A stop bar is provided along the bicycle path / multi-use pathway. If an intersecting sidewalk is provided, a 3.0 metres should be provided between the curb and the crossing (2). If a median island is present, it should be a minimum of 3.0 metres in width (3).

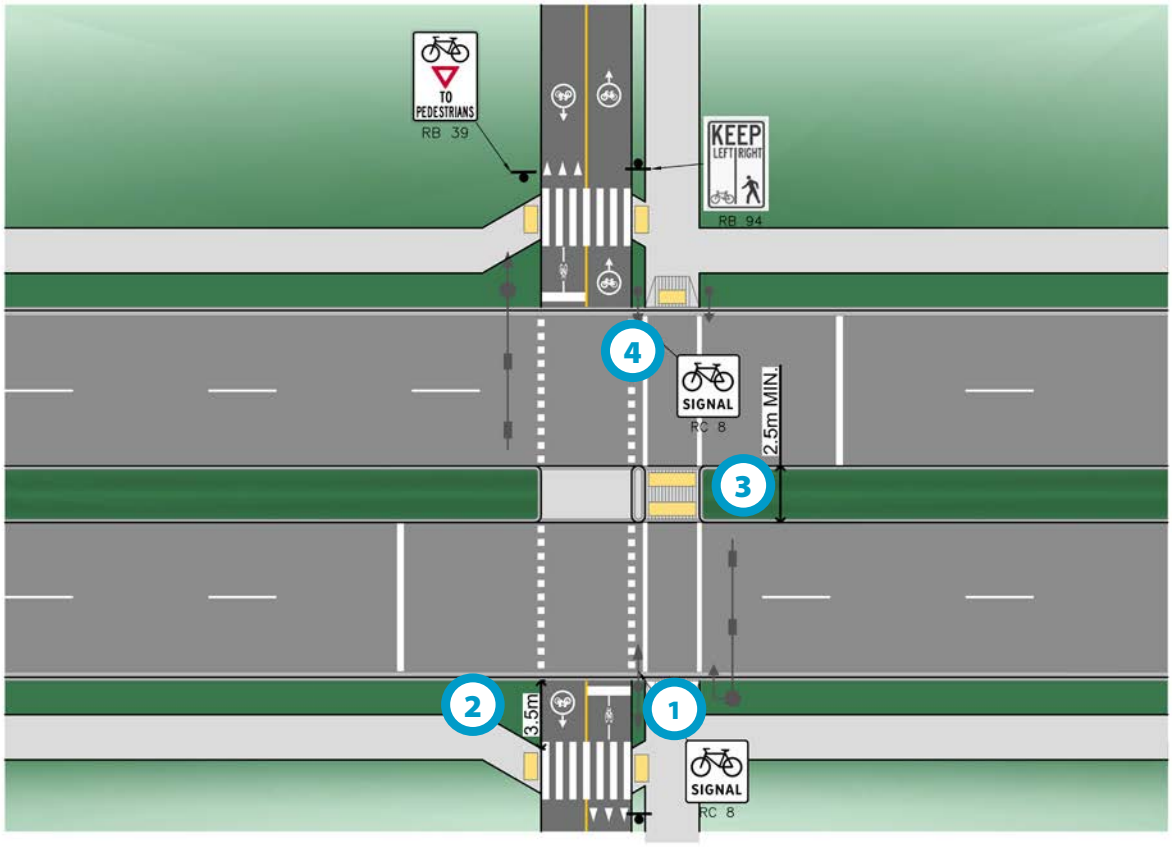


FIGURE 25 - SIGNALIZED MID-BLOCK CROSSING

1. Bicycle signal with automatic detection for activation or bicycle push button
2. Provide a minimum width 2.5 metres / desired 3.5 metres between pedestrian crossing and curb
3. Median island (minimum 3.0 metres)
4. Bicycle signal or stop control required for bicycle crossing

4.7 TRANSITIONS

The transition area is the space or zone where the BC Parkway changes from one facility type to another – for example, where a multi-use pathway transitions into a sidewalk and an on-road bicycle facility. This includes transitions such as off-street pathway to bicycle lane, bicycle ramps and channels, and making a left turn from an off-street pathway onto an on-road facility. This section provides general design guidance on how to enable this transitional movement and reviews common transitional areas. Transitions are very case specific, so the general design intent described below should be applied with a focus on moving transitions out of conflict areas.

DESIGN GUIDANCE

Off-street pathways generally have two-way operation for all pathway users. When pathway users are separated to allow people cycling and walking additional transitions occur. Typically, transitions are more relevant for cyclists since all pedestrian facilities allow two-way travel. Transitioning from a two-way pathway to a facility with one-way bicycle operation requires clear pavement markings and signage for the transition areas to ensure that contraflow bicyclists do not go the wrong-way down the one-way bicycle facility (See **Figure 26**, **Figure 27**, and **Figure 28**). Transitions between an off-street pathway and one-way bicycle facilities requires similar considerations for cyclists transitioning to the opposite side of the roadway with additional space designated for pedestrians.

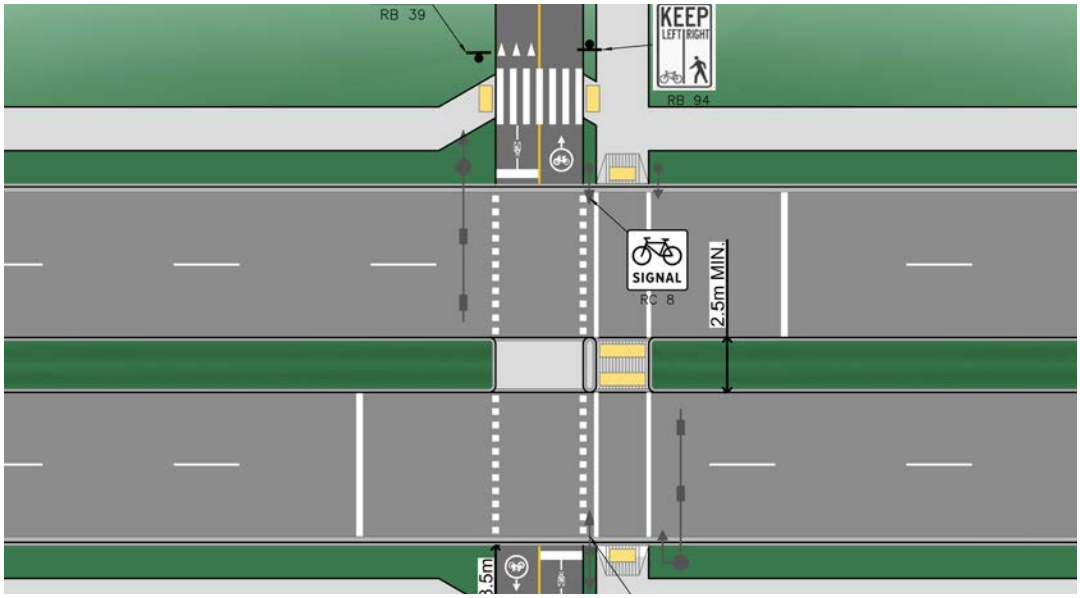


FIGURE 26 - BICYCLE LANE TO MULTI-USE PATHWAY TRANSITION

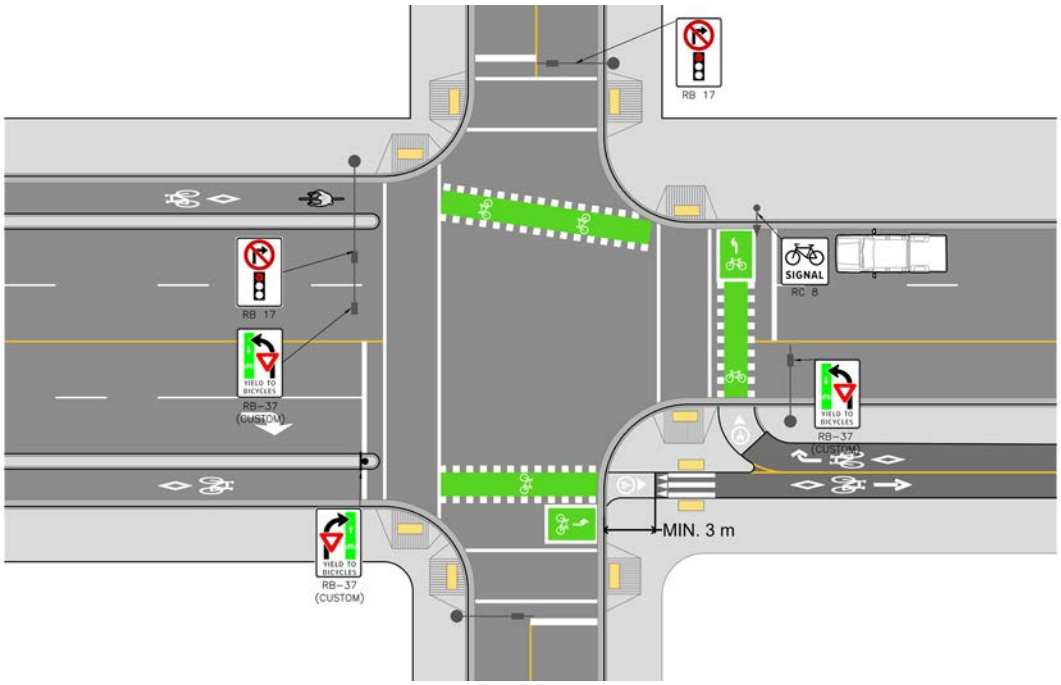


FIGURE 27 - TRANSITION SEPARATED PATHWAY TO ON-STREET (AND VICE VERSA) BI-DIRECTIONAL TO UNI-DIRECTIONAL – EXAMPLE 1

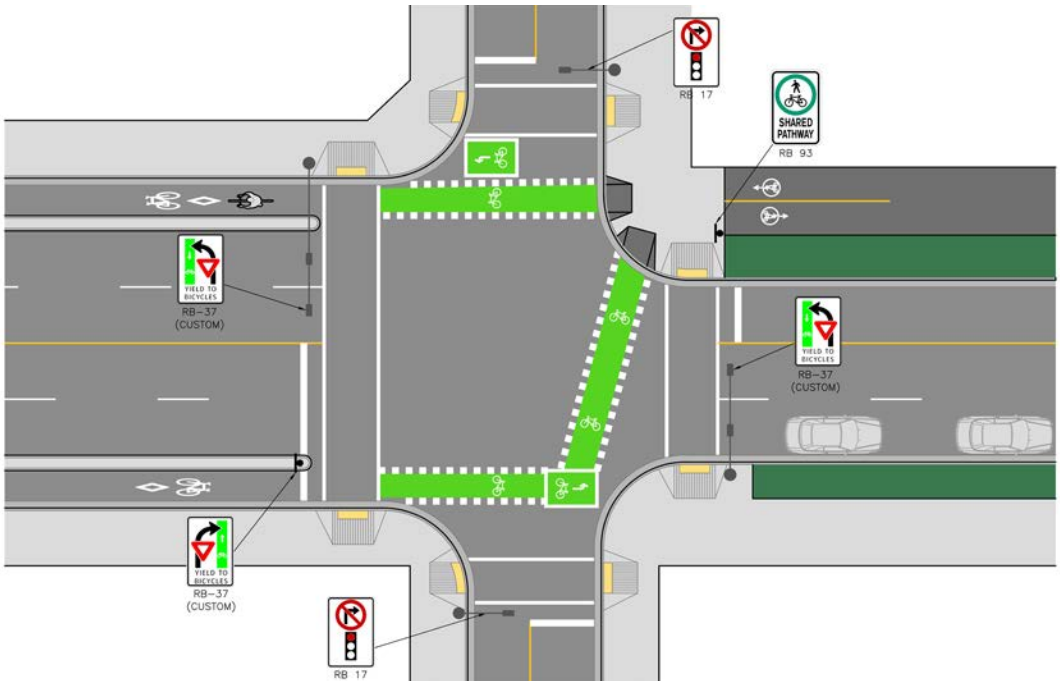


FIGURE 28 - TRANSITION MULTI-USE PATHWAY TO ON-STREET (AND VICE VERSA) BI-DIRECTIONAL TO UNI-DIRECTIONAL – EXAMPLE 2

TRAFFIC CONTROL AND SIGNAGE:

- Bicycle traffic signals should be provided, and signal timing should be coordinated with the cross street traffic to ensure that people cycling are protected. A No-Right Turn-On-Red phase shall be implemented when bicyclists have a green phase. Near side bicycle signals may be appropriate for some facilities.
- Bicycle route and/or directional signage should be installed at the intersection to indicate the shift in cycling facility.

PAVEMENT MARKINGS:

- Higher level conflict zone markings should be used to provide more visual guidance to other users at the intersection.
- Bicycle symbols with directional arrow provide visual guidance for bicyclists transitioning between the two facilities.
- Bicycle boxes or protected corners can be used to help transition between facilities.

BC Parkway Transition to Protected Bicycle Lanes (City of Surrey)

Transitioning between an off-street pathway and an on-street neighbourhood greenway with an adjacent sidewalk requires special considerations to ensure the transition is safe and comfortable for all ages and abilities. Full traffic closure is the preferred treatment to create a safe and comfortable transition for all BC Parkway users by eliminating the need for people cycling to conflict with opposing motor vehicle traffic (See **Figure 29**). When a full closure is not possible or suitable consider directional closures for motor vehicle traffic to reduce volumes or moving the transition in advance of the intersection.

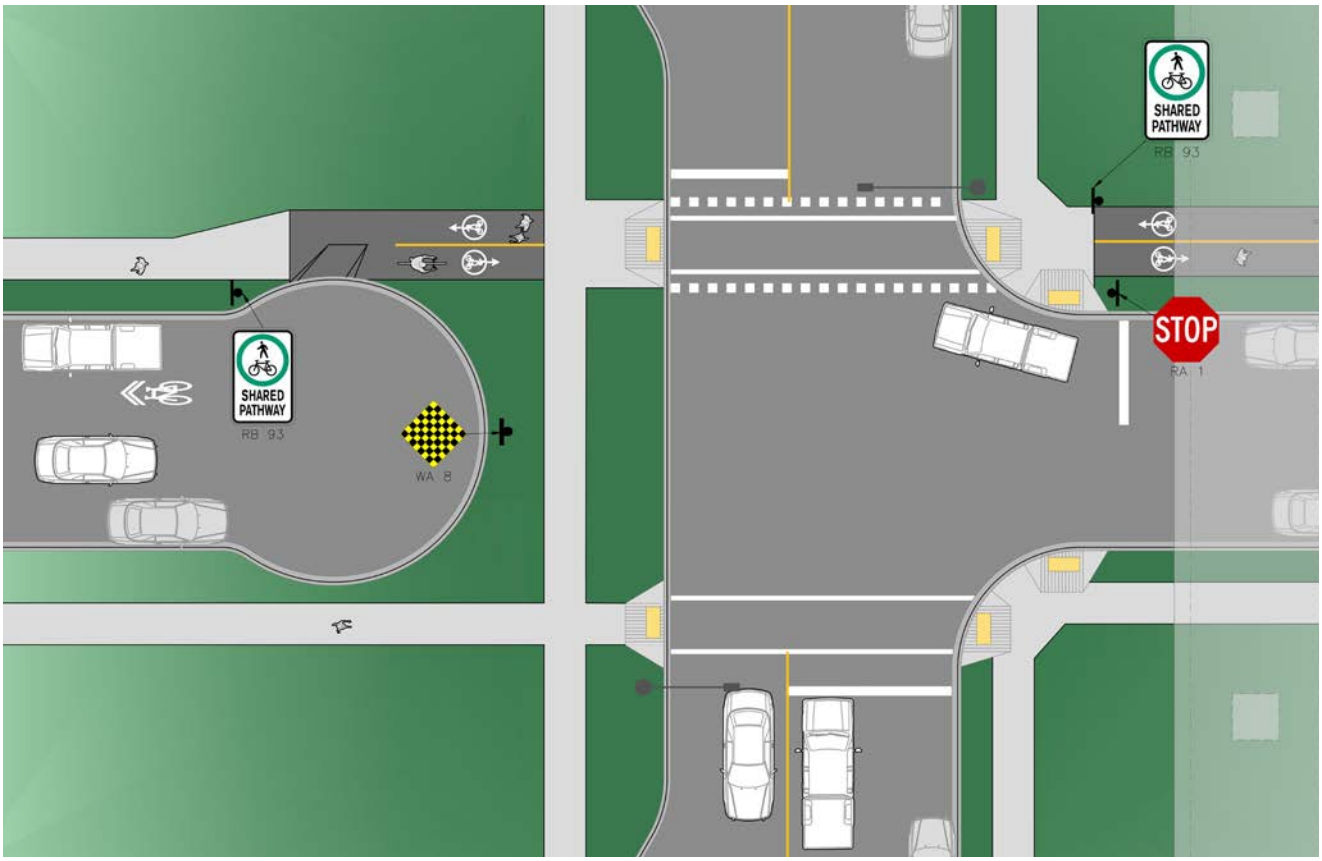


FIGURE 29 - NEIGHBOURHOOD GREENWAY TO MULTI-USE PATHWAY TRANSITION

PROTECTED INTERSECTIONS

There are also opportunities to provide protected intersections at crossings along BC Parkway. Protected intersections are intersections that use a number of enhanced design elements, to provide increased protection for people walking and cycling. Protected intersections provide a high level of safety and comfort for people cycling by clearly indicating right-of-way, promoting predictable movements, reducing the distance and time during which people on bicycles are exposed to conflicts, and adding protected design elements to the intersection. These design elements result in intuitive, low-stress movements in all directions. Conflicts between right turning vehicles and through bicycle users approaching an intersection are eliminated, while conflicts at the intersection itself are mitigated by adding physical protection for bicycle users and reorienting motor vehicles to increase visibility and encourage eye contact between users. Signal phasing may be used to completely eliminate all conflicting movements. There are several design guides that provide information about designing protected intersections including the B.C. *Active Transportation Design Guide*, the *MassDOT Separated Bike Lane Planning and Design Guide*, and the *NACTO* document titled *Don't Give Up at the Intersection*.

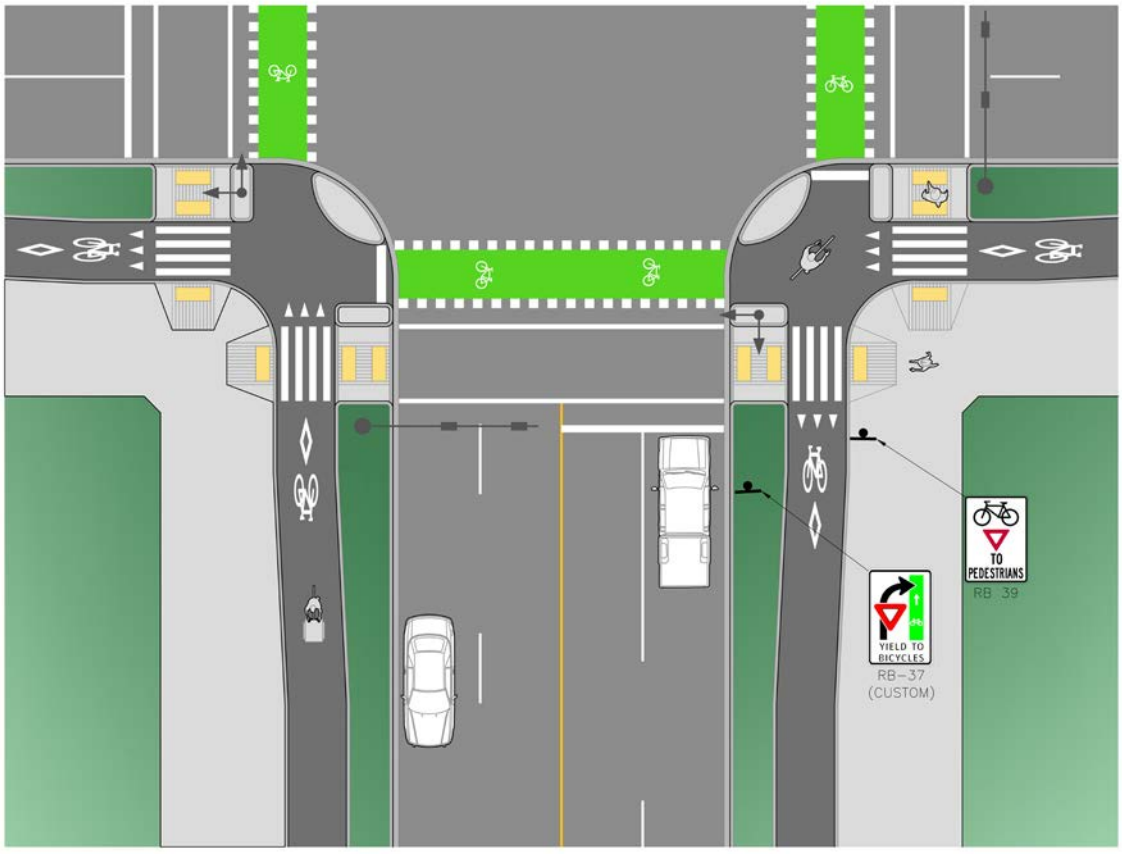
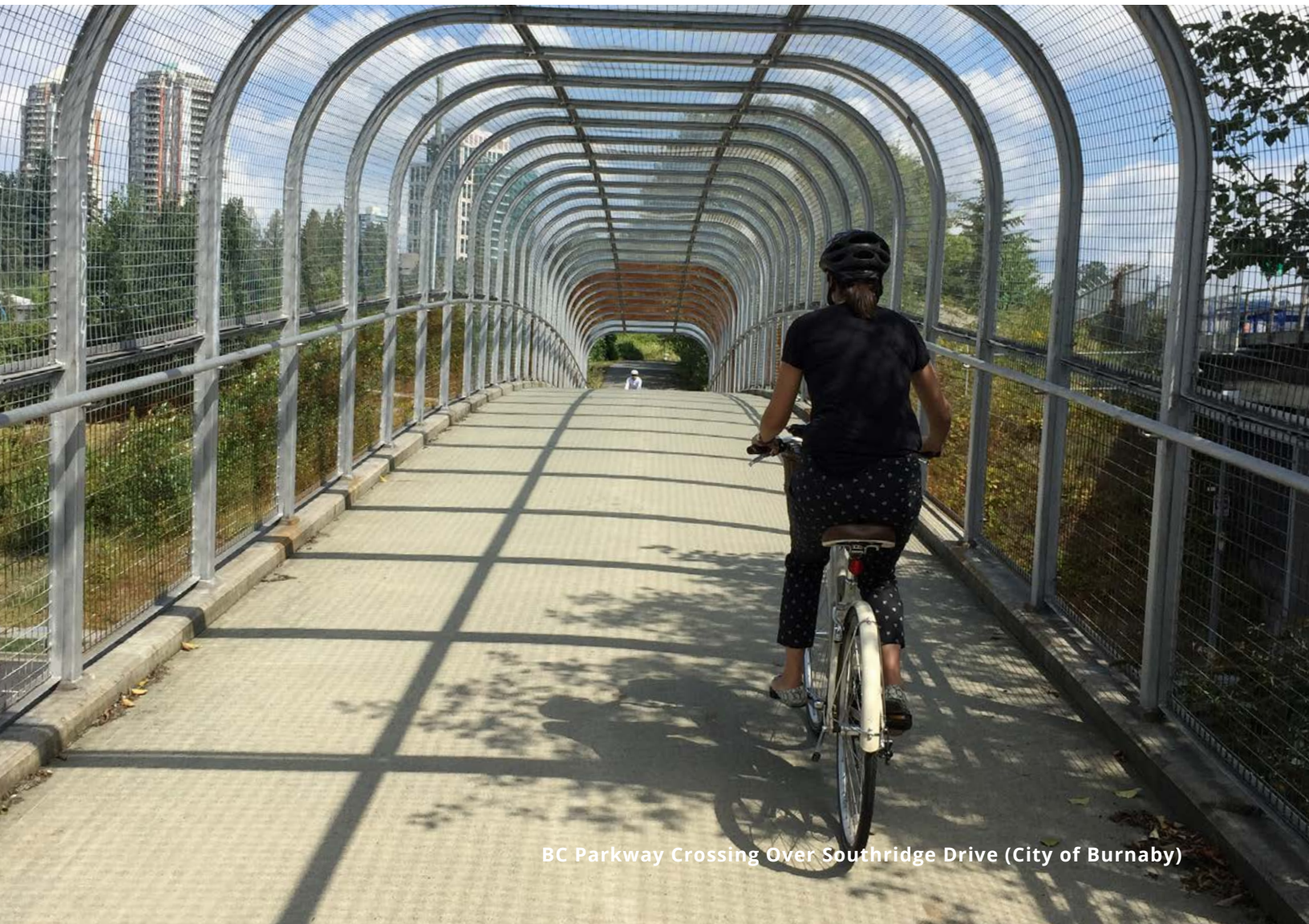


FIGURE 30 - PROTECTED INTERSECTION

4.8 GRADE-SEPARATED CROSSINGS

Grade separation of the BC Parkway from motor vehicle traffic can allow for improved safety and uninterrupted flow of pathway users. This separation requires additional space, higher costs for construction and maintenance of the crossing facility, and may not provide as direct a route for the pathway users, which can be a deterrent to use. When grade-separated crossings are discussed in an urban context, considerations need to be made for other at-grade options as well as the implications of the key destinations and connections adjacent to the proposed grade-separated crossing. Additionally, safety can be a concern with both overpasses and underpasses. In both cases, pathway users may be temporarily out of sight from public view and may have poor visibility themselves.



BC Parkway Crossing Over Southridge Drive (City of Burnaby)

The following should be considered when designing grade-separated crossings:

- Consider safety concerns and evaluate the risk at an at-grade crossing, considering potential exposure for the volume of pathway users expected, and the potential delay for pathway users at an at-grade crossing.
- Use in higher traffic volume locations where roadways with many travel lanes create an environment where at-grade crossings cannot be achieved safely and comfortably. Such locations include high speed on/off ramps, interchanges, highways, major arterials, and other geographic barriers.
- Use where rail crossings create a barrier to safe and comfortable pathway crossings.
- Use where high volumes of people walking and cycling exist or are planned. Grade separation may be considered where either it would not be safe to stop the through road or where significant operational issues would be created by an at-grade crossing.
- Overpasses are most applicable where the topography allows for a structure that has little grade change for people cycling and walking, such as when the roadway is lower than the pathway. Overpasses have a greater visual impact on the landscape but can be designed as an architectural feature.
- Underpasses are generally lower cost for construction than overpasses, except in areas with high groundwater, and are most applicable when the design allows for an open and accessible crossing that feels safe and secure. Underpasses provide better protection from weather, but because of their shelter effect, they can also lead to loitering. Other issues can arise with underpasses include drainage, snow clearance, lighting, and perceived safety.

DESIGN GUIDANCE FOR PROVIDING GRADE-SEPARATED CROSSINGS INCLUDES:

- Ensure the crossings accommodate persons of all ages and abilities through the use of ramps. Ramps should be designed so that they are not too steep for wheelchair users or a deterrent for people on bicycles. See Section 6.5.2.1 of the 2017 *TAC Geometric Design Guide for Canadian Roads* for details about accessible ramps.
- In situations where large grade differences exist, and stairs are unavoidable, bicycle channels should be installed.
- The minimum radius for the pathway needs to consider stopping sight distance, superelevation (increased cross-slopes through curves), bicycle speed, turning radii for larger bicycles (i.e. cargo, tandem, trailers), and coefficient of friction.
- At-grade access and connectivity to other facilities must be maintained.
- Minimize crossing distances to encourage use. If the at-grade crossing distance is significantly shorter, the grade-separated crossing may be poorly used.

- Entrances and exits should be clearly visible and accessible.
- The crossing width of a facility should remain consistent, except at entrances and exits where additional widths can better facilitate movements between different users.
- Minimum lateral clearance to obstacles should be provided; 0.2 metres to obstructions that are 100 millimetres to 750 millimetres high and 0.5 metres to obstructions that are greater than 750 millimetres high.
- Provide a flat landing area with less than 2% slope for turns, at prior to intersections, and following any steeper grades.

4.8.1 OVERPASSES AND BRIDGES

- The minimum width for overpasses to accommodate two-way travel with lateral clearance is 5 metres.
- Protective railings should be a minimum of height of 1.4 metres.
- For facilities on bridges, structures (i.e. cantilever) may need to be added to the bridge if it cannot be retrofitted with the appropriate width of facility.

4.8.2 UNDERPASSES AND TUNNELS

- Ensure design is well lit to increase the sense of security for users.
- Minimum width for underpasses that accommodate two-way travel with lateral clearance is 5 metres. Consider increasing width of facility if length of underpass is greater than 20 metres to allow for more opportunity to pass and improve sightlines for people using the pathway.
- Minimum vertical clearance is 2.7 metres, with a desirable clearance of 3.6 metres, which allows for a small service motor vehicle to use the underpass. The clearance is measured from the surface of the multi-use pathway to the underside of the structure.

5

LIGHTING AND SIGNAL DESIGN

5.0 LIGHTING AND SIGNAL DESIGN

5.1 LIGHTING

Lighting is an important element to consider on off-street pathway facilities and is critically important at intersections. Lighting is important for active transportation users because it increases comfort and safety, and helps with wayfinding, navigation, and observation. Lighting also helps to enhance the visibility of street and pathway surfaces, other street and pathway users, and makes pathway users more visible to motor vehicle drivers.

Potential conflict areas such as intersections, driveways, and alleyway entrances are especially important to illuminate, as all users, especially those at higher operating speeds, need sufficient time to see, assess, and take appropriate action prior to entering the intersection. Caution should be exercised with street light pole placements adjacent to driveway and alleyway entrances. Maintaining a 1.0 metre clearance between the edge of the driveway and pole placement is recommended.

5.1.2 DESIGN PRINCIPLES AND CONSIDERATIONS

Several key principles should be considered when designing lighting at locations where BC Parkway crosses a roadway, including the positioning of luminaires, local context, safety and security, location, life-cycle considerations, and ensuring the lighting is appropriate for all users. Many municipalities require the use of LED technology for luminaire selection.

POSITIONING AND SPACING OF LUMINARIES: Proper positioning of lighting components will illuminate key features of off-street pathway facilities. Continuous sections of off-street pathway facilities may require lighting, as do the key features. Key features include wayfinding signage, conflict and decision points, and intersections. The position, placement, and angle of luminaries can maximize positive contrast and minimize glare. Consideration should be made to ensure that lighting components are positioned sufficiently away from existing lighting systems to avoid over lighting. Lighting posts and lighting fixtures should also be placed in such a way to minimize barriers to users of pedestrian and cycling facilities.

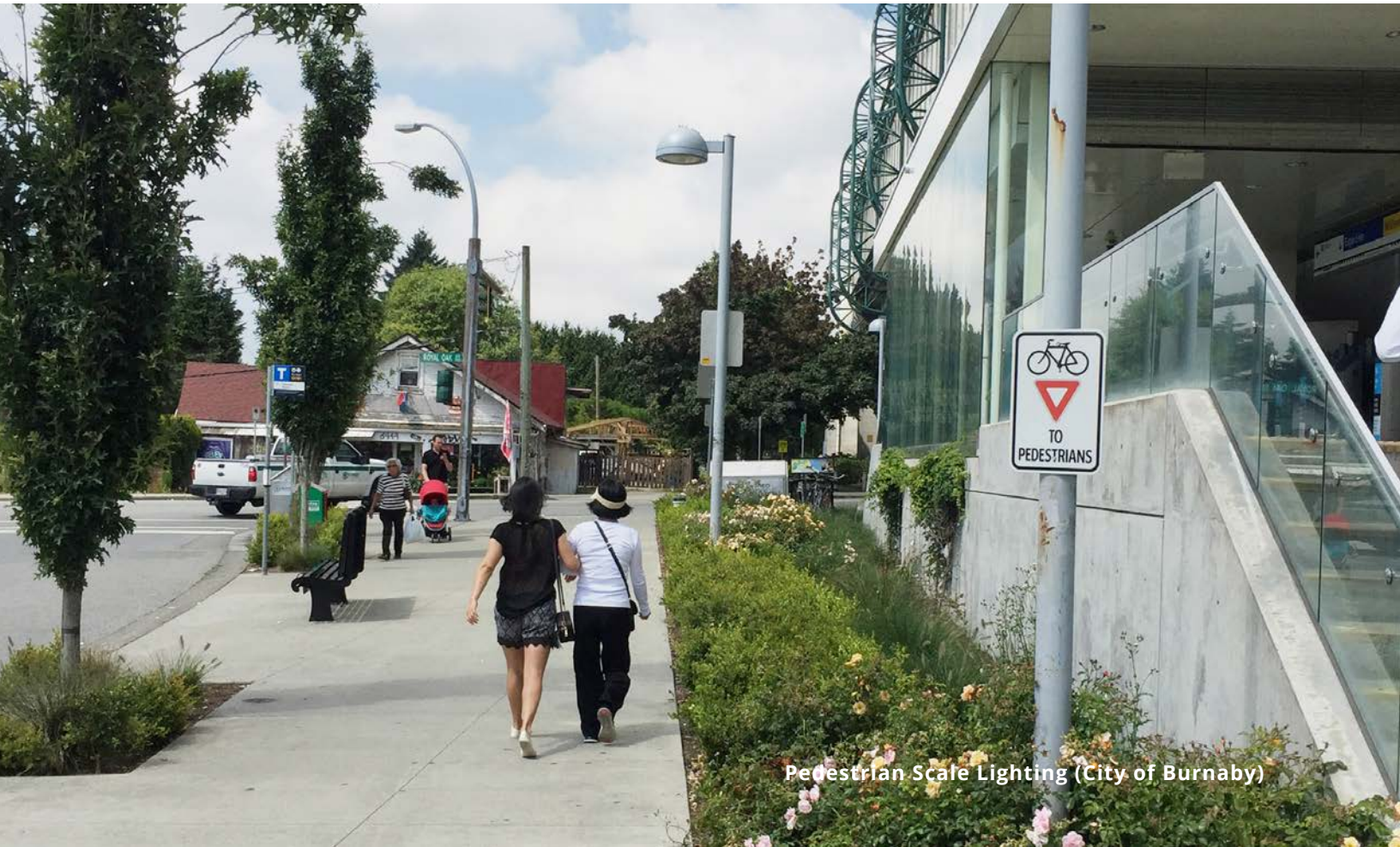
LOCAL CONTEXT: Lighting design should always consider the aesthetic, environmental, safety, security, and social contexts in which a pedestrian or cycling facility is located. The design should simultaneously provide the minimum required lighting to meet desired lighting requirements and address all relevant safety and security considerations, while respecting the local context, minimizing over lighting and trespass, and complementing the built environment. This tends to be more applicable when discussing off-street pathway corridor lighting rather than lighting at intersection and crossing locations.

SAFETY AND SECURITY: Lighting is used to illuminate locations where off-street pathways cross a roadway as it improves the visibility of the intersection, surrounding environment, and other users. Lighting should provide users with enough sight distance to observe, navigate around, and avoid slower facility users so as to reduce the potential for collisions and traffic-related conflicts.

Street Lamps (City of Surrey)

USERS: Lighting design should always consider all users of a facility, as the users determine the type of lighting used, the lighting illumination levels, and the placement and positioning of lighting infrastructure. Lighting design for pedestrians should seek to provide gradual lighting transitions, provide an appropriate colour temperature, and minimize cast shadows. Specific lighting considerations for people with visual impairments should be considered in high traffic areas and frequent points of interest such as arterial roadways and transit facilities.

Lighting design requirements, generally, are categorized into lighting for pedestrians and lighting for bicyclists. The users of BC Parkway can be comprised of children, adults, and seniors who walk or cycle as their main mode of transportation. They can also include users with wheelchairs, scooters, roller blades, skateboards, and reclining bicycles. Users of BC Parkway typically operate at different speeds, therefore requiring different lighting needs. At intersections, the needs of roadway users also need to be considered to ensure that they can clearly see BC Parkway crossing locations and users in the intersection.



Pedestrian Scale Lighting (City of Burnaby)

5.1.2 TYPES OF LIGHTING

Many active transportation facilities require different types of lighting than typical street lighting because of the smaller surface area requiring illumination and the human scale of the users.

STREET LAMPS

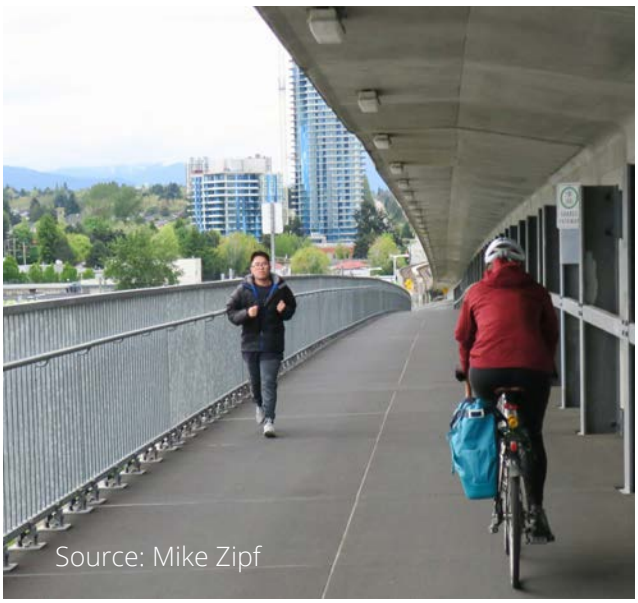
The most common lighting used at BC Parkway intersection locations are street lamps. Street lamps are typically used to illuminate the crossing and surrounding roadway infrastructure. Street lamps may be equipped with secondary, shorter luminaires to enhance lighting in dense tree canopies along tree-lined boulevards, where pruning is not possible.

PEDESTRIAN-SCALE LAMPS

Pedestrian-scale lamps are small-scale street lamps typically placed on off-street facilities such as off-street pathways and separated bicycle and pedestrian pathways. Pedestrian scale lights are typically mounted at a lower mounting height and have a lower lumen output compared to roadway lighting. While pedestrian lamps are more aesthetically pleasing for off-street facilities, their size makes them more conducive to vandalism. They also may not provide a level of illumination appropriate for an intersection crossing. Illuminated bollards can also be considered pedestrian-scale lighting providing an alternative to street lamps. This type of lighting would be more appropriate along the pathway rather than at an intersection.

MISCELLANEOUS LIGHTING

Other types of lighting for pedestrian and cycling facilities exist, such as illuminated bollards, in-ground lighting, and emerging technologies. These types of lighting are mainly used for wayfinding and decorative purposes as they may not provide sufficient illumination for safety and navigation. These types of lighting do not allow users to make out upper bodies and/or faces. They may also require higher maintenance because of vandalism concerns associated with their ease of access to pedestrian and cycling facilities. They do not adequately illuminate a BC Parkway intersection crossing. Also included under miscellaneous lighting includes structure mounted lighting, which can be integrated into the guideway structure as a temporary or long-term measure.


Source: Mike Zipf

5.1.3 DESIGN GUIDANCE

Design requirements for lighting are largely dependent on the facility requiring illumination and the intended users of the facility. There are some additional resources available that provide specific design guidance for lighting on transportation facilities, including:

- *American National Standards Institute Illuminating Engineering Society RP-8-14 Standard Practice for Roadway Lighting* (2018)
- *TAC Guide for the Design of Roadway Lighting* (2006)
- *American Association of State Highway and Transportation Officials Roadway Lighting Design Guide* (2005)

It is important to note that detailed lighting design is generally conducted with the support of detailed lighting software used by an electrical engineer. The guidance in this section is not intended to be a replacement but rather provide best practice considerations and guidance for lighting design specific to BC Parkway intersections.

INTERSECTION APPROACHES

As BC Parkway is an off-street pathway, off-street pedestrian and cycling facilities are defined by TAC as those areas that are located 5 metres or more away from an adjacent roadway. Regardless of the presence of lighting along the pathway corridor, lighting is required on off-street facilities a minimum of 25 metres in advance of an intersection[2]. If the pathway is further than 5 metres from an adjacent street, it is recommended that it have its own independent lighting system that follows the *TAC Guide for the Design of Roadway Lighting*, Chapter 16 (Off-Street Facilities) and **Table 3**. This applies to both lit and unlit streets. If the street is unlit, transitional lighting should be provided leading up to the intersection so that drivers' vision can adjust to the illuminated intersection.

The municipalities BC Parkway is located within have their own standards for lighting within their jurisdiction. All lighting design will be designed at a minimum according to these municipal standards.

[2] OTM Book 18 Cycling Facilities. (2013). Section 5.9.3 pg. 116 - https://ontario-traffic-council.s3.amazonaws.com/uploads/2018/05/OTM-Book-18.pdf-Dec.-2013.pdf

SIGNALIZED INTERSECTIONS

At minimum, lighting requirements for BC Parkway at the approach to a signalized intersection should be illuminated to the same levels as that of the intersection. If vertical illuminance is required, the vertical levels should be equal to or better than required horizontal illuminance levels. When the configuration of an intersection changes, or the classification of a street is modified, the pedestrian conflict level of the intersection (as identified in **Table 4** and **Table 5**) should be revised. When this occurs a lighting evaluation of the entire intersection is recommended to ensure compliance with current standards. RP-8-14 also provides recommended levels for pedestrian areas and bikeways (**Table 4**, **5**, **6**, **7**) . The RP-8-14 requirements are based on pedestrian signal activity levels, and includes requirements for vertical illumination for increased uniformity.

> *Illuminance is defined as the total luminous flux incident on a unit area of a surface. Horizontal illuminance is the amount of light on a horizontal surface. Vertical illuminance is the amount of light on a vertical surface.*

TABLE 3 - RECOMMENDED ILLUMINANCE LEVELS FOR WALKWAYS AND BIKEWAYS SOURCE: (TAC GUIDE FOR THE DESIGN OF ROADWAY LIGHTING – VOLUME 2 – CHAPTER 16 – TABLE 16.1) RECOMMENDED ILLUMINANCE LEVELS FOR PEDESTRIANS

Area	Minimum Average Horizontal Illuminance (LUX)	Max. Horizontal Uniformity (Ave. to Min. illuminance)
Walkways and Bikeways	5.0	10.0:1
Pedestrian Stairs	5.0	10.0:1
Pedestrian and Cyclist Tunnels	43.0	10.0:1

UNSIGNALIZED INTERSECTIONS

Signalized intersections require horizontal and vertical illuminance whereas unsignalized intersections require only horizontal illuminance. Chapter 12 of the *TAC Guide for the Design of Roadway Lighting* recommends that all pedestrian crosswalks with nighttime traffic be illuminated. It is worth noting that RP-8-14 does not distinguish between signalized and unsignalized intersections. Distinctions are made based on roadway classification and pedestrian conflict classification.

The principle purpose of lighting is to allow accurate and comfortable visibility at night of possible hazards in sufficient time to allow appropriate action. Night is defined by TAC as the hours between the end of evening civil twilight and the beginning of morning civil twilight. Civil twilight ends in the evening when the centre of the sun's disk is 6° below the horizon and begins in the morning when the centre of the sun's disk is 6° below the horizon (TAC Guide for the Design of Roadway Lighting).

Generally, existing roadway lighting is sufficient for facilities located within the roadway allowance, provided the roadway lighting has properly accounted for the level of pedestrian and vehicle activity. On-street facilities with high levels of pedestrian activity or high potential for pedestrian and vehicle conflict will require additional or supplementary illumination through the use of additional lamp posts, secondary luminaires, or pedestrian-scale lighting.

The levels of illuminance for on-street facilities are shown in the tables below (**Table 4** and **Table 5**). Generally, where the volume of existing or anticipated active transportation users is high, the level of illuminance should be greater.

The levels of pedestrian activity are defined as:

- **High:** Areas where a significant number of pedestrians are expected to be on the sidewalks or crossing the streets after dark (over 100 pedestrians per hour). Examples of high activity areas are, downtown retail areas, near theaters, concert halls, stadiums, and transit terminals.
- **Medium:** Areas where lesser numbers of pedestrians utilize the streets at night (10 to 100 pedestrians per hour. Typically this includes downtown office areas, blocks with libraries, apartments, neighborhood shopping, industrial, parks, and streets with transit routes.
- **Low:** Areas with very low volumes of night pedestrian usage (10 or fewer pedestrians per hour). These areas can be on any type of roadway but are likely to be along local and residential streets with single family dwellings, very low density residential developments, and rural or semi-rural areas.

For more information on levels of lighting required based on pedestrian activity and area, refer to *TAC Guide for the Design of Roadway Lighting* – Volume 2 – Chapter 9 – Table 9.3. RP-8-14 also provides guidance on luminance levels that differs from TAC.

TABLE 4 - RECOMMENDED ILLUMINANCE LEVELS FOR PEDESTRIANS SOURCE: (TAC GUIDE FOR THE DESIGN OF ROADWAY LIGHTING – VOLUME 2 – CHAPTER 9 – TABLE 9.3)

Pedestrian Activity	Minimum Average Horizontal Illuminance (LUX)	Minimum vertical illuminance at 1.5m above pavement (LUX)	Max. Horizontal Uniformity (Ave. to Min. illuminance)
High	20.0	10.0:1	4.0:1
Medium	5.0	2.0:1	4.0:1
Low	3.0	0.8:1	6.0:1

As seen in **Table 5**, there are two areas that are identified as high conflict areas: 'Mixed Vehicle and Pedestrian' areas, where no physical separation exists between vehicles and pedestrians, and 'Pedestrian Only' areas. For all other areas, the classification is for pedestrian only areas (no mixed vehicle/pedestrian). Areas with a greater level of conflict should have a higher level of illuminance.

TABLE 5 - RECOMMENDED ILLUMINANCE LEVELS FOR PEDESTRIANS (SOURCE: (RP-8 (2014) - TABLES 4, 5 AND 6)

Area	Pedestrian Conflict Area	Minimum Average Horizontal Illuminance (LUX)	Minimum vertical illuminance at 1.5m above pavement (LUX)	Max. Horizontal Uniformity (Ave. to Min. illuminance)
Mixed Vehicle and Pedestrian	High	20.0	10.0	4.0:1
Pedestrian only	High	10.0	5.0	4.0:1
Pedestrian	Medium	5.0	2.0	4.0:1
Pedestrian	Medium Density Residential	4.0	1.0	4.0:1
Pedestrian	Low Density Residential	3.0	0.8	6.0:1
Pedestrian	Rural/Semi Rural	2.0	0.6	10.0:1

MID-BLOCK CROSSINGS

Lighting at pedestrian and cycling facilities at mid-block crossings is important to ensure that motor vehicle drivers can anticipate and predict pathway users crossing the street. To achieve positive contrast, light poles should be strategically placed in advance of the crosswalk. The placement of poles along with the luminaire selection, light distribution, and house side shielding can help to minimize light pollution. Mid-block crossings are typically designed with lighting poles that are similar in height to adjacent poles or poles that are specified by the authority having jurisdiction. For more information on lighting at mid-block crossings refer to *TAC Guide for the Design of Roadway Lighting* - Volume 2 – Chapter 12 – Section 12.5.2.

OTHER LOCATIONS

Tunnels and Underpasses: Tunnels and underpasses should be well lit for the security and comfort of pedestrians and cyclists. Ideally, users should be able to clearly see what is happening throughout the entire tunnel or underpass, though this is dependent on the geometry of the tunnel.

Bridges and Overpasses: Overpasses should be lit to ensure that users can see any hazards or obstructions as well as other users. There are opportunities to use bridge and overpass lighting to enhance and showcase the structure.

Warrants: There are cases where communities and jurisdictions have identified locations and scenarios where lighting is warranted along pedestrian and cycling facilities. These vary by community but often take into consideration the volume of users, likelihood of conflict, and presence of hazards. A warrant may be required for a street or pathway corridor. However, it is always recommended that lighting is provided at an intersection crossing.

5.2 SIGNALS FOR PATHWAY USERS

Traffic signals provide traffic control at street and pathway crossings. There are a variety of types of signalized crossing systems that can be used to provide various levels of control or warning to gain motor vehicle drivers attention. The needs of all street and pathway users need to be considered in the design of signals. This section summarizes considerations for off-street pathway users with the design of signalized crossing systems.

Each municipality within the study has implemented some of the enhancements indicated below. Because each municipality has their own standards for signalization, any new installation should follow the standards of the respective municipality and any deviation should be discussed and approved. Design professionals are reminded that any signal timing plans, particularly those involving bicycle signal phasing, shall be signed and sealed by a professional engineer experienced in traffic engineering.

Section 3.3 of this guide outlines the different types of signalized crossing systems, including full and half signals, overhead pedestrian flashers, and RRFBs. The purpose of this section is to specifically look at signalization considerations for pathway users including signal phasing, activation, and the use of countdown timers.

Multi-Use Pathway Crossing (City of Portland)

5.2.1 BICYCLE SIGNALS

A bicycle signal is a three-coloured traffic control device that can be used in conjunction with a full signal. The signal head can have a conventional circle with a supplementary Bicycle Signal tab sign or it can have a bicycle symbol for each head with an optional supplementary Bicycle Signal tab sign (**Figure 30**). Alternatively, bicycle traffic can also be controlled with pedestrian signal indications with a custom Bicycle Use Pedestrian Signal sign.

The Motor Vehicle Act (MVA) currently does not recognized bicycle signals as a traffic control device and as such, they have no legal meaning under current legislation. Municipalities should only consider the installation of bicycle signals based on sound engineering and legislative review.

TYPICAL APPLICATION

There are various ways in which the movement of people on bicycles through an intersection can be controlled using traffic signals. A separate bicycle signal may be used to provide guidance to bicyclists at intersections where they may have different needs from the other street users. A separate bicycle signal head and phase may also be installed at locations to improve safety or operational concerns, such as where sightlines may not be achieved, where there is a high volume of conflicts with motor vehicles turning, or when there is a bi-directional bicycle facility, such as the BC Parkway. A review of existing motor vehicle volumes, traffic signal equipment, and traffic signal timing and phasing should be completed prior to the installation of bicycle signals to ensure that a separate signal phase can be accommodated. Guidance on separate signal phasing is provided in further detail below.

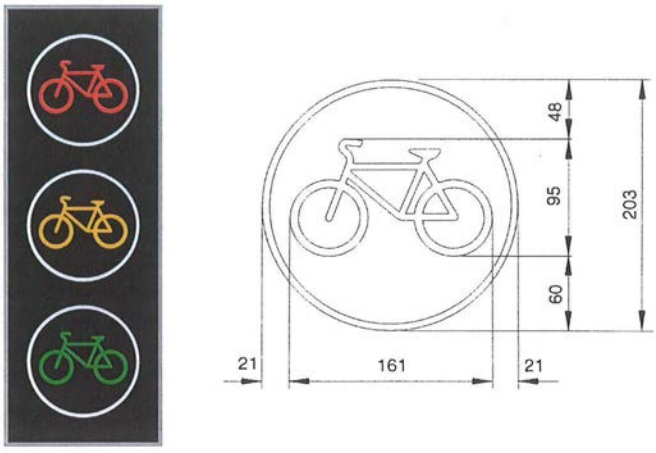
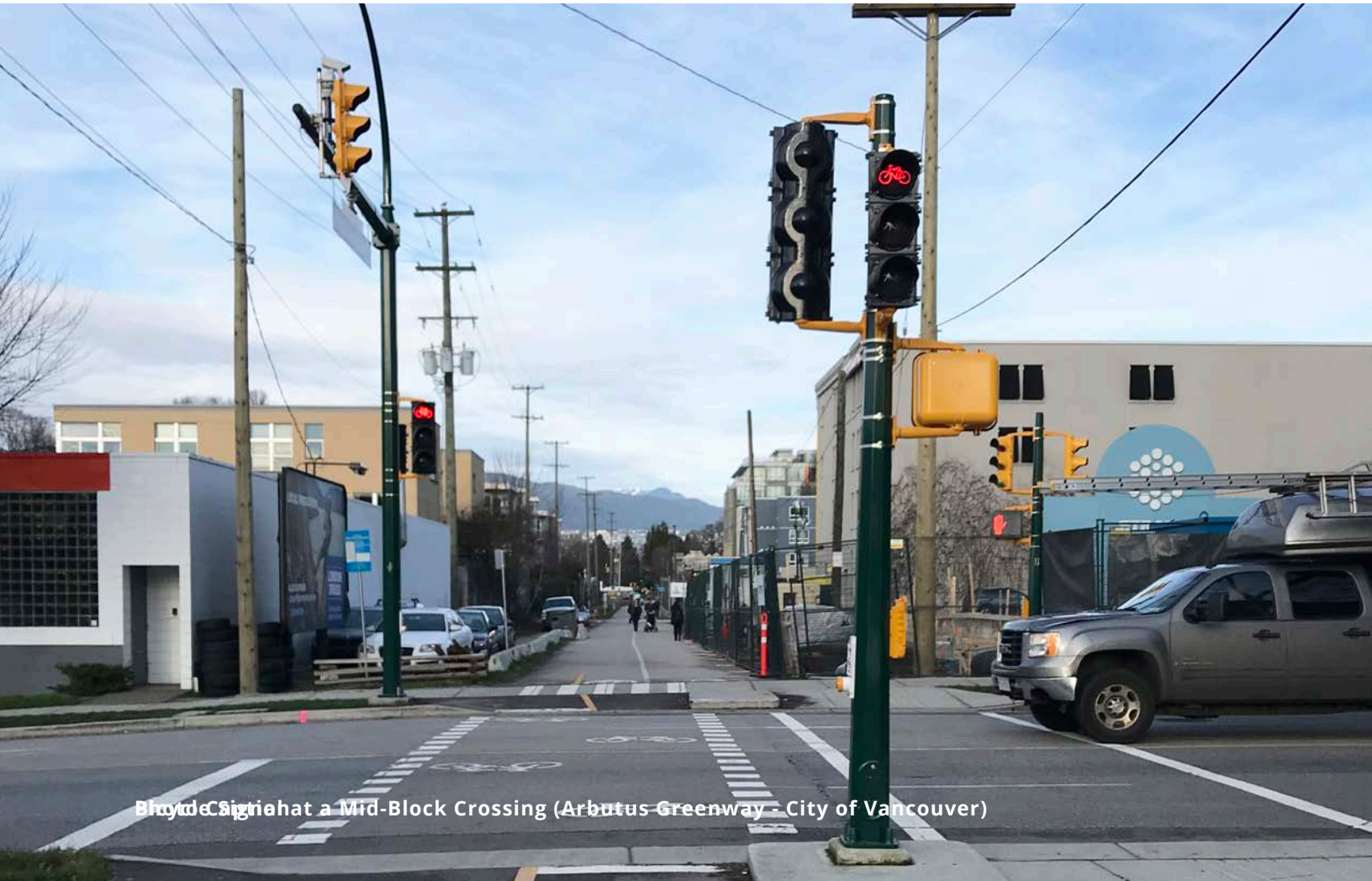


FIGURE 31 - BICYCLE TRAFFIC SIGNAL HEAD DISPLAY

PLACEMENT: Where possible and in order to reduce the number of poles, dedicated bicycle signals should be placed on the existing signal and lighting infrastructure at intersections and other crossings required. The bicycle signal head should be visible to people cycling and the placement should not physically impede people walking.

Bicycle signals are typically side mounted on the far side of the intersection within 1.5 horizontal metres of the edge of the bicycle facility. The *TAC Traffic Signal Guidelines for Bicycles* indicates that if the far side is greater than 30 metres from the stop bar of the cycling facility, consideration may be given to the use of 300 millimetres bicycle signal lenses or the installation of a supplementary bicycle signal on the near side of the intersection or on the median of the intersecting street.

The *TAC Traffic Signal Guidelines for Bicycles* also suggest that a near side signal can include smaller (200 millimetres) bicycle signal lenses that are mounted in combination with a supplemental bicycle signal sign. In the United States, the MUTCD Interim Approval on bicycle signals allows a 100 millimetre bicycle signal head to be used as a supplementary nearside indication. This can be used to increase understanding that signals are only for people cycling. Overhead bicycle signals can be considered if practical and only when side mounted is not feasible.



Bicycle Signal at a Mid-Block Crossing (Arbutus Greenway - City of Vancouver)

TYPES OF SIGNAL HEADS: Depending on the type of bicycle facility, the signal head that controls bicycle movements at signalized intersections can vary. For example, a bicyclist traveling in a shared lane is controlled by the vehicular signal head. Bicyclists traveling along an off-street pathway typically use a pedestrian signal. Where it is necessary or desirable to control a bicycle separately from motor vehicle traffic, bicycle users can be controlled by a traffic signal head designated for bicycle use, a bicycle signal face, or a pedestrian signal. Each of these three options are described below. Along a corridor, it is recommended that traffic signal indications for bicyclists are consistent and as uniform as possible.

STANDARD TRAFFIC SIGNAL HEAD DESIGNATED FOR BICYCLE USE

While not standard practice in many municipalities, a vehicular traffic signal head may be designated for bicyclists by mounting a Bicycle Signal sign (CUSTOM) adjacent to the traffic signal. This may be beneficial at locations where:

- It is necessary to add a signal head where bicyclists cannot see existing vehicle signal faces;
- Bicyclists have a separate directional movement, phase, or interval; and
- It is desired to maximize the time a bicyclist may legally enter a crosswalk.

Traffic signal heads or bicycle signal heads must be visible to approaching bicyclists. At least one signal head should be visible for a minimum of 30 metres before the stop line based on stopping sight distance for a bicycle traveling at 25 km/h. Where bicyclist approach speeds are higher, the approach visibility should be lengthened to match the minimum stopping sight distance required for the higher bicycle approach speed.

Where bicyclists do not have a continuous view of the signal for the minimum sight distance, a Signal Ahead (WB-4, BC W-012 Series) sign should be installed warning of the approaching signal. Where existing vehicle traffic signal heads are anticipated to be the sole source of guidance for bicyclists, design professionals should check that the signal heads are located within the cone of vision measured from the bicycle stop line as described in the *MUTCDC*. If the vehicle signal faces fall outside the cone of vision, supplementary vehicular or bicycle signal faces should be provided. The cone of vision from the bicycle facility is especially important to consider in locations where contraflow or two-way bicycle facilities are operating on one-way streets. It may be necessary to install new signal faces that are visible to approaching bicyclists.

BICYCLE SIGNAL HEADS

A bicycle signal head can also include a signal head with bicycle symbols on the lenses. There is significant variation between the many sources on best practices of signal head/lens sizing and placement for far/near side applications:

- The *TAC Traffic Signal Guidelines for Bicycles* recommends 300 millimetres for far side or complex intersections, 200 millimetres for less complex intersections, and near side for complex intersections
- The Alberta Bicycle Facilities Design Guide recommends 300 millimetres for far side intersections and 200 millimetres for near side, with near side placement only required if the lateral distance between stop bar and signal is greater than 30 metres.
- The *MassDot Separated Bike Planning and Design Guide* recommends the use of 200 millimetres and 100 millimetres lenses for far and near side applications, respectively.

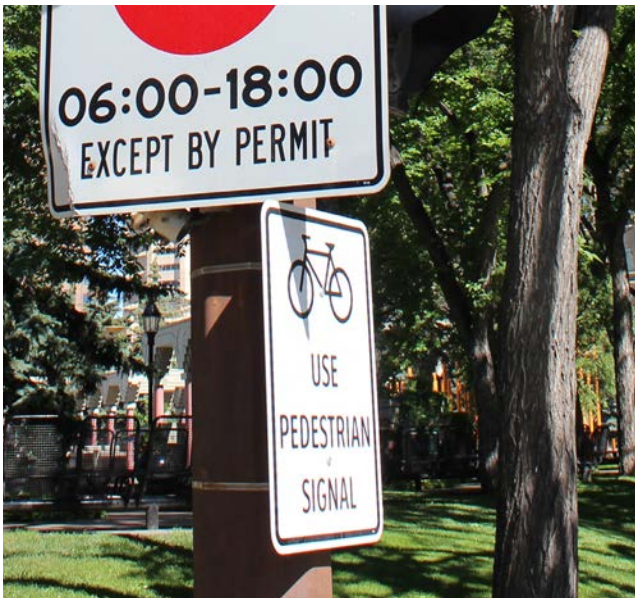
In the Metro Vancouver context, the most common application is the use of 200 millimetres and 300 millimetres signal lenses, with the most common being the use of 300 millimetres signal lenses. The recommendation is to provide 300 millimetre signal lenses on the far side of intersections and 100 millimetre signal lenses on the near side of intersections.

Traffic signal mounting heights are based on the type and location of poles, and the size of traffic signal faces chosen. Bicycle signal heads should ideally be mounted in line with the bicycle facility. However, there are cases where the conspicuity of the bicycle signal is better mounted adjacent to the bicycle facility. Bicycle signal heads must be mounted so that they are do not result in obstructions in the right-of-way for people cycling or walking.

If a 100 millimetre bicycle signal lens is used as a near side supplemental signal, the bottom of the signal housing should be between 1.2 metres and 2.5 metres above the ground. The bicycle signal head should be oriented to maximize visibility to approaching bicycle traffic.

PEDESTRIAN SIGNAL HEADS

The use of pedestrian signal heads can be an acceptable alternative for controlling bicycle traffic depending on the local laws associated with bicycle travel. If a pedestrian signal head is being used, then it should be supplemented with a Bicycles Use Pedestrian Signal sign. However, the inherent conflict in the rights and responsibilities of pedestrians and bicyclists in crosswalks may lead some design professionals to choose to install bicycle signal faces instead and separate bicycles and pedestrians at the intersection. Bicyclists who operate on multi-use pathways with pedestrians and other active users may be allowed to operate on sidewalks. It should be noted that the B.C. MVA indicates that cyclists may not ride on a sidewalk unless authorized by a bylaw made under B.C. MVA Section 124 or unless otherwise directed by a sign.



In these scenarios, bicyclists must follow the indications of pedestrian signal heads where they are crossing in crosswalks unless a traffic signal face or bicycle signal face is located for bicyclists.

Where bicyclists are directed to follow a pedestrian signal, they are only legally allowed to ride in the crosswalk if authorized to do so by municipal bylaw. In such cases, they may enter the crosswalk during the walk indication, as the BC MVA restricts users from entering an intersection during a flashing 'Don't Walk' interval. Caution should be exercised when using pedestrian signals to provide guidance to bicyclists at locations with long crossings or unique signal timing phases.

Nearside Bicycle Signal (Source: Derek Yau)

5.2.2 SIGNAL PHASING

Traffic signal phasing represents the method by which a traffic signal divides the overall signal cycle to accommodate the turning movements of various users at an intersection. The signal phasing establishes the movements and users that are allowed to operate together at intersections. A phase consists of the necessary intervals of green, yellow, and red assigned to a particular traffic movement or combination of movements (i.e. pedestrian crossing, left turn movement, combined left turn and through movements). Evaluating signal phasing options requires an assessment of the benefits of a separate phase and the resulting tradeoffs that a protected phase has on efficiency. There are also the other factors that must be considered, including:

- Volumes of all movements by all modes
- Number of opposing lanes (through or adjacent/turning);
- Cycle length and resulting delay;
- Speed of opposing traffic;
- Sight distance;
- Collision history or potential for future collisions;
- Conflicts (turning paths) between all road users including, motorists and bicyclists, motorists and pedestrians, and bicyclists and pedestrians; and
- Continuity of bicycle system and proximity to schools, parks for all users and abilities.

THRESHOLDS FOR SEPARATE PHASES

The decision to provide a separate phase should be based on a need to eliminate conflicts and improve safety at an intersection. **Table 6** provides recommended traffic thresholds in terms of motor vehicles per hour turning across a protected bicycle lane to determine when a time-separated bicycle movement should be considered based on the posted motor vehicle speed. This example refers to protected bicycle lanes but this threshold could be applied to other active transportation facilities, including multi-use pathways as well. At locations where bicycle volume varies and may not meet the minimum required levels whereby bicyclists may not be present each cycle, detection should be used to skip a bicycle phase if not already designed to do so as part of fully signal timing plans for fully actuated signals. It should be noted that the volume thresholds for permissive conflicts are lower if a vehicle is crossing a two-way protected bicycle lane compared to a one-way protected bicycle lane. As BC Parkway allows for bi-directional bicycle movements, the bi-directional numbers should be used unless directions are separated in future designs.

For left turns on two-way streets, the thresholds vary depending on the number of opposing through lanes. Research shows that as the workload increases for motorists to look for gaps in approaching traffic, they are less likely to be looking towards the crosswalk or left side of the roadway for approaching bicyclists or pedestrians[3].

MANAGING TURNING CONFLICTS

Where vehicle movements need to be managed and separate phases are not provided for turning movements, various geometric treatments can be considered to reduce motor vehicle speeds and increase sight distance. Turn conflicts can also be mitigated by time of day restrictions for movements. At locations where conflicts are high and the provision of a separate phase is not feasible or desirable, the following should be considered:

- Install regulatory signs, such as the turning vehicles yield to (or stop for) bicyclists (or pedestrians) (RB-37 OR RB-38);
- Install crossing islands, medians, or hardened centerlines to slow vehicle left turn speeds;
- Offset the bicycle crossing to create space for yielding (such as bend out elements or protected intersections); and
- Prohibit turns by time of day or when gaps are unavailable (through signal detection).

A separate signal phase at a signalized intersection for pathway users can help to reduce conflicts at intersections. Comparison of the operational and safety impacts of signal phasing changes are necessary in relation with necessary geometric modifications. Separated movements often require longer signal cycle lengths which may result in reduced user compliance with signal indications. The following summarizes some of the different types of signal phasing. The following section outlines some of the various phasing schemes that can be used. For more details about these schemes and for diagrams refer to the *B.C. Active Transportation Design Guide* (Chapter G.2).

Protected-Only Right Turn Phase: This phasing scheme represents a time-separated bicycle and pedestrian movement. All vehicle movements, including conflicting vehicle turns across the off-street facility, are restricted during an exclusive phase (similar to split phasing). Exclusive turn lanes for the conflicting motor vehicle turns are not required since all motor vehicle movements are stopped. Bicyclists may be directed to follow pedestrian signals during a shared active transportation phase. In this case a Bicycle Use Pedestrian Signal (CUSTOM) should be used. Right turn on red must be prohibited during the protected right turn phase. The use of a blanket No Turn on Red (NTOR) sign (*MUTCDC* RB-17R) should be considered.

[3] Canadian Council of Motor Transport Administrators (2013). Countermeasures to Improve Pedestrian Safety in Canada. http://ccmta.ca/images/publications/pdf/CCMTA_Pedestrian_Report_Eng_FINAL.pdf

TABLE 6 - CONSIDERATIONS FOR TIME-SEPARATED BICYCLE MOVEMENTS - LOW SPEED STREETS (50KM/HR AND BELOW)

Protected Bicycle Lane Operation	Motor Vehicles Per Hour Turning Across Protected Bicycle Lane			
	Two-Way Motor Vehicle Road			One-Way Motor Vehicle Road
	Right Turn	Left Turn Across One Lane	Left Turn Across Two Lanes	Right of Left Turn
Uni-Directional	250	150	50	250
Bi-Directional	150	0	0	150

TABLE 7 - CONSIDERATIONS FOR TIME-SEPARATED BICYCLE MOVEMENTS – HIGH SPEED STREETS (>50 KM/HR)

Protected Bicycle Lane Operation	Motor Vehicles Per Hour Turning Across Protected Bicycle Lane			
	Two-Way Motor Vehicle Road			One-Way Motor Vehicle Road
	Right Turn	Left Turn Across One Lane	Left Turn Across Two Lanes	Right of Left Turn
Uni-Directional	100	100	0	100
Bi-Directional	50	0	0	0

Depending on the turning volumes, this phasing scheme is more likely to have an impact on motor vehicle operations. To accommodate queues or an increase in signal cycle, an agency may consider the extension of turn lane storage lengths.

Concurrent Protected Active Transportation Phase: This phasing scheme also represents a protected movement for people walking and cycling. The active transportation phase runs concurrently with parallel through vehicle phases, but conflicting vehicle turns across the pathway facility is restricted. Turn movements across the pathway facility operate under a protected only phase. The provision of exclusive turn lanes for the conflicting motor vehicle turns are desirable for the adjacent through movement while the turning movements are held. In this phasing scheme, pathway users need to be controlled by a signal that is separate from the motor vehicle signal. Right (or left) turns on red should be prohibited during the protected active transportation phase. At locations where additional motor vehicle capacity is desired, the use of a blanket No Turn on Red sign (*MUTCDC* RB-17R) should be considered. The reduction of split times for other phases may require an increase in the signal cycle length. This phasing scheme can be effective for bicycle facilities along roadways with high through movement volumes and low turning volumes.

Leading Active Transportation Interval: At locations where active transportation user volumes and/or motorist turning volumes are lower than the threshold to provide a protected phase, or at locations where provision of a protected phase is not feasible, leading bicycle and pedestrian intervals may be considered. This scheme represents a partially separated walking and cycling movement. Leading intervals are typically between 3 and 8 seconds long and occur in advance of the green indication for turning motor vehicles. A leading bicycle and/or pedestrian interval allows a cyclists and pedestrians to enter the conflict area prior to a turning motorist, improving visibility. In some cases, a leading bicycle interval may allow bicyclists to clear the conflict point before motor vehicles enter. In this phasing scheme, a bicycle needs to be controlled by either the pedestrian 'walk' indication or via a separate signal face from the vehicle signal. Each of the three options outlined previously could be used. Right (or Left) Turn on Red must be prohibited during the leading bicycle active transportation phase.

Concurrent Phase with Permissive Vehicle Turning Movements: This phasing scheme represents a common scenario at most intersections where bicyclists and pedestrians are not provided any exclusive time in the intersection. In this case, bicyclists and pedestrians are crossing the intersection concurrently with parallel through vehicles, and motorists can make permissive turns. This phasing scheme has the least impact on motor vehicle operations, but does not address conflicts between turning motorists and through moving bicyclists and pedestrians. Geometric and signing treatments should be considered with this phasing scheme to improve safety.

Exclusive Bicycle Phase (City of Portland)

5.2.3 COUNTDOWN TIMERS

PEDESTRIAN COUNTDOWN-TO-RED TIMERS

Pedestrian countdown timers provide information for pedestrians to cross within the allotted green time. With pedestrian countdown timers, people crossing are aware of how much time they have to cross the street. Research has shown that fewer people are in the crosswalk once the countdown timer expires. Before and after case studies on the effects have been inconsistent among studies, with some studies claiming that timers increase pedestrian compliance[4][5][6] and others reporting increased pedestrian erratic behavior in the presence of countdown timers[7] and a decrease in pedestrian compliance[8]. In addition, drivers may behave differently when pedestrian countdown timers are installed compared to when pedestrian countdown timers are not installed.

BICYCLE COUNTDOWN-TO-GREEN TIMERS

Traffic Signal Countdown Timers (TSCTs) are technologies to assist users in decision-making at signalized intersections with real-time signal duration information. A study[9] in a simulated environment revealed that driver responses in the presence of a Red Signal Countdown Timer (RSCT) increased efficiency by reducing the mean headway between motor vehicles by 0.82 seconds. This result is suggestive of a reduction in start-up lost time at signalized intersections, or an improvement in signalized intersection efficiency when an RSCT is present.

5.2.4 SIGNAL ACTIVATION

Traffic signals should passively detect bicycles or allow bicyclists to manually call a phase with a push button. Cyclists should not have to dismount to use a push button. One of the primary purposes of detectors is to call the signal phase. If detection is used on an intersection approach where bicyclists are expected, it should be designed to sense bicycles whether they are mixed

[4] Arhin, S. A., & Noel, E. C. (2007). Impact of countdown pedestrian signals on pedestrian behavior and perception of intersection safety in the District of Columbia. Intelligent Transportation Systems Conference, 337-342.
[5] Eccles, K. A., Tao, R., & Mangum, B. C. (2003). Evaluation of Pedestrian Countdown Signals in Montgomery County, Maryland. Transportation Research Board.
[6] Schattler, K., Wakim, J., Datta, T., & McAvoy, D. (2007). Evaluation of pedestrian and driver behaviors at countdown pedestrian signals in Peoria, Illinois. Transportation Research Record, 2002(98), 106.
[7] Huang, H., & Zegeer, C. (2000). The effects of pedestrian countdown signals in Lake Buena Vista. Florida Department of Transportation.
[8] Botha, J., Zabyshny, A., Day, J., Northouse, R., Rodriguez, J., & Nix, T. (2002, May). Pedestrian Countdown Signals: An Experimental Evaluation. San Jose State University & City of San Jose Department of Transportation Final Report to the California Traffic Control Devices Committee.
[9] Mohammad R.Islama, David S.Hurwitza , Kristen L.Macugab, "Improved driver responses at intersections with red signal countdown timers", Transportation Research Part C: Emerging Technologies,Volume 63, February 2016, Pages 207-221.

with vehicle traffic or in their own lane. Various technologies are available for passively detecting bicycles, including inductive loops, microwave, video, and magnetometers. To provide a backup to passive detection devices, a bicycle push button may be used. The detection layout and design should be based on intersection geometry and the intended use and operation of the detectors. The design must reliably and accurately detect bicycle traffic and should provide guidance on how to actuate detection. Each type of detection should be monitored to evaluate effectiveness and field calibrated as needed to ensure the detection systems are working as intended.

PUSHBUTTONS

- This type of activation should be used at signalized crossings of a major street and where dedicated bicycle detector loops cannot be installed.
- Dedicated pushbuttons should be installed such that the cyclist does not need to dismount or make a significant jog in their travel path in order to operate the device.
- Pushbutton could be either discrete (bicycles only) or joint use with pedestrians.
- The Integrated sign at the pushbutton will define the intended user group.
- Pushbuttons should be oriented the same direction as the direction users are travelling.
- Pushbuttons may also include a detection confirmation light to provide positive feedback to the user and potentially improve compliance with the traffic signal.

DETECTION LOOPS

- Loops can have either a discrete or joint use with vehicle loops. Discrete bike loops are more sensitive to bikes and this level of sensitivity must be carefully considered. Additionally, some loops may have difficulty vehicles with limited metal in them (e.g. carbon fibre bicycle frames).
- Bike loops are generally located at a dedicated bicycle facility.
- It is good practice to install bike symbol pavement markings to show bike operators the best detection location.

OTHER TYPES OF DETECTION

Infrared, microwave (radar), LED, ultrasonic, video and/or motion detectors can also be used for detection at signalized bicycle crossings of major streets. These forms of detection can offer more flexible arrangements than inductive loops. There are situations, particularly during periods of poor weather conditions, where their use may present accuracy problems. In other cases, these types of detectors can be susceptible to false detections, so while they can be used, there should be a plan to ensure that accuracy is assured where loops or push button detection is undesirable or not available.

- **Video**: Video detection for bicyclists is usually part of the vehicle video detection.
- **Radar and MicroRadar**: Radar is generally used to detect bicycles or pedestrians in advance of a crossing and activate a signal to indicate motorist.
- **Infrared**: Thermal cameras are being used for the detection of vehicles, bicycles and pedestrians at intersections based on their thermal signature. This detection technology does not require street lighting to operate.
- **Indicator Light**: Indicator lights can be considered with the bicycle signal head. Indicator lights indicate that bicyclist has been detected by the sensor. These lights are relatively small and are mounted at or near the traffic signal face controlling the approach. The purpose of the confirmation light is to reduce users' concerns that they have not been detected. This can be particularly helpful at locations with long signal cycle lengths where bicyclists may be required to wait 60 seconds or more for a green signal. Compliance may increase for people riding bicycles when they know that they have been detected.

Detection Indicator (City of Portland)

6 SIGNAGE AND PAVEMENT MARKINGS

6.0 SIGNAGE AND PAVEMENT MARKINGS

This chapter provides an overview of the different signage and pavement markings that direct all road users at intersections along the BC Parkway. Signage and pavement markings play an important role in creating awareness to both motorists and pathway users. The information provided in this section is based on the 5th edition of the *Manual of Uniform Traffic Control Device of Canada (MUTCDC)* and the 2012 *TAC Bikeway Traffic Control Guidelines for Canada*.

6.1 SIGNAGE

The Ministry of Transportation and Infrastructure (MOTI) oversees the B.C. Provincial Sign Program and maintains the Catalogue of Standard Traffic Signs and Supplemental Traffic Signs, which apply on all roadways under provincial jurisdiction. Meanwhile, the *MUTCDC* provides national guidance for the use of traffic control devices, including signage and pavement markings. *MUTCDC* signage is typically used on roadways that are under local and regional government jurisdiction. Other sources of signage and pavement markings include the *TAC Bikeway Traffic Control Guidelines for Canada* and the *TAC Pedestrian Crossing Control Guide*.

The TAC guidance and the B.C. Provincial Sign Program use different sign codes. For example, the sign code for a Stop sign is *MUTCDC* RA-1, using TAC guidance, or B.C. R-001 Series, using the B.C. Provincial Sign Program. There is overlap between the two systems, but there are also signs that are unique to each system. There are also some signs that have similar meanings but different designs – some with minor differences and some more noticeable. Where two different codes exist for the same sign, each code has been referenced in the Design Guide. If the sign appears in only one guide, that code has been referenced.

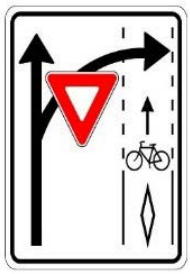
Design professionals are encouraged to review each signage system and consider the jurisdiction and the most appropriate sign for each application.

Please note that the information provided in this section is based on the TAC guidelines and the B.C. Provincial Sign Program, as indicated above. All pavement markings and signage should reflect the most current edition of each of the reference documents. Design professionals are reminded that the traffic control devices included in this section are not an exhaustive list of traffic control devices. A more exhaustive list of available traffic control devices that includes signage, pavement marking, and signals can be found in the documents referenced above.

It is important to note that TransLink has developed their own BC Parkway Regulatory Signage and Pavement Marking Guidelines along with Wayfinding guidelines. These are more applicable to the signage and pavement markings along the BC Parkway corridor as opposed to the intersections but still can be used as a resource.

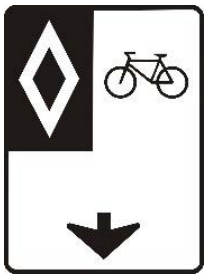
Pedestrian and Bicycle Crossing Ahead Sign (Stanley Park Causeway)

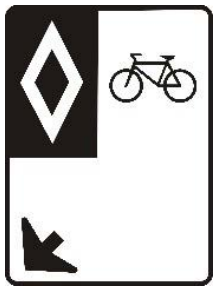
Regulatory Signs		
MUTCDC Sign Code	**BC Sign Code**	**Description**
RA-1	**R-001 Series**	**Stop Sign** The Stop sign indicates to cyclists that they must stop before entering the intersection and must not proceed until it is safe to do so.
RA-2	**R-002 Series**	**Yield Sign** The Yield sign indicates to drivers and bicyclists that they must yield the right-of-way before entering the intersection or roundabout, and must not proceed until it is safe to do so.
RA-4R, RA-4L	**PS-003 Series**	**Pedestrian Crosswalk Sign** The Pedestrian Crosswalk sign is used to indicate the location of a crosswalk. The right or left version of the sign is placed on either side of the crosswalk so that the pedestrian symbols are walking toward the centre of the road.
RA-5		**Special Crosswalk Overhead Sign** The Special Crosswalk Overhead sign indicates the location of a special crosswalk. This sign must be installed over the road.

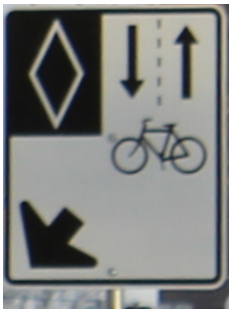
Regulatory Signs			
MUTCDC Sign Code	**BC Sign Code**	**Custom Signs**	**Description**
RA-4R, RA-4L 	**R-009 Tabs** 		**Except Bicycles Tab Sign** The Except Bicycles Tab Sign is used with Turn Control signs, Entry Prohibited signs and other regulatory signs, where bicycles are exempt from the specific regulation.
RB-37 		**Custom: City of Vancouver** 	**Turning Vehicles Yield to Bicycles Sign** The Turning Vehicles Yield to Bicycles sign may be used at conflict zones where motorists are required to cross a cyclist facility and are required to yield to the cyclist. The sign should incorporate the type of cycling facility present in the conflict zone (e.g. dashed bicycle lane lines, green paint, direction of travel etc.) Customized versions of the RB-37 sign with a supplemental 'Yield to Bicycles' tab have been developed by other municipalities (e.g., City of Vancouver) for improved visibility and readability.

Regulatory Signs			
MUTCDC Sign Code	**BC Sign Code**	**Custom Signs**	**Description**
RB-38 		**Custom (MassDOT)**  R10-15 alt.	**Turning Vehicles Yield to Bicycles and Pedestrians Sign** The Turning Vehicles Yield to Bicycles and Pedestrians sign may be used where motorists are required to cross or share a facility used by cyclists and/or pedestrians and are required to yield to the cyclists or pedestrians. Customized versions of the RB-38 sign have been illustrated in other guidelines, such as the R10-15 alt. sign shown in the MassDOT guide.
RB-39 			**Yield to Pedestrians Sign** The Yield to Pedestrians sign may be used where cyclists are required to cross or share a facility used by pedestrians and are required to yield to pedestrians.

Regulatory Signs			
MUTCDC Sign Code	**BC Sign Code**	**Custom Signs**	**Description**
RB-90, RB-91			**Reserved Bicycle Lane Sign** The Reserved Bicycle Lane sign indicates that a lane is reserved for the exclusive use of bicycles. Reserved Bicycle Lane signs should be mounted either directly above (RB-90) or adjacent to (RB-91) the reserved lane. Reserved Bicycle Lane signs should be installed at a minimum of one sign between each intersection, with the first sign installed a maximum of 15 metres past the end of the curb radius. Signs should be installed at 200 metre intervals after the first signs. The City of Vancouver uses a CUSTOM regulatory sign with the skateboard decal at Protected Bike Lanes. The City of Vancouver Streets and Traffic By-Law No. 2849 was updated to include: *"Protected Bicycle Lane" means that a part of a roadway or path which is separated from motor vehicle traffic by a bicycle lane buffer and is designated by the City Engineer for use by persons on bicycles, non-motorized skates, skateboards, or push scooters.*

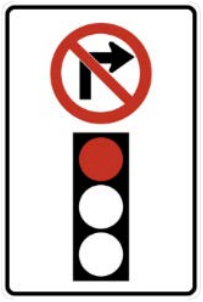




Regulatory Signs			
MUTCDC Sign Code	**BC Sign Code**	**Custom Signs**	**Description**
RB-92 			**Reserved Bicycle Lane Ends Sign** The reserved Bicycle Lane Ends sign must be installed at the end of the reserved lane denoting the end of the bicycle lane.
			**Reserved Bicycle Lane Begins Sign** The reserved Bicycle Lane Begins sign must be installed at the beginning of the reserved lane denoting the start of the bicycle lane.
			**Custom Reserved Bi-directional Bicycle Lane Sign** Custom signage for bi-directional protected bicycle lanes, such as the custom Reserved Bi-directional Bicycle Lane sign used by the City of Edmonton, may be used to further clarify the facility for cyclists and motorists.
RB-93 			**Shared Pathway Sign** The Shared Pathway sign indicates that both cyclists and pedestrians are permitted to use the path. This sign is often paired this sign with 'Bicyclists Yield to Pedestrians' (RB 39).

Regulatory Signs			
MUTCDC Sign Code	**BC Sign Code**	**Custom Signs**	**Description**
RB-94L 	**B-G-003-1 Series**  **B-G-003-1R Series** 		
RB-94R 	**B-G-003-1L Series**  **B-G-003-2L Series**  **B-G-003-2 R Series** 		**Pathway Organization Sign** The Pathway Organization sign indicates to cyclists and pedestrians how to share a path on which there is a designated area provided for each.

Regulatory Signs			
MUTCDC Sign Code	**BC Sign Code**	**Custom Signs**	**Description**
			**Multi-Use Crossing Sign** The custom Multi-Use Crossing sign is used to indicate the location of a multi-use crosswalk.
			**Bicycle Signal Sign** The custom Bicycle Signal sign is used to inform people on bicycles and motorists of a bicycle signal.
			**Bicycles Use Pedestrian Signal Sign** The custom Bicycles Use Pedestrian Signal sign is used to inform people on bicycles and motorists that people cycling are to follow the pedestrian signals instead of the motor vehicle signals.

Regulatory Signs			
MUTCDC Sign Code	**BC Sign Code**	**Custom Signs**	**Description**
RB-17R 	**R-117-R** 		**Right Turn on Traffic Signal Prohibited Sign** The Right Turn on Traffic Signal Prohibited sign indicates to drivers that during the red traffic signal indication, they are not permitted to turn right.
RB-17L 	**R-117-L Series** 		**Left Turn on Traffic Signal Prohibited Sign** The Left Turn on Traffic Signal Prohibited sign indicates to drivers that during the red traffic signal indication, they are not permitted to turn left.

Warning Signs			
MUTCDC Sign Code	**BC Sign Code**	**Custom Signs**	**Description**
WC-20  **WC-20S** 			**Shared-Use Lane Single File Sign** Used to warn motorists and cyclists that cyclists are allowed full use of the lane ahead and to warn motorists that the lane is too narrow for side-by-side operation. Shared-use lane markings should be used to mark the location where cyclists should position themselves within the lane. **Single File Supplementary Tab Sign** The Single File supplementary tab sign (WC-20S) must be used to convey the meaning of this sign.
WC-19  **WC-19S** 	**W-132-1 Series**  **W-132-1 Tab** 		**Share the Road Sign** Used to warn drivers that they are to provide adequate driving space for cyclists and other vehicles on the road. **Share the Road Supplementary Tab Sign** The Share the Road supplementary tab sign (WC-19S) must be used to convey the meaning of this sign.

Warning Signs			
MUTCDC Sign Code	**BC Sign Code**	**Custom Signs**	**Description**
WC-44 			**Bicycle Trail Crossing Side Street Sign** The Bicycle Trail Crossing Side Street sign indicates to drivers that a bicycle path, which runs parallel and in close proximity to the through road, intersects a crossroad such that insufficient distance is available on the crossroad between the bicycle trail crossing and the through road for proper siting of the WC-7 sign.
WC-44T 			**Trail Crossing Tab Sign** The temporary Trail Crossing Tab sign is used for educational purposes after the WC-44 sign is installed.
WA-36L 	**W-054-L Series**		**Object Marker (Left)** The Object Marker (Left) is used to mark obstructions on the left side of the road or bikeway.

Warning Signs			
MUTCDC Sign Code	**BC Sign Code**	**Custom Signs**	**Description**
WA-36R	**W-054-R Series**		**Object Marker (Right)** The Object Marker (Right) is used to mark obstructions on the right side of the road or bikeway.
WA-36	**W-054-D Series**		**Object Marker** The Object Marker is used to mark obstructions adjacent to or within the road or bikeway, such as bridge piers and traffic islands.
WA-8	**W-014 Series**		**Checkerboard Sign** The Checkerboard sign indicates the termination of a road.

Warning Signs			
MUTCDC Sign Code	**BC Sign Code**	**Custom Signs**	**Description**
WC-43 			**Contraflow Bicycle Lane Crossing Sign** The Contraflow Bicycle Lane Crossing sign indicates to drivers that they are approaching a road with one-way vehicular traffic and two-way bicycle traffic. This sign is also installed on a laneway with compromised sight lines on the approach to a bi-directional separated bike facility.
WC-46 	**W-129-2 Series** 		**Pedestrian and Bicycle Crossing Ahead Sign** The Pedestrian and Bicycle Crossing Ahead sign indicates to drivers that they are approaching a location where a multi-use path crosses the road. The WC-7S Crossing Supplementary tab sign must be used to convey the meaning of the Bicycle Crossing Ahead sign.

Warning Signs			
MUTCDC Sign Code	**BC Sign Code**	**Custom Signs**	**Description**
WC-7R 	**W-129-1 Series** 		**Bicycle Crossing Ahead Sign** The Bicycle Crossing Ahead sign indicates to drivers that they are approaching a location where a bicycle path crosses the road.
WC-7S 	**W-129 Tab** 		**Crossing Supplementary Tab** The Crossing Supplementary tab sign must be used to convey the meaning of the Bicycle Crossing Ahead sign.

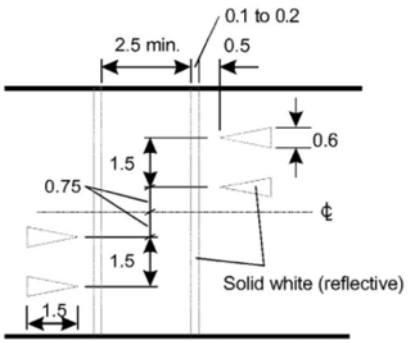
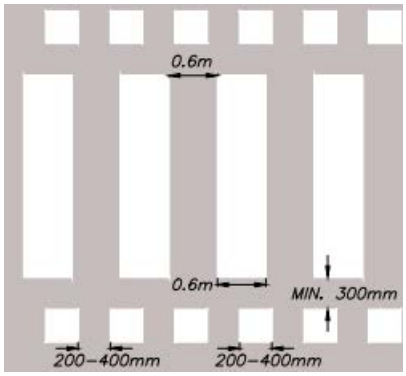
6.2 PAVEMENT MARKINGS

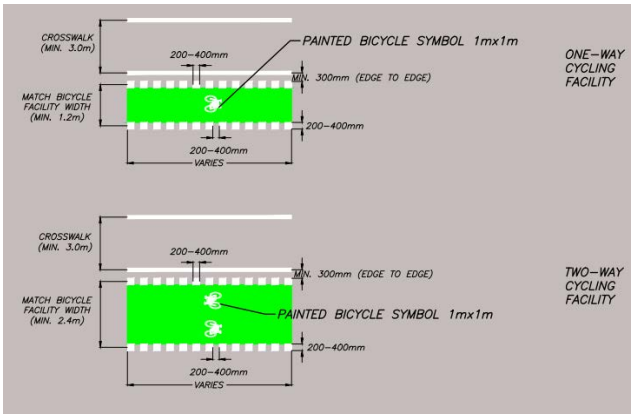
Pavement markings are an important element of the traffic control system for all road users. As stated in the *MUTCDC*, they serve a variety of functions, including defining lanes, separating opposing traffic flows, passing controls, lane usage and designation, pedestrian crosswalks, stop lines, parking areas, and symbol and word messages. Under favourable conditions, pavement markings convey information to the motorist, people walking, and people cycling without diverting their attention from the road or bikeway. However, they have limitations: they may be entirely covered by snow; they may not be clearly visible when wet; and they may have limited durability.

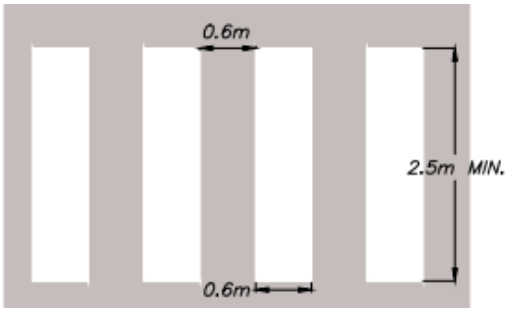
Pavement markings for bicycle and pedestrian facilities fall into three categories: longitudinal, transverse, and symbol markings. The principles for the design of pavement markings are outlined in Division C1 of the *MUTCDC*. Pavement markings must be uniform in design position and application. Pavement markings should be designed in accordance with the design standards in Division C1 of the *MUTCDC* as well as the *MOTI Manual of Standard Traffic Signs and Pavement Markings*. Design professionals are reminded that the pavement markings included here are not an exhaustive list.

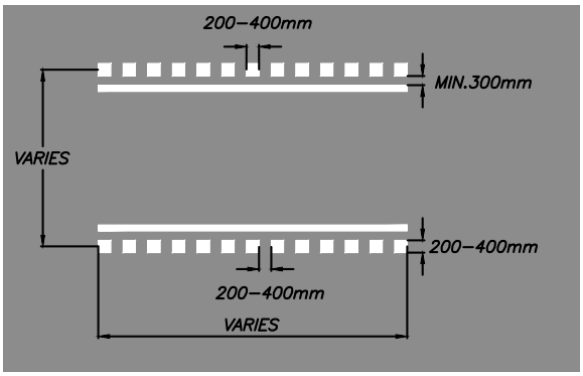
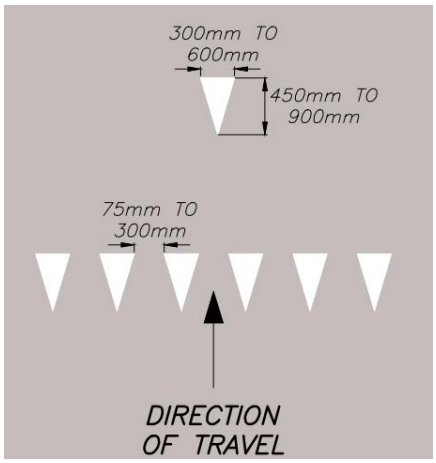
BC Parkway Multi-Use Pathway Pavement Marking (City of New Westminster)

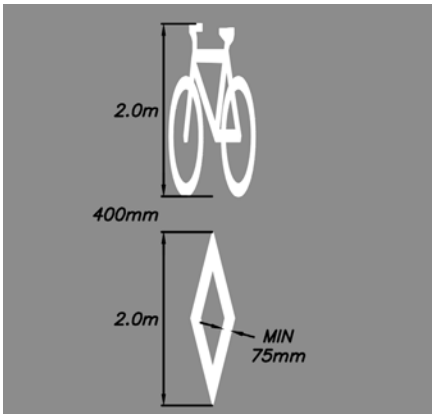
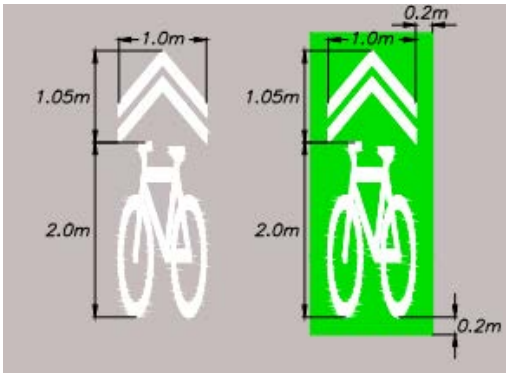
Name	Dimensions	Description
Longitudinal		
The longitudinal pavement marking widths shown in the figures indicate the desired widths. Acceptable ranges are noted in the table below.		
Bicycle Lane (Solid)		Delineates the edge of a travel lane dedicated for bicycle use where travel is permitted in the same direction on both sides of the line.
Bicycle Lane (Dashed)		Permits motor vehicles to cross the bicycle lane to perform a turning movement
Pathway Centre Line		Used to define a combined crossing area for people cycling and walking at multi-use pathways and on a separate bi-directional bicycle path. These markings are not sufficient by themselves and should always be used in conjunction with crosswalk signs or signals.

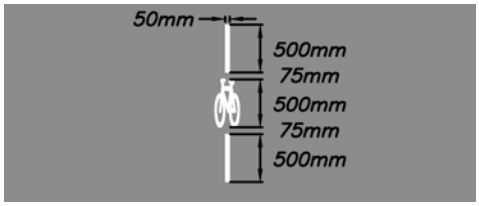
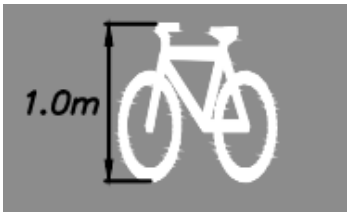
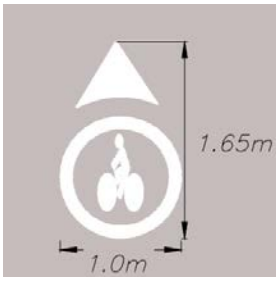
Name	Dimensions	Description
Transverse		
Triangular Pavement Markings (transitions to raised treatment)	 Pavement Markings (two-way street)	Pavement markings are used to identify the location of the transition to a raised intersection, crosswalk, or speed hump. These markings appear similar to the Advance Yield markings above but have a different size, spacing and triangle orientation.
Combined Cross-ride / Elephant's Feet at Zebra Multi-Use Crossing		Used to define a combined crossing area for people cycling and walking at multi-use pathways that cross where a zebra crosswalk would be installed. **Note:** The use of enhanced green pavement markings should not be used at multi-use crossings (combined cross-rides and crosswalks). The use of green should only be used for dedicated cycling facilities (see below).

Name	Dimensions	Description
Transverse		
Cross-ride / Elephant's Feet and Crosswalk at Protected Bicycle Lane or Multi-Use Pathway Crossing		Used to define a street crossing area for people walking and cycling at a protected bicycle lane or separated multi-use pathway.
Twin Parallel Line Crosswalk		Used to define a crossing area for people walking at intersections with traffic control, such as traffic signals or stop control. Twin parallel line crosswalks can be combined with elephant's feet markings to indicate a shared-use crossing.

Name	Dimensions	Description
Transverse		
Zebra Crosswalk		Used to define a crossing area for people walking at uncontrolled intersections where heightened visibility is desired and at all mid-block crossings. Zebra crosswalk markings offer greater conspicuity than twin parallel line crosswalk markings and shall be used at all school crosswalk locations. Zebra crosswalk markings may be considered at locations with large numbers or percentages of older pedestrians or locations with high activity of pedestrians with mobility or visual impairments.
Stop Bar		Used to define the location for people on bicycles to stop.

Name	Dimensions	Description
Transverse		
Cross-ride / Elephant's Feet at Twin Parallel line Multi-Use Crossing		Used to define a crossing area for people cycling at multi-use pathways. These markings are not sufficient by themselves and should always be used in conjunction with crosswalk signs or signals.
Advance Yield (Shark's Teeth)		Used in advance of marked or signed crossing to discourage the approaching vehicle from stopping too close to the crossing. Advance Yield markings also can be used to increase awareness that the approaching vehicle must yield to those in the crossing. Advance Yield pavement markings can be directed at either motor vehicle traffic or in bicycle facilities directed at people cycling.

Name	Dimensions	Description
Symbols		
Bicycle Symbol Reserved Use Lane		Pavement marking to indicate exclusive use of non-motorized vehicles. Symbols should be centered in the bicycle lane spaced at 75 m or as conditions dictate and approximately 10 m downstream from an intersection or crosswalk. Directional arrow markings may also be used to identify the correct direction of cyclist movement in a bicycle lane.
Bicycle Shared Use Lane Symbol (Sharrow)		Pavement marking to indicate shared use of the roadway with people on bicycles and motorized vehicles. Symbols should be spaced at a minimum 75 m and approximately 10 m downstream from all intersections. Green backed sharrows should be used where protected bicycle lanes merge into a shared-use lane and locations without physical protection where enhanced visibility is desired.

Name	Dimensions	Description
	Symbols	
Bicycle Detection Symbol		Pavement marking to indicate location of bicycle actuation loop. Symbol should be placed at the most sensitive area of detection.
Non-elongated Bicycle Symbol		Pavement marking used at conflict markings, bicycle pathway crossings, bicycle boxes or in two-stage turn boxes applications.
Custom Wayfinding Symbol		Wayfinding pavement marking to direct people on bicycles along bicycle routes.
Custom Multi-Use Wayfinding Symbol		Wayfinding pavement marking to direct people on bicycles and walking along multi-use pathways.

BC Parkway Intersection Design Guidelines