Final Design Guidelines

Design Guidelines for Separated Cycling Facilities, Multi-use Paths & Trails

City of Markham Active Transportation Master Plan

Prepared for City of Markham
by IBI Group
In association with Mobycon
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1 Introduction

1.1 Scope

The City of Markham plans, operate and maintains a network of cycling facilities, multi-use paths and off-road trails. As part of their vision to create a future in which more Markham residents are encouraged to walk and cycle, the City has initiated the development of *Design Guidelines for Separated Cycling Facilities, Multi-use Paths & Trails* through the Active Transportation Master Plan.

These guidelines are intended to provide details on the geometry and treatments for separated cycling facilities, multi-use paths and trails to:

- Promote consistency across the City of Markham active transportation network;
- Ensure the safety of active transportation network users;
- Utilize existing active transportation infrastructure to its maximum potential;
- Expand a high-quality network of protected cycling facilities and paths/trails to form part of an all ages and abilities (AAA) City-wide network; and
- Provide guidance to practitioners on common scenarios encountered when designing these facilities (i.e. driveway crossings, facility transition or treatments at signalized intersections).

The definitions of the cycling facilities covered by this guideline are presented in Section 1.3.

These guidelines also include pavement markings and signage for separated cycling facilities to supplement existing guidance available for multi-use paths and on-road cycling facilities in the following City of Markham guidelines:

- *Signage & Pavement Marking Guidelines for On-Road Cycling Facilities (2019)* – provides detailed guidance on the appropriate application of pavement markings and signage for a variety of on-road cycling facilities (incl. signed routes, advisory bike lanes, marked shared lanes (“sharrows”), bicycle lanes and buffered bicycle lanes). These guidelines include some facility transitions and intersection applications, focused on retrofit applications (i.e. with minimal civil works).
- *Signage & Pavement Marking Guidelines for Multi-use Paths (2015)* – provides detailed guidance on the appropriate application of pavement markings and signage for multi-use paths. These guidelines include some facility transitions and intersection

applications, focused on retrofit applications (i.e. with minimal civil works).

As noted, the City above guidelines focus largely on retrofit projects that can be completed with minimal civil construction. By contrast, the *Design Guidelines for Separated Cycling Facilities, Multi-use Paths & Trails* focuses on facility transitions and intersection treatments that require more extensive civil works to provide a higher degree of separation in time (through dedicated traffic signal phases) and space (through bend-out facilities), leading to improved comfort and safety. The treatments in these guidelines incorporate an All Ages & Abilities (AAA) approach, wherever possible. The AAA approach centres around the idea that cycling should be safe, comfortable, and convenient for all users, including children, seniors, and new riders. AAA facilities are generally those that:

- Provide shared cycling facilities along street with low motor vehicle speeds and volumes; or
- Provide physical separation from motor vehicles with higher order cycling facilities such as cycle tracks, protected bike lanes and bike paths.

These guidelines focus on the latter type of AAA facility.

These City guidelines are also supplemented by guidance at the Regional level, *York Region Pedestrian & Cycling Planning and Design Guidelines* (2018) which provide guidance across a variety of facility types focused on Regional road contexts and applications. The City's guidelines focus on City roads but anticipate a high-level of overlap and integration with the Region's guidelines.

1.2 References

These guidelines are based on recommendations from the following industry-standard guidelines:

1. *Ontario Traffic Manual (OTM): Book 18—Cycling Facilities*, Ministry of Transportation, Ontario, 2021: The updated version of Book 18 (2021) was released after much of these design guidelines had already been written. Efforts have been made to incorporate changes to Book 18 where practical within the scope of the project, but practitioners are encouraged to refer to the full document for the latest guidance.
2. *Geometric Design Guide for Canadian Roads (TAC): Chapter 5 – Bicycle Integrated Design,* June 2017
3. *Ontario Traffic Manual (OTM): Book 15—Pedestrian Crossing Facilities*, Ministry of Transportation, Ontario, December 2010

In addition to these established references, a variety of other guidelines from across the US and beyond were also considered. These include:

- NACTO Designing for All Ages & Abilities: Contextual Guidance for High-Comfort Bicycle Facilities, December 2017;
- NACTO Urban Bikeway Design Guide, Second Edition, 2014; and the
- CROW Design Manual for Bicycle Traffic, 2017.

As noted in the Ontario Traffic Manuals, no guideline can cover all situations encountered in the field. Therefore, the knowledge of application and field experience are essential in deciding the appropriate course of action in the absence of specific direction from the guideline itself. The practitioner's fundamental responsibility is to exercise good engineering judgement that is in the best interest of the public. Guidelines are provided to supplement professional expertise and assist in making those judgements.

1.3 Facility Types

The types of cycling and shared use facilities covered in these guidelines are described at a high-level in Exhibit 1-1 for reference.

Note that sample typical cross-sections depicting separated cycling facilities (protected bike lanes and cycle tracks) have been developed considering the class, typical volumes and speeds along City of Markham's standard cross-section drawings.

Exhibit 1.1: Cycling & Shared-Use Facility Types Covered by these Guidelines

 Source: IBI Group	**Protected Bike Lanes** An on-road bike lane separated from the adjacent travel lane via some physical element – e.g. a painted "buffer" area with bollards, planter or parking stops, a poured concrete curb, or parked cars. Protected bike lanes are typically (but not always) implemented in a retrofit condition without extensive midblock civil work.
 Source: IBI Group	**Cycle Tracks** Cycle tracks provide space for cyclists behind the roadway curb, typically at sidewalk level or mid-height between sidewalk and road level. Cycle tracks may be implemented as retrofit facilities through boulevard reconstruction but are more commonly implemented through new road construction/reconstruction projects.

	**Multi-use Paths** Multi-use paths are facilities shared by pedestrians and cyclists that operate two-way. Within the City of Markham, these are typically concrete facilities with widths of 3.0-4.0m. Cyclists and pedestrians share space along these facilities.
	**Off-Road Trails** Off-road trails are shared use facilities located outside of road rights-of-way, typically passing through parklands or open space. Depending on the context of the trail, there are various types of off-road trails with different surface materials, widths and design characteristics which support different types of users (i.e. pedestrian-only, cyclist and pedestrian-only, multi-use, etc.).

2 Selecting Separated Facilities

2.1 Overview

The selection of cycling facilities along a corridor is context-dependent and relies on practitioner knowledge and experience.

As noted in OTM Book 18 (p. 25):

1. **The choice to separate is not simple:** The choice to provide a separated versus non-separated bicycle facility is not a simple “yes” or “no” decision;
2. **Design criteria need to recognize context:** The design criteria and associated thresholds used to select one bicycle facility type over another need to be flexible to accommodate site specific characteristics; and
3. **The final decision requires professional judgement:** The experience and judgement of a qualified engineering designer or practitioners should ultimately influence the bicycle facility type, plus the added design features or enhancements that are selected.

While physically separated infrastructure can provide the safest conditions for all road users, design choices must be considered not only within context of land use, traffic volumes and speed, but also in cost, with the need to balance the expense with and the value of safety improvements[1].

Historically in the City of Markham, there has been little adoption of separated cycling facilities such as protected bike lanes and cycle tracks. Many of the

[1] Integrating Health and Transportation in Canada, November 2019. Transportation Association of Canada.

higher-order cycling facilities built along Regional and Major collector roads consist of shared multi-use paths. These guidelines emphasize a shift towards increasing application of cycle tracks and protected bike lanes based on several contributing factors:

- **The City is evolving** – As Markham continues to evolve towards a highly urbanized and increasingly dense City, increased demand for walking and cycling infrastructure produces incompatibility with shared facilities;
- **Concerns about conflicts are increasing** – Many of the operational concerns shared by City staff, stakeholders and residents over the course of the Active Transportation Master Plan centred on path etiquette and conflicts between user groups. While there are design interventions that can help to mitigate these conflicts (for example, building wider multi-use paths and trails, increasing network density, or incorporating signage and pavement marking practices routinely as part of pathway construction), a more fulsome solution is to separate these user groups. These conflicts are anticipated to grow with the increasing evolution and adoption of micromobility and different forms of transportation (e.g. e-bicycles, e-scooters, e-trikes, etc.);
- **Design practices are changing** – We increasingly have more options to accommodate cyclists and other vulnerable road users through intersections and across major streets, such as protected intersections. While limited solutions for intersections have historically been a barrier to widespread adoption of separated cycling facilities, new tools provide opportunities to ensure high-quality design at and through intersections as well.

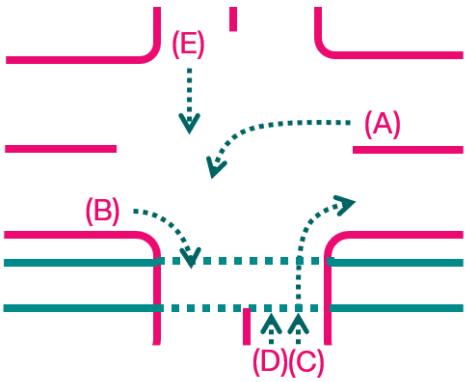
2.1.1 One-way vs. Two-way Facilities

It is important to consider directionality when planning for and designing cycling infrastructure. Some relevant considerations are summarized below:

- **Safety** – Two-way active transportation facilities along roads have generally been shown to increase risks for the wrong-way cyclist, particularly along corridors with a significant number of driveways. The risk to the cyclist going unnoticed by motorists turning in and out of side streets and driveways is a real safety concern particularly as the number of cyclists (exposure) increases. For example, as shown in Exhibit 2-1, a motorist turning left or right out of a driveway or side street will notice the cyclist coming towards them on their left, but will generally not anticipate the cyclist approaching from the right (the motorists is generally looking forward or left to accept a gap in traffic). The motorist turning left from the main street into the side street or driveway is looking forward to accept a gap in traffic. As they accelerate to cross opposing traffic, the motorist will not see a cyclist on their left approaching from behind (the wrong-way cyclist). The

speed at which the motorist is trying to cross opposing traffic and the lack of visibility of the cyclist approaching from behind on their left combine to increase risk. It is noted that treatments like raised crossings can be used to reduce driver speeds across cycling facilities and mitigate these safety concerns in some contexts (see 5.3.1). In addition, there are some specific contexts in which two-way cycling facilities may be preferable from a safety perspective by limiting the number of road crossings required (e.g. providing a two-way facilities along the frontage of a school located along a busy road on the same side as most of its students to avoid introducing unnecessary crossings).

Exhibit 2.1: Concerns and Potential Conflicts for Two-way Cycling or Shared Use Facilities



(A) Left-turning motorist is focused on gap selection. Accelerating through the turn, the driver is then faced with the unexpected trail crossing. While the driver was waiting to make the turn, a fast-moving right-to-left cyclist outside the driver's field of view may overtake arriving in the crossing. Slowing or stopping for trail users, this left turning motorist may interfere with through traffic on the parallel roadway.
(B) Left-to-right trail users are out of the field of view of higher speed right-turning motorists
(C) Right-turning motorists are looking left while turning right; right-to-left trail users are out of their field of view. They may also obstruct the trail crossing.
(D) Through motorists may obstruct the trail crossing or obscure the view of right-turning motorists and of left-to-right trail users.
(E) Motorists crossing the road at a signal need a clearance interval that is long enough to allow them to cross the trail before the signal changes providing the trail right-of-way.

- **Convenience** – Providing two-way cycling or shared use facilities on one side of the road is often seen as a way to save space. However, where there are destinations on both sides of a road, this can add a layer of inconvenience for pedestrians and cyclists that may lead to increasing demand for midblock crossings and/or encourage sidewalk riding. The provisions of two-way facilities on both sides can help to mitigate these issues, but the trade-off is complexity of movements at intersections. For these reasons, the use of one-way facilities can often provide more intuitive intersection designs and routes for cyclists.
- **Feasibility & Property Considerations** – In some cases, roadway corridors may be located within a corridor such that the available boulevard width is significantly constrained on one side (whether due to utility constraints such as hydro poles or right-of-way). In these instances, it may be impractical to provide one-way facilities in each direction, and two-way facilities within one boulevard may be all that is feasible. Where these situations arise, it is important that two-way facilities which may limit access to destinations on the opposite side of the street are mitigated with formal traffic-controlled crossings.

2.2 Facility Selection Guidance

As described in OTM Book 18, the first step in selecting a cycling facility is pre-selecting a desirable facility type. As motor vehicle volumes and the speed of a roadway increase, the need to provide separation of vulnerable road users grows. Cycling and shared use facilities are generally categorized into one of three classes of operating space: shared, designated or separated.

Shared Operating Space

Shared operating spaces are appropriate on local roads with low volumes and speeds. Shared cycling facilities include:

- Shared roadways & signed routes
- Neighbourhood bikeways (bicycle boulevards): signed routes that are optimized for bicycles and incorporate a variety of traffic calming features to control speeds and volumes
- Advisory bike lanes

Designated Operating Space

Designated operating spaces are appropriate along corridors with moderate speeds and volumes. These facilities provide dedicated space for cyclists without providing physical protection from vehicular traffic. Designated cycling facilities include:

- Bike lanes
- Buffered bike lanes
- Paved shoulders and buffered paved shoulders

Separated Operating Space (Physically Separated Bikeways)

Separated operating spaces are appropriate along higher-speed, higher-volume roadways or through off-road corridors. They provide physical protection or separation from motorized vehicles. Separated cycling facilities include:

- Protected bike lanes
- Cycle tracks
- In-boulevard multi-use paths
- Off-road multi-use trails

Separated facilities are the focus of these guidelines.

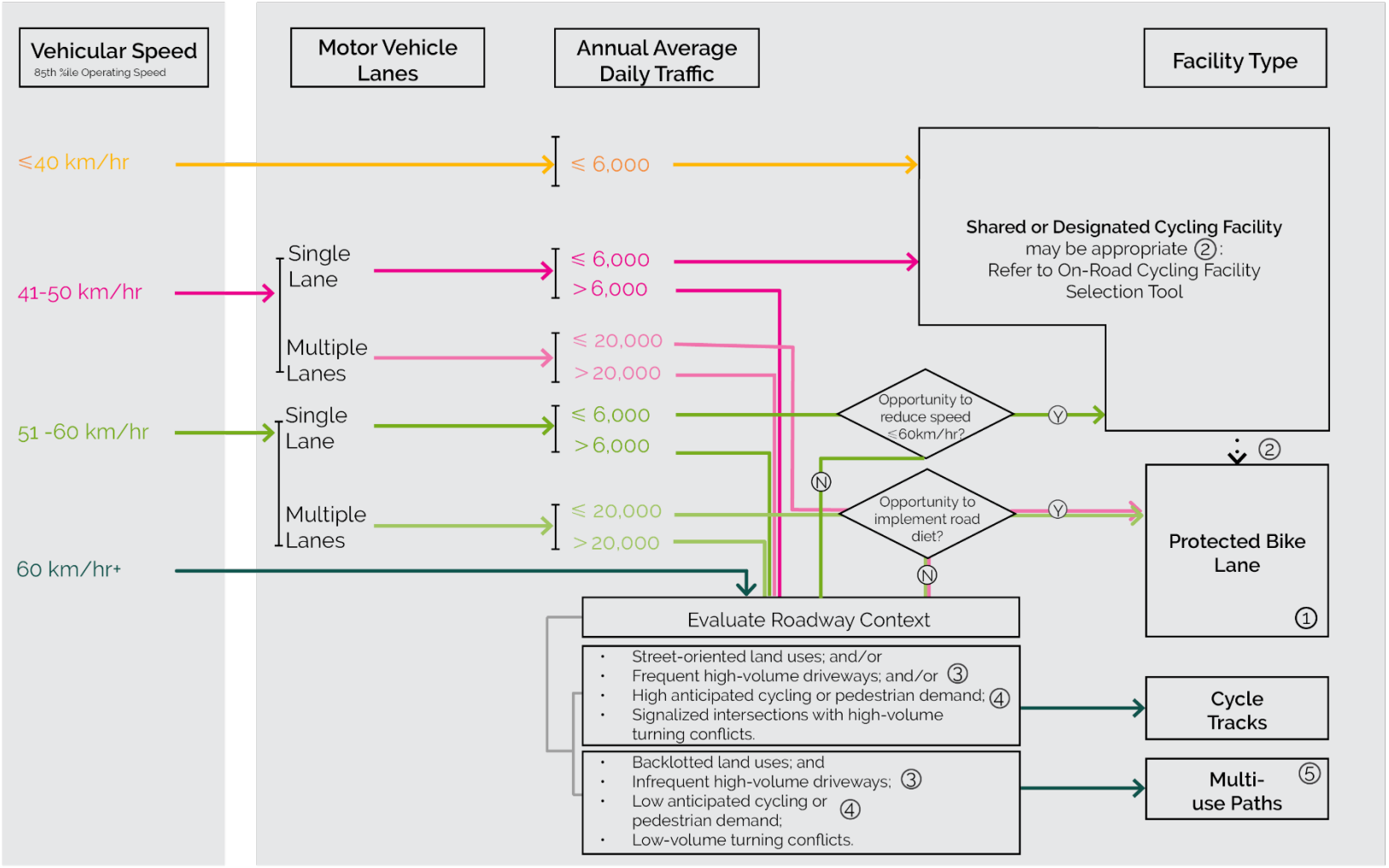
Recognizing that there is a desire for consistency in the application of various separated cycling facilities across the City of Markham, these guidelines include a facility selection tool for separated facilities in an urban context, as shown in Exhibit 2-3. This tool follows the higher-level guidance of OTM Book 18, specifically the Facility Pre-Selection Nomograph for Urban/Suburban contexts,

and incorporates relevant detailed characteristics from Step 2 of the selection process as applicable/possible.

Note that a standalone facility selection tool for new developments based on the anticipated road classification for new roads has also been developed through the Active Transportation Master Plan.

These tools are intended to provide practitioners with additional guidance on the selection of various separated cycling facilities, however they are not intended as a substitute for professional judgement. The application of this tool is not intended to prohibit the construction of facilities that do not meet the criteria, as there is flexibility inherent in the OTM Book 18 guidance, however it does provide a framework for selecting a context-sensitive cycling or shared-use facility. Note that is always possible to justify exceeding the minimum class of cycling facility considering network context. .

Exhibit 2.2: Supplementary Cycling Facility Selection Guidance for Separated Cycling Facilities



Cycling Facility Selection Tool for Separated Facilities

① The goal when incorporating physical separation into the painted buffer of a cycling facility should be to provide at least 2.0m of total clear space to allow sweepers and other smaller maintenance vehicles access to the separated facilities.

② Other factors that may indicate a need for separation: heavy truck/bus volumes, collision history, major intersections with multiple turn lanes, high volumes of anticipated youth cyclists. Each corridor to be evaluated using professional judgment on a case-by-case basis.

③ Frequent driveways are generally defined as < 200-250m spacing on average as a starting assumption.

④ TAC suggests separating users where there is:
- A high percentage of pedestrians (more than 20% of users) and total user volumes greater than 33 persons per hour per metre of path width or
- A low percentage of pedestrians (less than 20% of users) and total user volumes greater than 50 persons per hour per metre of path width

⑤ Multi-use paths should be provided on both sides unless there is a demonstrated lack of destinations or access points on one side.

2.2.2 Case Studies

The application of the facility selection tool requires professional judgement. As noted in OTM Book 18: “It is imperative that the practitioner document each decision made during the bicycle facility type selection process. The steps taken to reach each decision and the rationale behind the selection should be documented” (p. 39).

The following examples discuss some of the trade-offs and decision-making process associated with applying the selection tool:

- Along a major collector roadway, the facility selection tool indicates a multi-use path as a potential facility type, based on the relatively low anticipated cycling and pedestrian demand and infrequent average driveway spacing. However, when the corridor is reviewed in more detail, although the average driveway spacing is within the 200-250m threshold, there are a series of closely spaced driveways with <50m spacing. These are high-volume, commercial driveways without controlled access management. In this case, a practitioner may wish to consider the application of one-way cycle tracks in lieu of a two-way multi-use path to reduce the risk of collisions for the wrong-way cyclist.
- Along an arterial roadway, the facility selection tool indicates a cycle track as a potential facility type largely due to high anticipated demand associated with mixed use land patterns along the corridor. However, as more detailed planning for the facility is initiated, it is identified that there are hydro poles located close to the edge of the road that narrow the available boulevard width and cannot accommodate cycle tracks and sidewalks. The roadway is scheduled for reconstruction in five years, and there is opportunity at that time to narrow the existing roadway corridor slightly to accommodate cycle tracks between the poles and new curb. As an interim treatment, a multi-use path could be considered, with the upgrade to cycle track and sidewalk to be paired with the future reconstruction work. The shorter-term provision of the multi-use path will help to build familiarity of the corridor as a cycling route and grow demand to further justify the future cycle tracks. This is a preferred interim option compared to implementing a lower order cycling facility – i.e. bike lanes, which would be inappropriate for the roadway context.
- Along a major collector roadway, cycle tracks are identified as a potential facility based on the facility selection review. However, there is insufficient width to accommodate the cycle tracks in the boulevard without relocating hydro poles and significant impacts on existing mature trees. Suggestions have come forward to consider applying sharrows along the corridor as an interim treatment. In this instance, the use of sharrows is not recommended as a linear treatment, given that a separated cycling facility is recommended along the corridor. Instead, practitioners may look to an alternate local street connection

that can provide a parallel option for the overall cycling network, and provide a highly visible route along the lower order roadway that will provide a high level of comfort and safety for cyclists. Choosing not to install a lower-order cycling facility that is inappropriate for the roadway context is a difficult but important part of the facility selection process.

3 General Design Guidance

3.1 Basic Design Parameters

Design Speed

Cyclist design speeds vary depending on the operating context, topography and cyclist type. Typical design speeds for cyclists include:

- Typical cruising speed: 11 – 20 km/hr
- Child cyclists, or while climbing: 6 – 10 km/hr
- Competitive cyclists, or e-assisted bicycles: 25 – 40 km/hr
- Downhill cyclists on significant grades: 50km/hr+

Source: Adapted from VeloQuebec's Pedestrian & Cycling Planning and Design Guide

Considering cyclist design speed is important to inform the following aspects of cycling facility design:

- Implementing radii and tapers that accommodate cyclist operating speeds (for example, selecting an appropriate taper on the approach to a protected intersection, or around a corner refuge island);
- Considering the appropriateness of facilities shared with pedestrians considering relative speed differentials in various contexts; and
- Considering the appropriateness of facilities shared with vehicles considering relative speed differentials in various contexts.

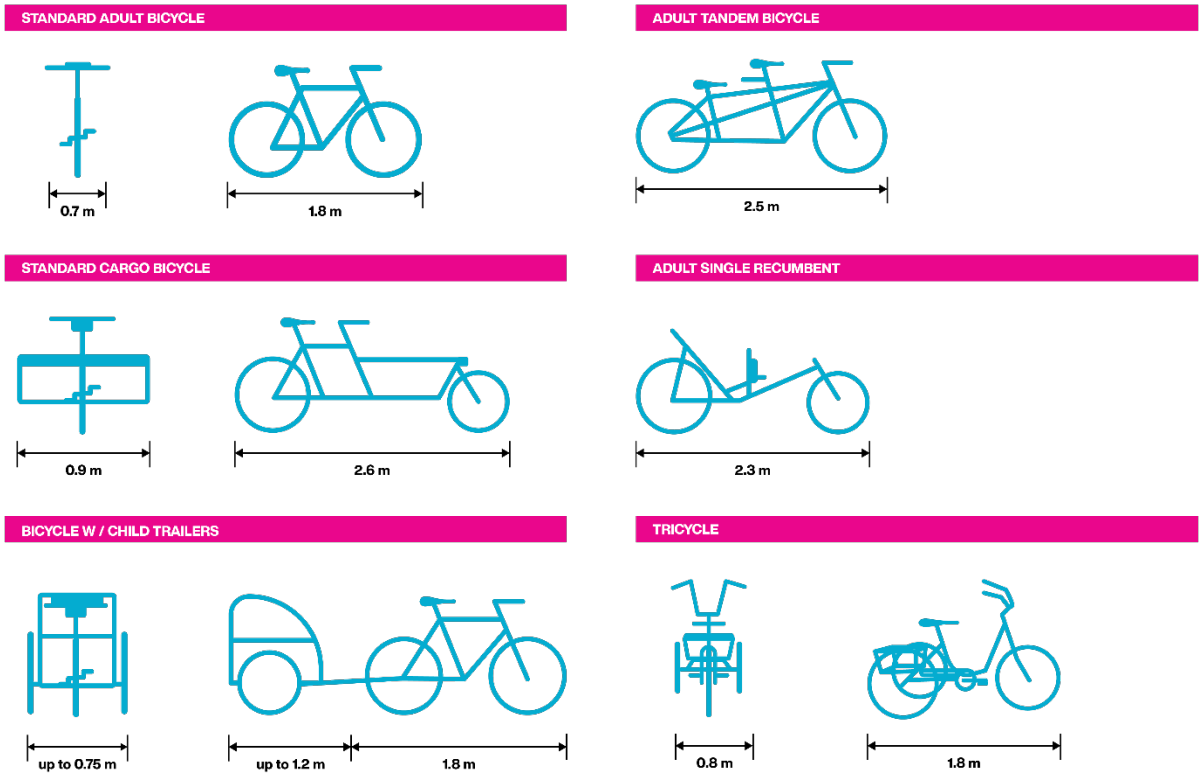
Since pedestrians typically travel much slower than cyclists, cyclist design speeds will govern the design of shared facilities such as multi-use paths and trails.

Cyclist Characteristics

There is a wide range of bike types currently in use. Adoption of these "non-conventional" bikes is anticipated to grow in the future alongside the increase in electric-assist bicycles. Wherever possible, cycling and shared use facilities should accommodate a variety of bike types.

Various bicycles and dimensions are illustrated in Exhibit 3-1.

Exhibit 3.1: Dimensions of Different Bicycle Types

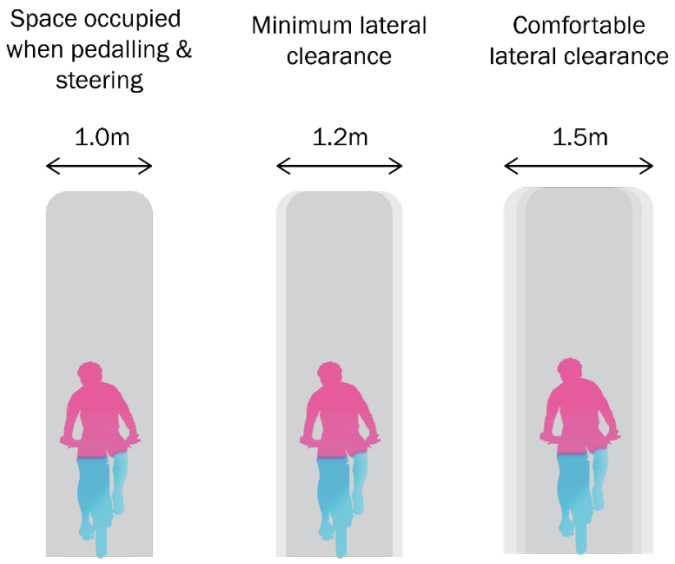


Source: Adapted from the BC Active Transportation Design Guide

At a minimum, conventional cyclists should be accommodated along facilities by considering operating space and lateral clearance, in addition to the basic dimensions. As cyclists pedal, they require additional operating space to account for lateral movements. Characteristics of a conventional cyclist to consider for cycling facility design at a minimum are illustrated in Exhibit 3-2.

It is important to consider other types of devices that may also be using these facilities. Shared use facilities such as multi-use paths and off-road trails may be used by wheelchairs, baby strollers, roller skates, mobility scooters, and other mobility devices. While restrictions around the types of devices permitted in dedicated cycling facilities vary, additional users may include mopeds, hoverboards, skateboards, and scooters which tend to have different travel characteristics than cyclists.

Exhibit 3.2: Cyclist Operating Space



3.2 Cross-Slope & Running Slope

Cross Slope

Cycling Facilities

For designated cycling facilities, cross slopes of no more than 2%-4% (1:50 – 1:25) are generally preferred (less than 2% is preferred for concrete facilities while less than 4% is preferred for an asphalt surface). While two-wheeled bicycles are generally unaffected by cross slope, steeper cross-slopes can become very uncomfortable for tricycles, or bikes with trailer. A steeper cross-slope of up to 7-8% for cycling facilities may be considered over limited distances where site conditions are challenging.

Shared-Use Facilities

Where facilities are planned to accommodate both pedestrians and cyclists, it should be assumed the facility will act as an exterior path of travel, with the exception of recreational trails, which are subject to alternative standards. According to AODA requirements, exterior paths of travel are required to have a maximum cross-slope of 5% (1:20) for any paved surfaces. Ideally, shared use facilities should incorporate a cross slope of 2-4% where no major constraints are present.

Running Slope

Cycling Facilities

For most cycling facilities, running slopes of no more than 2% (1:50) are preferred. Running slopes up to 5% can reasonably be managed by an adult cyclist on a conventional cycle, while up to 7-8% is considered a maximum

cyclable slope. Slopes above 8% should generally be avoided through the use of switchbacks or by considering alternate paths/routes.

Shared-Use Facilities

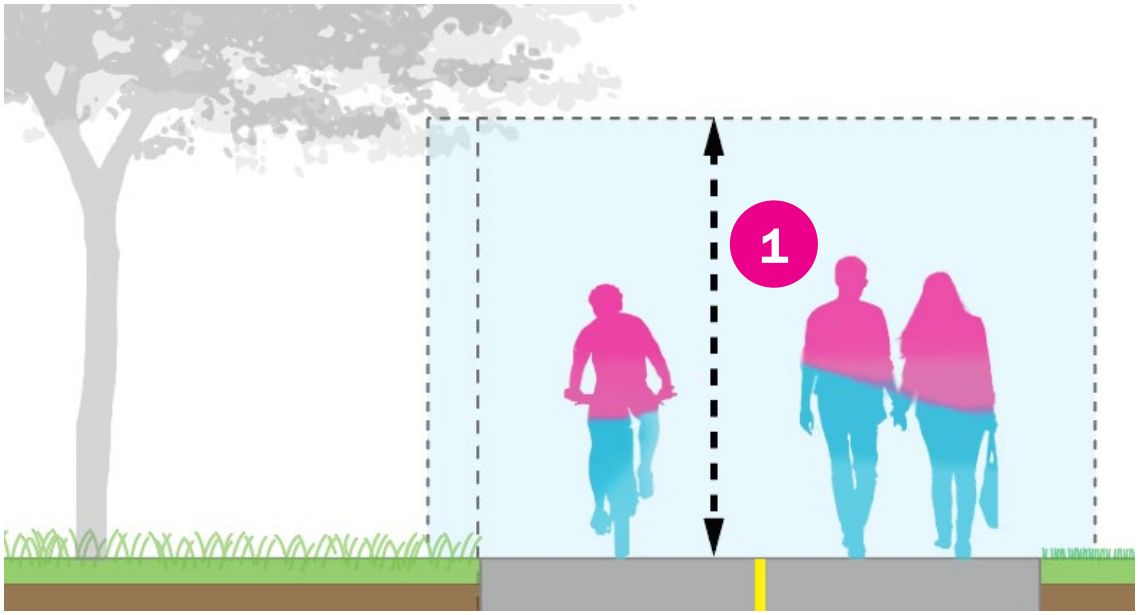
Where facilities are planned to accommodate both pedestrians and cyclists, it should be assumed the facility will act as an exterior path of travel, with the exception of recreational trails which are subject to alternative standards. According to AODA requirements, exterior paths of travel are required to have a maximum running slope of 5% (1:20), except where the path runs alongside a road with a slope steeper than 5%, in which case the path may match (but not exceed) the slope of the roadway). In general, shared use facilities should be targeted at 2-4% running slope where no major constraints are present. To accommodate cyclists, slopes should be treated with level-surface ramps rather than stairs or multi-level boardwalks.

3.3 Horizontal & Vertical Clearance

3.3.1 Vertical Clearance

Vertical clearance refers to the area of space above cycling and shared use facilities which should be kept clear of all obstructions. Refer to Exhibit 3-3 for vertical clearance guidelines.

Exhibit 3.3: Vertical Clearance Guidelines



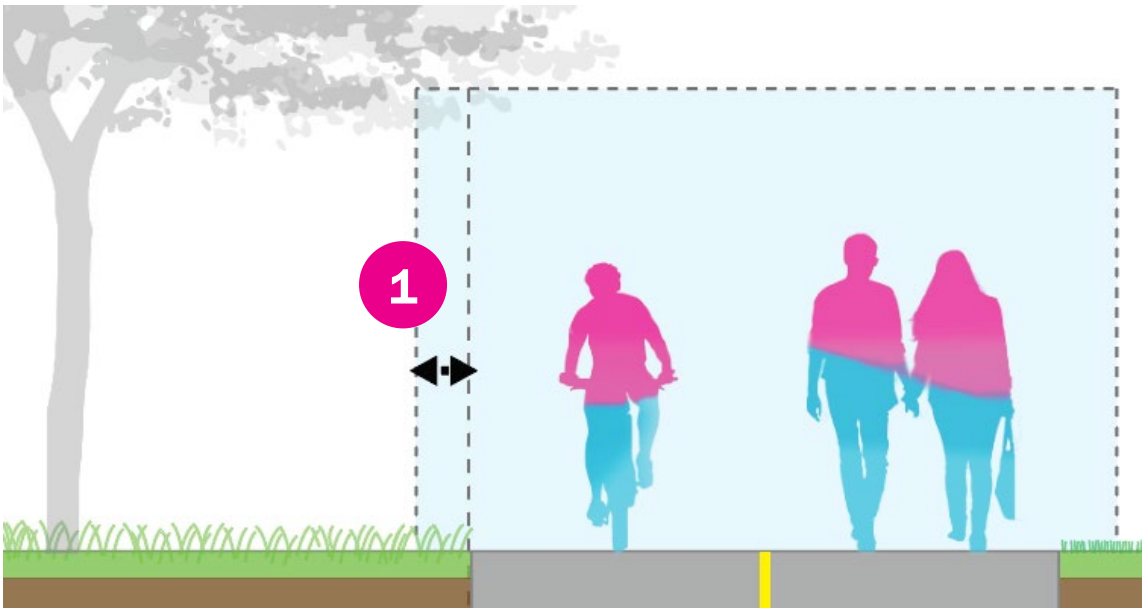
#	PARAMETER	MINIMUM	PREFERRED
1	Vertical Clearance	2.5m	3.0m

If vertical clearances less than 2.5m cannot be avoided, warning signs should be installed to warn users of potential hazards.

3.3.2 Horizontal / Lateral Clearance

Horizontal or lateral clearance refers to the area of space adjacent to a cycling facility or shared use which is kept clear of obstruction to improve safety of users and provide recovery space. This lateral clearance also provides “elbow space” for cyclists riding adjacent the edge of the facility, or while passing. Refer to Exhibit 3-4 for horizontal clearance guidelines.

Exhibit 3.4: Horizontal Clearance Guidelines

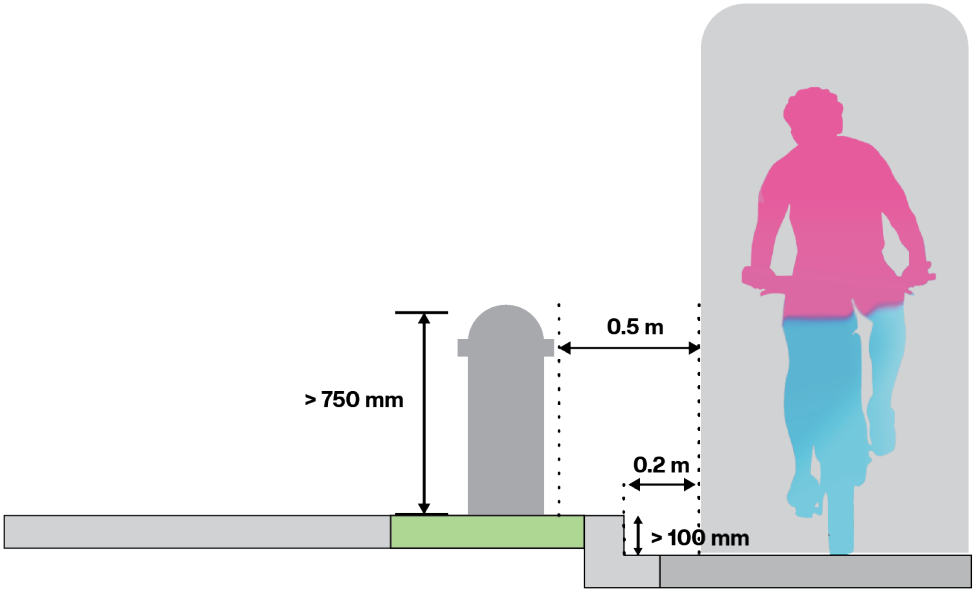


#	PARAMETER	MINIMUM	PREFERRED
1	Horizontal Clearance	0.25-0.5m	1.0m

3.3.3 Clearance to Hazards

Clearance to hazards are important to ensure cyclists and trail users can avoid various objects without impacting the safety of other users. Refer to Exhibit 3-5 for design standards and recommendations.

Exhibit 3.5: Clearance to Hazards



PARAMETER	MINIMUM
Clearance to Hazards	Minimum = 0.2m for features between 100mm & 750mm high Minimum = 0.5m for features > 750mm *Clearance to utility poles to be confirmed with local utility providers

3.4 Signage & Pavement Markings

The guidance related to regulatory signage and pavement markings throughout these guidelines focuses on signage specifically for the cycling or shared use facilities. More detailed information on pavement markings and signage for various cycling facilities (including multi-use paths and on-road cycling facilities) are available in other City guidelines, as noted in Section 1.2.

OTM sign codes are used unless otherwise noted. They can be distinguished by the first two letters of the code being an upper and a lowercase letter. TAC signs are so noted and the code includes two uppercase letters.

4 Protected Bike Lanes

4.1 Context

Protected bike lanes may be applied on a variety of roadway types but are most appropriate on collector and arterial roadways. Since protected bike lanes are attractive for a wide variety of cyclists, they can make up part of the City's all ages and abilities (AAA) cycling network.

Protected bike lanes vary significantly in terms of the level of protection provided by different bikeway separators. Typical forms of separation include:

- Bollards / flex-posts;
- Parking stops;
- Planters;
- Concrete barriers (temporary or permanent); and/or
- Rigid bollards.

Trade-offs and benefits of each type of separator are discussed in Section 4.2.1.

It is anticipated that protected bike lanes will be most likely applied in retrofit scenarios within Markham, along corridors where it is feasible to either remove or reduce parking capacity or travel lanes.

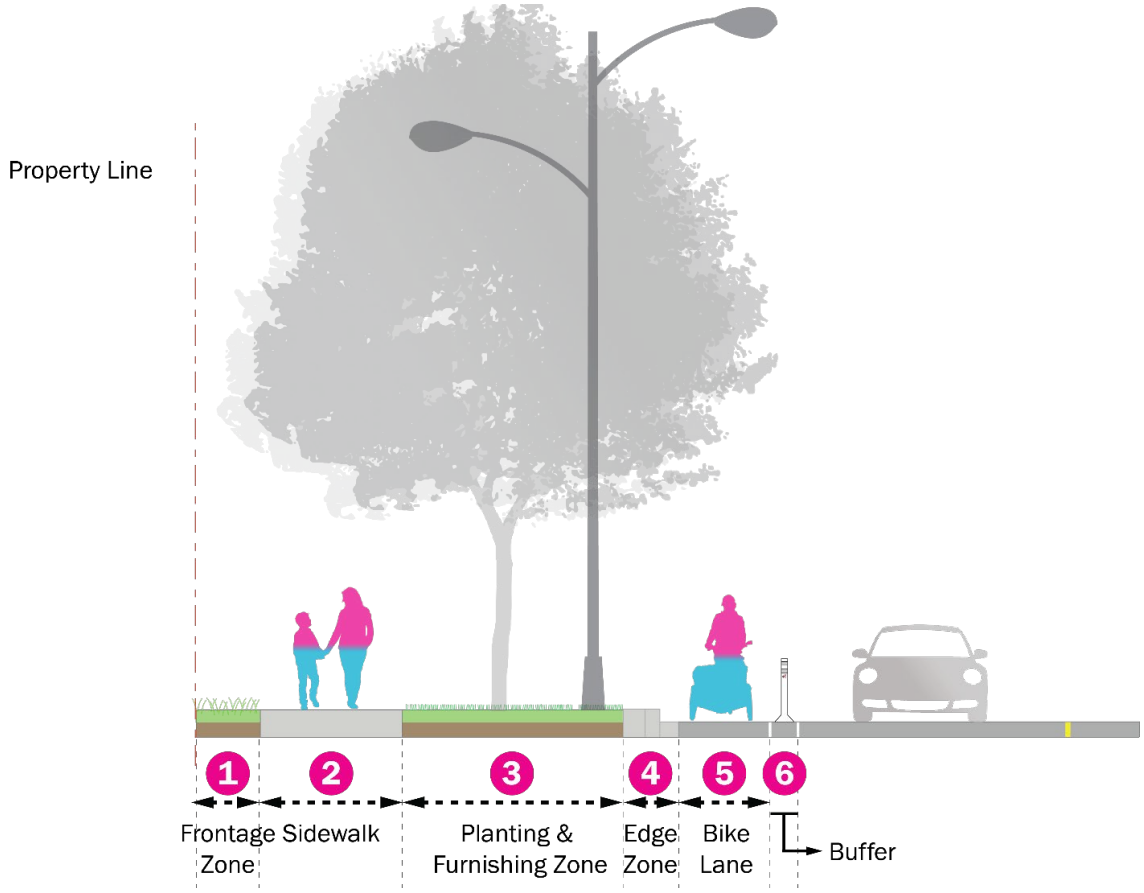
In cases where a road reconstruction or capital project is occurring, cycle tracks (refer to Section 5) are anticipated to be used more regularly than protected bike lanes. Accordingly, this chapter focuses on primarily retrofit applications for protected bike lanes.

Exhibit 4.1: Example of a Protected Bike Lane

4.2 Mid-block Design Elements

A typical cross-section for a corridor with a protected bike lane is illustrated in Exhibit 4-2.

Exhibit 4.2: Protected Bike Lane Typical Cross-Section



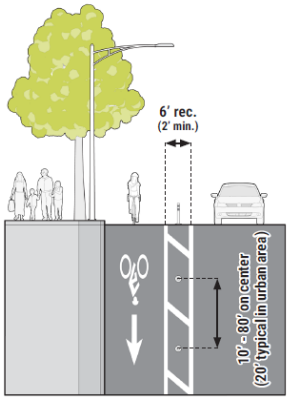
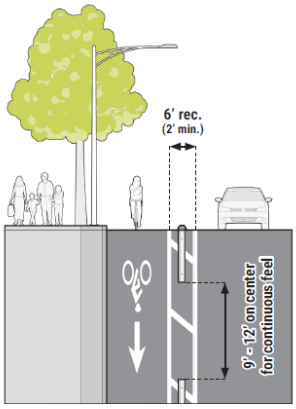
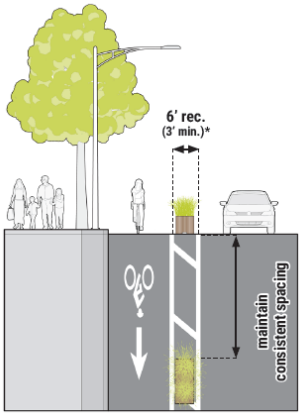
Protected Bike Lane			
#	**Parameter**	**Minimum**	**Preferred**
1	Frontage Zone	Varies (per existing conditions); Typically 0.3m or less	
2	Sidewalk	Varies (per existing conditions); 1.5m absolute minimum	
3	Planting & Furnishing Zone	Varies (per existing conditions)	
4	Edge Zone	*note lateral clearance to any hazards (see Section 3.3.2)	
5	Bike Lane Width	1.5m[2]	2.0m
6	Buffer/Protection Width	0.5m[2]	1.8m

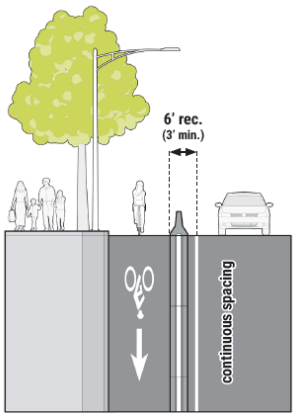
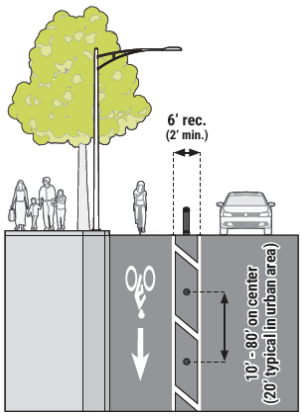
[2] The goal when incorporating physical separation into the painted buffer of a cycling facility should be to provide at least 1.85-2.0m of total clear space to allow sweepers and other smaller maintenance vehicles access to the separated facilities, so the use of a minimum bike lane width in combination with a narrow buffer should be avoided whenever possible.

4.2.1 Forms of Bikeway Separators

MassDOT's Separated Bike Lane Planning & Design Guide covers a variety of separator types and highlights some of the important features of each type, as summarized in Exhibit 4-3.

Exhibit 4.3: Various Types of Bikeway Separators & Design Features

Bollards / Flex Posts • Removable • Lowest initial capital costs • May require closer spacing where parking encroachment is likely • Small footprint compatible with a variety of buffer widths • Low durability • May need routine replacement, increasing long-term maintenance costs	
Parking Stops • Removable • Highly durable • May need supplemental vertical objects or on-street parking to increase visibility • Maintain consistent spacing between parking stops	
Planters • Removable • May be closely spaced for near-continuous vertical separation • Can be used to enhance community aesthetics • May serve as a gateway treatment • May be incompatible with clear zone requirements for roadways with higher motor vehicle speeds • Plants require routine care, increasing long term maintenance costs	

Concrete Barriers • Provides continuous vertical separation • Highly durable • Recommended for locations where physical protection from motor vehicles is needed, for example on bridges with high speed traffic • May need crash cushion at barrier ends • Incompatible with on-street parking	
Rigid Bollards • Typically permanent • Higher capital cost • May require closer spacing where parking encroachment is likely • May be incompatible with clear zone requirements for roadways with higher motor vehicle speeds • Removable rigid bollards may require substantial maintenance	

Source: Adapted from MassDOT Separated Bike Lane Planning & Design Guide, p. 36

4.2.2 Spacing and Installation of Separators

Installation of bikeway barriers must be reviewed on a site-specific basis. For reference, typical installation practices are summarized below:

- **Lateral placement of separators** must consider appropriate clearance between the face of curb and separator – typically a minimum of 1.8 – 2.0m of clearance is required for maintenance equipment. Where a minimum clearance is maintained, separators are typically centered within the bikeway buffer. Where separators are located next to a parking lane, consider positioning the curbs adjacent to the parking lane to prevent motorists from parking within the buffer of the protected bike lane.
- **Typical spacing of separators** will vary by the separator type:
  - Bollards (flex-posts or rigid bollards): Typically spaced 3-6m apart
  - Parking Stops: Typically 2-3 parking stops are placed continuously, with 1-2m gaps between continuous runs or parking stops

  - Planters: Spacing will vary depending on the desired effect from continuous runs to 3-5m between planters
  - Concrete barrier: may be continuous

  In some cases, wider spacing between separators may be required to provide opportunities for intermittent snow removal or debris clearing.

- **Driveways:** Separators must maintain access into and out of driveways. For residential driveways, an offset of 1 – 2m off the edge of the driveway apron is typically sufficient. For larger commercial or industrial driveway, site-specific swept path analysis may be used to confirm offsets.
- **Intersections:** Separators must not be installed within the anticipated swept path of appropriate design and control vehicles. For most unsignalized intersections, an offset of 4 – 7m from the face of curb of the intersecting street is typically sufficient (assuming a medium single unit truck control vehicle). At signalized intersections, a site-specific review should be completed considering design and control vehicles.
- **Catch Basins:** Where continuous concrete separators are provided, they should generally be broken for a minimum of 2 m in front of catch basins.
- **Waste Management Considerations:** In residential areas with curb-side garbage collection, consider providing 2m gaps between separators which will allow for access to garbage bins by waste collection workers. Bollards placed at the start of the gaps can enhance visibility of these collections points in winter when windrows may be present.

4.3 Driveways

Where protected bike lanes cross driveways, there is typically limited opportunity to introduce geometric shifts into the bikeway on the approach (particularly in retrofit conditions). Because there are limited opportunities to introduce geometric elements, pavement markings and signage should be used to ensure drivers are aware of potential cyclists, and to reinforce the requirement for drivers to yield to cyclists. At higher volume driveways such as multi-family residential or commercial driveways where crossings may occur more frequently, signs and enhanced pavement markings may be warranted to address potential conflicts.

Treatments may vary depending on the type of driveway (and motor vehicle volume). The categories of driveways and their corresponding treatment requirements are summarized in Exhibit 4-4.

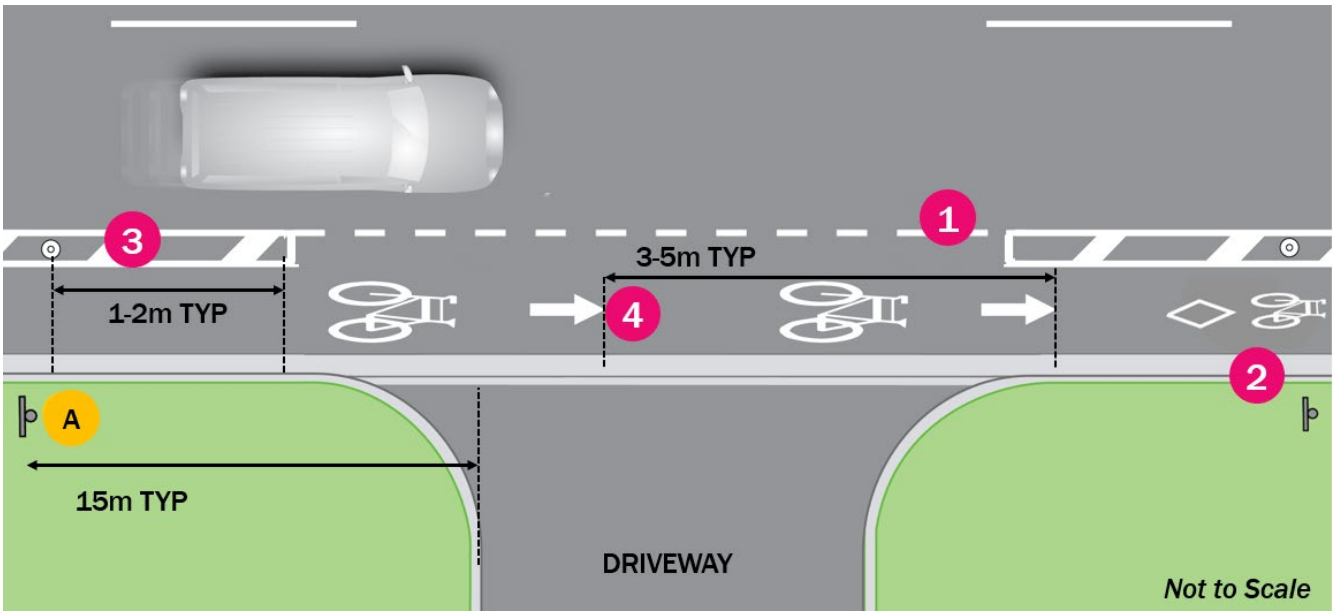
Exhibit 4.4: Required & Optional Elements along Protected Bike Lanes through Driveways

TYPE	FEATURE	REQUIRED ELEMENTS	OPTIONAL ELEMENTS
Multi-Family Residential	Signage	• N/A	• Custom TAC RB-37
Multi-Family Residential	Pavement Markings	• Dashed outer edge of buffer • Bike symbol + arrow	• N/A
Non-Residential, Higher Volume Driveway (<100 vph); no stop sign	Signage	• TAC Wc-15 & Wc-32T tab	• Custom TAC RB-37
Non-Residential, Higher Volume Driveway (<100 vph); no stop sign	Pavement Markings	• Dashed outer edge of buffer • Bike symbol + arrow	• Green conflict zone marking
Non-Residential, Higher Volume Driveway (>100 vph); with stop sign	Signage	• N/A	• Custom TAC RB-37
Non-Residential, Higher Volume Driveway (>100 vph); with stop sign	Pavement Markings	• Dashed outer edge of buffer • Bike symbol + arrow	• Green conflict zone marking

Treatments for a multi-family residential driveway are illustrated in Exhibit 4-5, with treatments for non-residential, higher volume driveways shown in Exhibit 4-6.

Protected Bike Lanes at Multi-Family Driveway

Exhibit 4.5: Protected Bike Lanes at Multi-Family Driveway



Required Elements

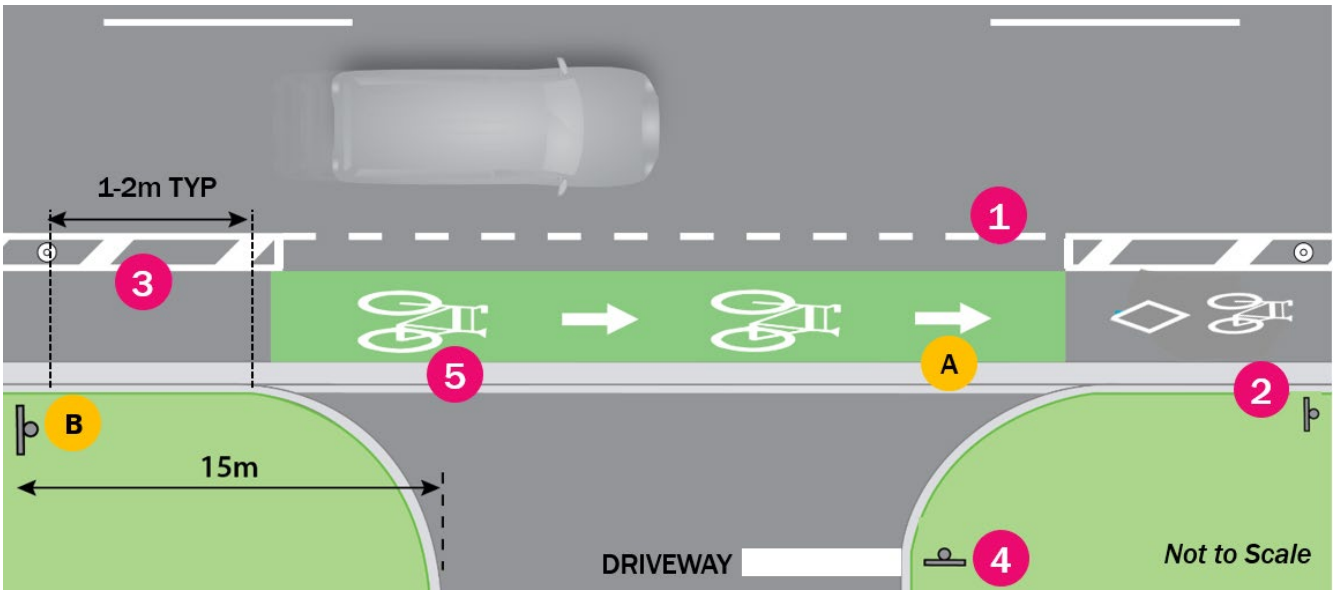
1. Dashed outer edge of buffer
2. Bike & diamond symbol with designated bike lane sign (Rb-84A) following the driveway. Where there are multiple consequent driveways within a short distance, consider installing the sign and markings once at the end of the row of driveways.
3. Appropriate clearance from driveway apron to nearest bikeway separator.
4. Application of bike symbol and arrow across lanes of the driveway

Optional / Context-Sensitive Elements

A Optional Custom TAC RB-37 signage. Where there are multiple consequent driveways within a short distance, consider installing the sign once at the beginning of the row of driveways

Protected Bike Lanes at Non-Residential, Higher Volume Driveway

Exhibit 4.6: Protected Bike Lanes at Non-Residential, Higher Volume Driveway



Required Elements

1. Dashed outer edge of buffer
2. Bike & diamond symbol with designated bike lane sign (Rb-84A) following the driveway. Where there are multiple consequent driveways within a short distance, consider installing the sign and markings once at the end of the row of driveways.
3. Appropriate clearance from driveway apron to nearest bikeway separator.
4. 'Stop' sign (Ra-1 – OTM) and stop bar.
5. Application of bike symbol and arrow across each lane of the driveway

Optional/Context-Sensitive Elements

A Optional green conflict zone marking

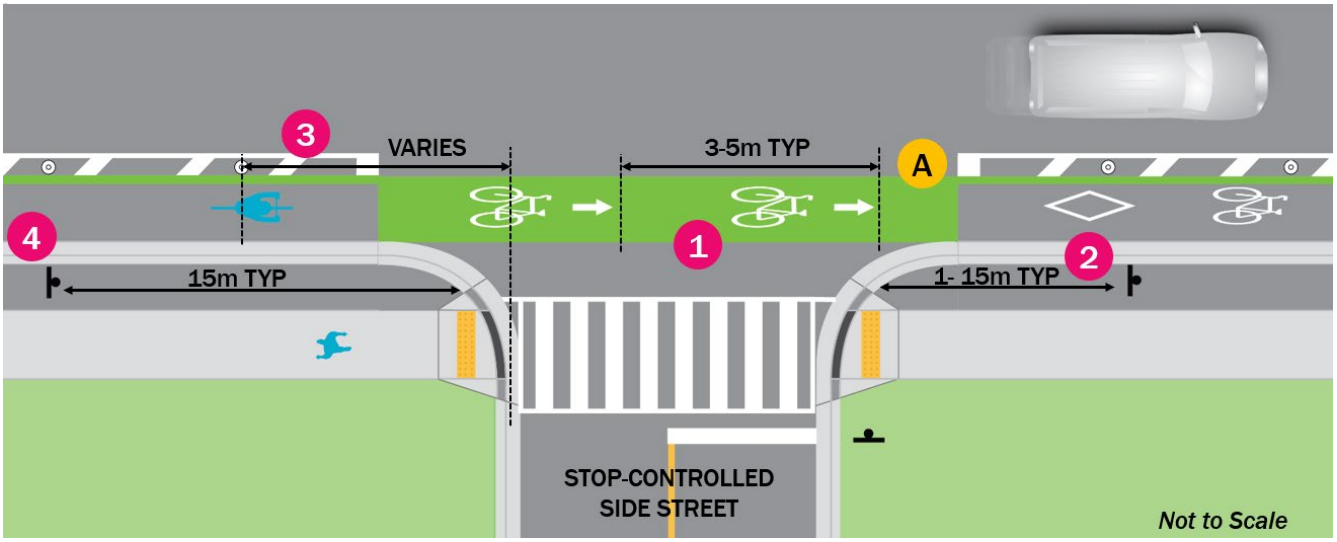
B Optional Custom TAC RB-37. Where there are multiple consequent driveways within a short distance, consider installing the sign once at the beginning of the row of driveways

4.4 Side Street Crossing (Stop-Controlled)

Cyclists on a major roadway crossing a side street intersection that is stop controlled on the side street have right-of-way over the side street traffic. Pavement markings & signage should be used to alert drivers to crossing cyclists. An example of a protected bike lane side-street crossing is shown in Exhibit 4-7.

Protected Bike Lane at Side Street Crossing (Minor Leg Stop-Controlled)

Exhibit 4.7: Protected Bike Lane at Side Street Crossing



Required Elements

1. Bike symbol and arrows across each lane of the cross-street
2. Bike & diamond symbol with designated bike lane sign (Rb-84A) following the driveway. Where there are multiple consequent driveways within a short distance, consider installing the sign and markings once at the end of the row of driveways
3. Bikeway separators must be terminated an appropriate distance away from the intersection based on a review of right-turning vehicle needs.
4. Custom TAC RB-37 to indicate to turning vehicles the right-of-way of through cyclists

Optional/Context-Sensitive Elements

A. Green conflict zone marking can be added to conflict zone marking

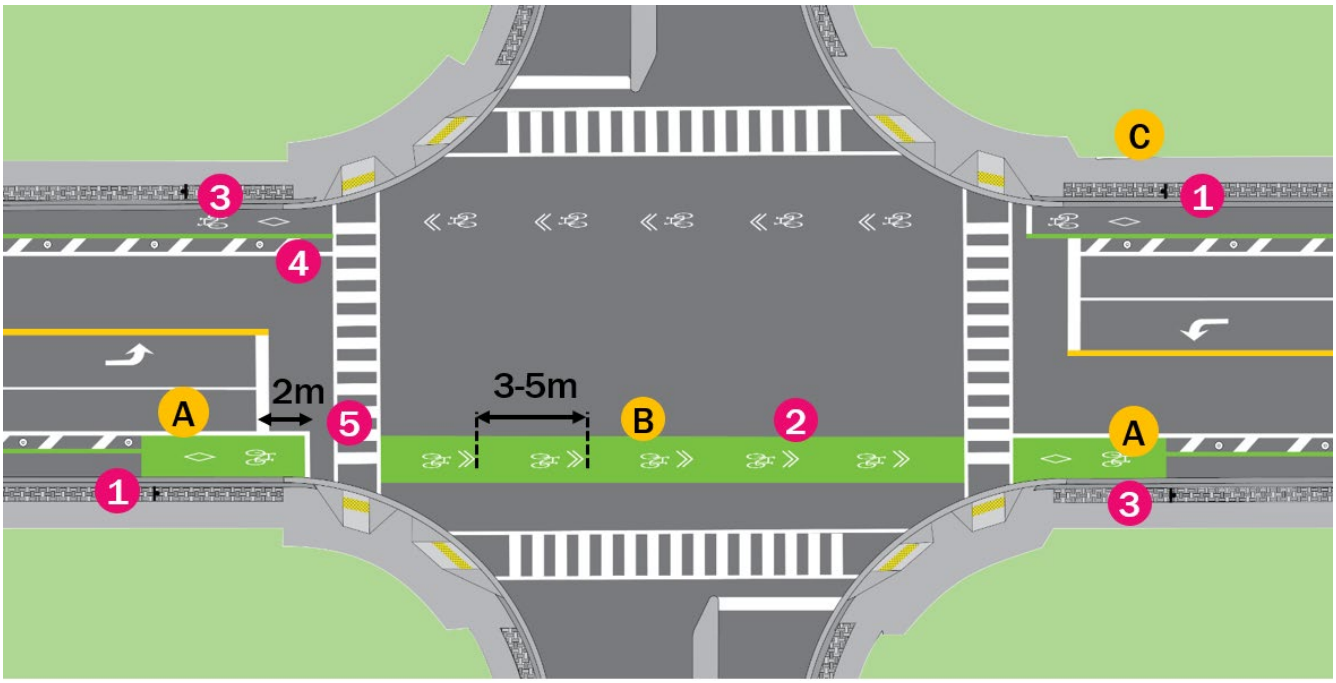
4.5 Intersection Crossing (Traffic Signal Controlled)

Signalized intersections create complex environments for cyclists and drivers. Additional pavement markings and signage can help to highlight and identify expected cyclist movements.

A typical intersection treatment for a protected bike lane at a signalized intersection is shown in Exhibit 4-8.

Protected Bike Lane Signalized Intersection Treatment

Exhibit 4.8: Protected Bike Lane at Signalized Intersection



Required Elements

1. Customized 'Turning Vehicles Yield To Bicycles' (RB-37 – TAC) signage to alert turning drivers that they must yield to through cyclists

2. Intersection crossing treatment should incorporate sharrows (3-5m spacing) to highlight the cyclist path of travel through the intersection

3. Bike & diamond symbol with designated bike lane sign (Rb-84A) following the intersection.

4. Bikeway separators must be terminated an appropriate distance away from the signalized intersection based on a review of right-turning vehicle needs. Separators should also start downstream with an appropriate offset.

5. Cyclist stop bar 2m ahead of vehicular stop bar to enhance visibility of cyclists

Optional/Context-Sensitive Elements

A. Green conflict zone markings may be applied approaching intersection or departing the intersection where heavy conflicting turn movements are expected.

B. Green conflict zone markings may be added to the sharrows as part of the intersection marking to enhance visibility. where there are heavy right or left-turn volumes. To preserve the impact of the green markings, consider marking only one movement of an intersection with green (where there is anticipated to be the highest potential exposure).

C. Separate bicycle signals (not shown) are preferred to provide consistency through the transition. Where phasing is identical to parallel vehicle heads, only one head is needed.

4.5.1 Signal hardware considerations at signalized intersections

Requirements for signal hardware will vary based on intersection geometry and constraints. Refer to OTM Book 12A for further discussion on bicycle signals. Consider the following interventions for cyclists travelling along protected bike lanes:

- Separate bicycle signals are preferred to provide consistency along the corridor and to allow for leading phases for path users. Where phasing is identical to parallel vehicle heads, only one head is needed. Otherwise, two bicycle heads should be provided.

Phasing options to prioritize vulnerable road users through intersections such as leading and protected bicycle/pedestrian phases are discussed in York Region Pedestrian & Cycling Planning and Design Guidelines (Section 8.2), as well as OTM Book 18.

5 Cycle Tracks

Cycle tracks provide separated space for cyclists behind the roadway curb. Within the City of Markham, they are most likely to be implemented along collector and arterial (or Regional) roadways. *It is important to note that any cycling facility within the boulevard portion of the Regional right-of-way must comply with Pedestrian Planning Guidelines for York Region Pedestrian and Cycling Facilities. In addition, all crossings at intersections and driveways within the Regional right-of-way must follow Regional design standards and be approved by the Region.*

Cycle tracks can be designed to operate one-way or two-way, but it is anticipated that primarily one-way cycle tracks will be most applicable within the City of Markham. Since cycle tracks are considered to be attractive for a wide variety of cyclists, they form part of the City's all ages and abilities (AAA) cycling network. Examples of existing cycle tracks within the City of Markham include facilities along Highway 7 and Birchmount Road.

As noted in Section 2.1, cycle tracks can play an important role in enhancing both the quality of cycling and pedestrian facilities, as they reduce conflicts between these different users. As the use of cycling facilities grows in Markham, there will be increasing pressure to separate pedestrians and cyclists within boulevards through the use of cycle tracks and sidewalks. Cycle tracks can be designed as part of an overall corridor streetscape and can incorporate coloured concrete or asphalt surfaces to help distinguish the facilities from pedestrian or shared-use facilities (refer to Exhibit 5-1).

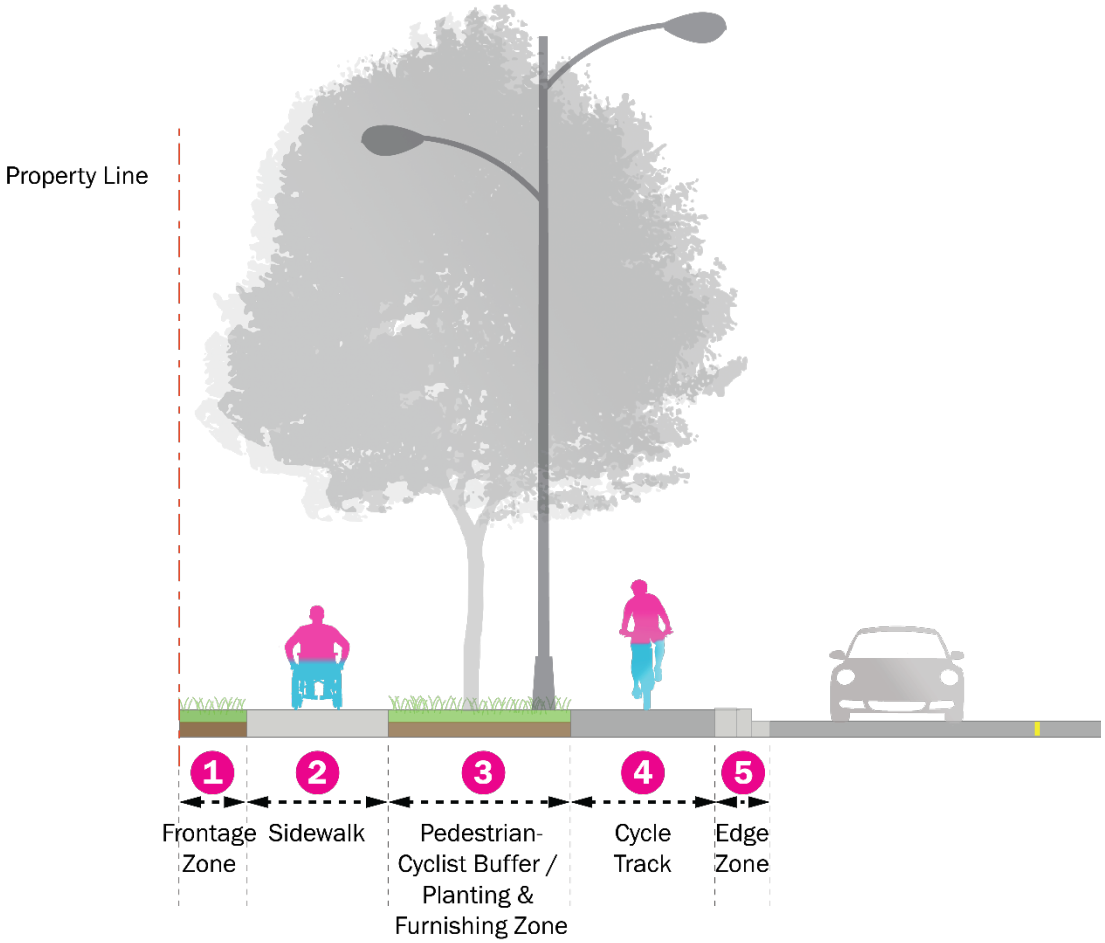
Exhibit 5.1: Example of a One-way Cycle Track Integrated into Corridor Streetscaping

5.1 Mid-block Design Elements

The following key elements summarized in Exhibit 5-2 define a cycle track.

Exhibit 5.2: Cycle Track Midblock Elements

Cycle Track



#	Parameter	Minimum	Preferred
1	Frontage Zone	Varies; Typically 0.3m or less	
2	Sidewalk	Varies; 1.5m absolute minimum	
3	Pedestrian & Cycling Buffer / Planting & Furnishing Zone		
	With Plantings / Furnishings	1.0m[3]	2.5m+
	Without Plantings / Furnishings	0.15m (vertical curb) 0.6m (buffer strip)	0.8-1.0m
4	Cycle Track Width	1.8m	2.2m
5	Edge Zone *(incl. curb & gutter)*	0.3m (without parking, [50km/hr)	1.8m

5.1.1 Delineation of Pedestrian & Cycling Space within the Boulevard

Since cycle tracks are installed within the boulevard, it is important to consider how pedestrian and cycling facilities are differentiated to reduce the opportunity for conflicts. Per OTM Book 18 (2021), "where cycling facilities such as cycle tracks are designed adjacent to pedestrian walkways, it is important to consider accessibility and coordinate with AODA requirements. Providing effective separation that is cane and visually detectable can improve safety and clarify paths of travel for all users. This can be done through adequate colour and texture contrast. For installations where the sidewalk and the cycle track are similar in colour and texture, or will become similar with time and weathering, careful consideration should be made in determining a separation treatment and surface material. Using asphalt for cycling facilities and concrete for pedestrian facilities is an example of a practical strategy to consistently communicate intended use of space." (p. 67)

Other strategies for delineating space between the cycle track and sidewalk where the two facilities are directly adjacent include:

- **Vertical curb delineation (i.e. mid-height curb):** Per Book 18, a 50 mm high and 150 mm wide bevelled curb is detectable by people with vision impairments using a cane and also minimizes the hazard for wheelchair users.
- **Continuous Tactile Buffer Strip:** Minimum 0.6m wide tactile buffer consisting of stamped, patterned or coloured concrete, textured unit pavers, truncated domes or other methods
- **Planting & Furnishing Zone:** Where there is sufficient boulevard width to accommodate a planting and furnishing zone, features such as sod, plantings, street trees, or other street furniture can provide delineation between pedestrian and cycling spaces.

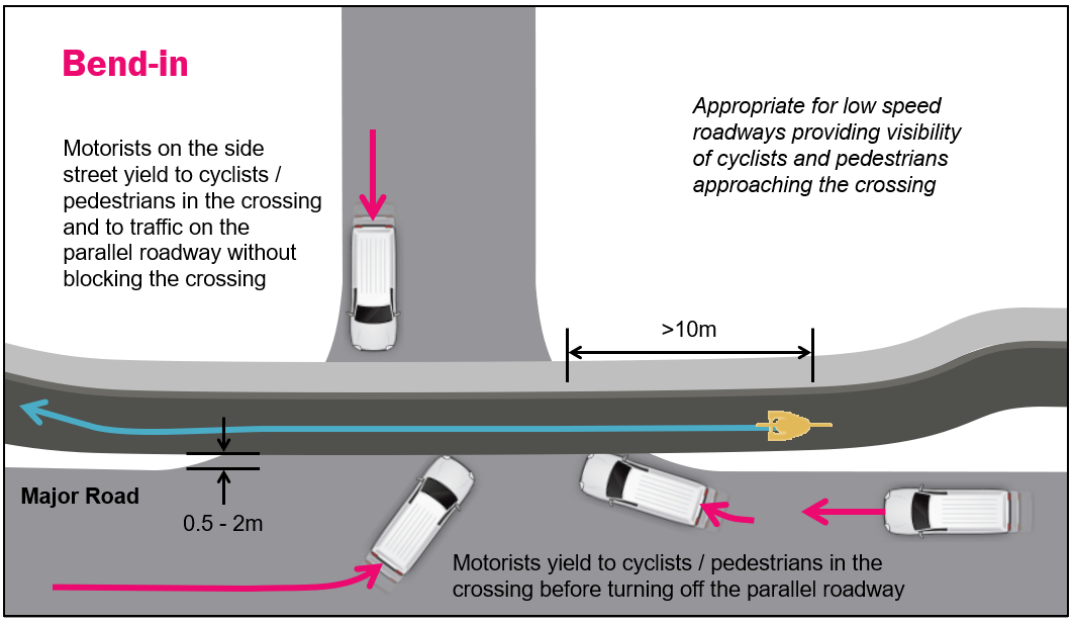
5.2 Bend-in & Bend-out Approaches

Where cycle tracks will cross driveways, side streets or travel through signalized intersections, it is important to consider the geometry of the cycle track on the approach to the crossing. Depending on various factors such as right-of-way and available property, utilities and other physical constraints, and the roadway/driveway context, cycle track should generally incorporate either a bend-in or bend-out design approaching a driveway or intersection.

Bend-in treatment: Cycle tracks are "bent" closer to the parallel roadway on the intersection approach to enhance visibility of cyclists (refer to Exhibit 5-3). Where a bend-in approach is applied, drivers turning will need to yield to cyclists in the crossing before turning off the parallel road. This is also the case for drivers crossing a cycling facility from the intersecting roadway or driveway before merging onto the major road.

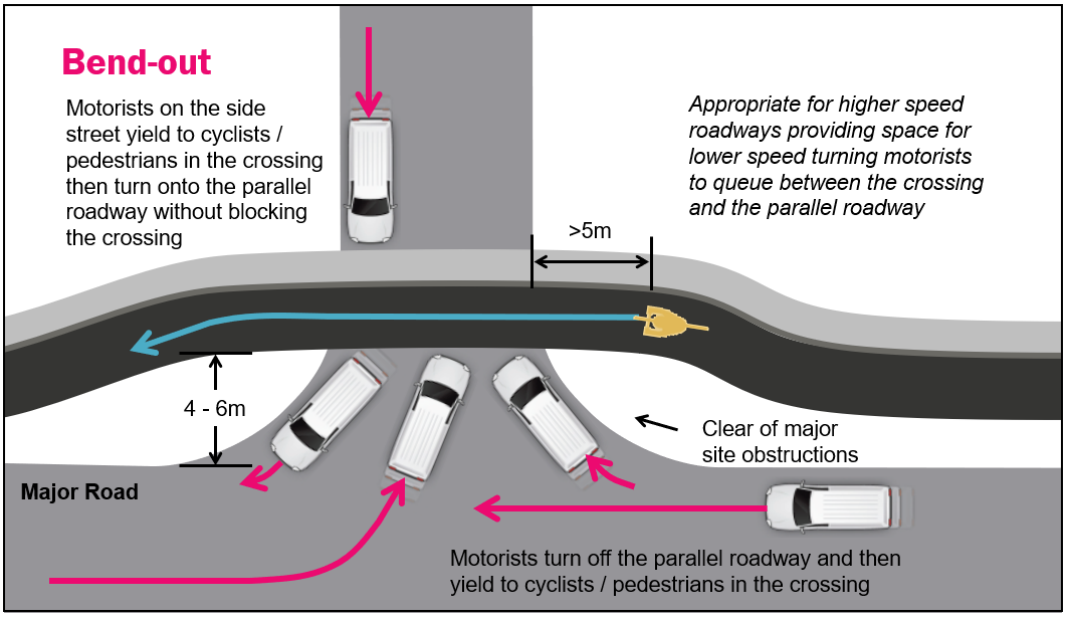
[3] The minimum will largely be driven by maintain appropriate clearance from the cycle track to any vertical elements (refer to Section 3.3). Where sod or other plantings are proposed, a minimum of 1.0m width is generally required for the sod to grow properly.

Exhibit 5.3: Bend-in Design



Bend-out treatment: Cycle tracks are "bent" further away from the road – generally about 4-6m – providing space for drivers from the main street to yield/stop after making the right turn (refer to Exhibit 5-4). Slow turning speeds are an important element of this design. One of the biggest benefits of a bend-out design is that drivers turning from an intersecting street are able to first yield to crossing pedestrians and cyclists before moving up past the crosswalk/crossride to be able to negotiate a right turn while focusing on gap selection for vehicles on the major road. Separating the two conflict points helps to ease driver workload and can reduce the likelihood of waiting drivers blocking the crosswalk or crossride.

Exhibit 5.4: Bend-out Design



5.3 Driveways

Through driveways, cycle track design should consider both geometric improvements (bend-in or bend-out alternatives as described in Section 5.2 and raised crossing as described in Section 5.4.1) as well as pavement markings & signage enhancements.

A key goal of pavement marking and signage treatments at driveways is to ensure drivers are aware of potential cyclists, and to reinforce the requirement for drivers to yield to cyclists. For higher volume driveways such as multi-family residential or commercial driveways where crossings may occur more frequently, enhanced pavement markings may be warranted to address potential conflicts.

Treatments vary depending on the type of driveway (and motor vehicle volume). The categories of driveways and corresponding treatments are summarized in Exhibit 5-5. The pavement marking & signage treatments are consistent with those identified for bike lanes, buffered bike lanes (refer to the City's *Signage & Pavement Marking Guidelines for On-Road Cycling Facilities)* and protected bike lanes (Section 4.2.2) to build consistency across facilities.

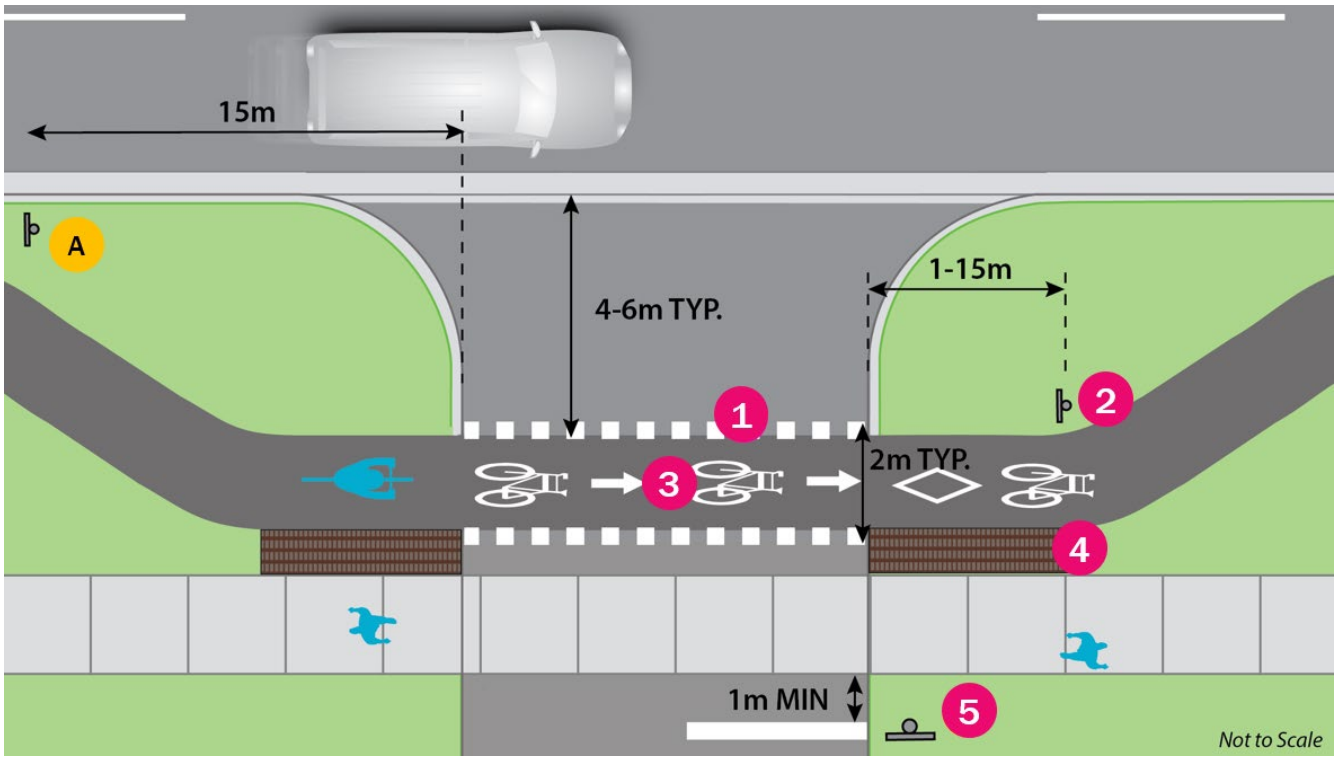
Exhibit 5.5: Recommended & Optional Elements along Cycle Tracks through Driveways

TYPE	FEATURE	REQUIRED ELEMENTS	OPTIONAL ELEMENTS
Single Family Residential Driveway	Signage	• N/A	• N/A
	Pavement Markings	• N/A	• N/A
Multi-Family Residential	Signage	• Ra-1 Stop Sign	• Custom TAC RB-37
	Pavement Markings	• Stop bar • Cross-ride markings • Bike symbol + arrow	• N/A
Non-Residential, Higher Volume Driveway (<100 vph); **no stop sign**	Signage	• TAC Wc-15 & Wc-32T tab	• Custom TAC RB-37
	Pavement Markings	• Cross-ride markings • Bike symbol + arrow	• Green conflict zone marking
Non-Residential, Higher Volume Driveway (>100 vph); **with stop sign**	Signage	• N/A	• Custom TAC RB-37
	Pavement Markings	• Cross-ride markings • Bike symbol + arrow	• Green conflict zone marking

Treatments for a multi-family residential driveway are illustrated in Exhibit 5-6, with treatments for non-residential, higher volume driveways shown in Exhibit 5-7.

Cycle Track at Multi-Family Driveway

Exhibit 5.6: Cycle Track at Multi-Family Driveway



Required Elements

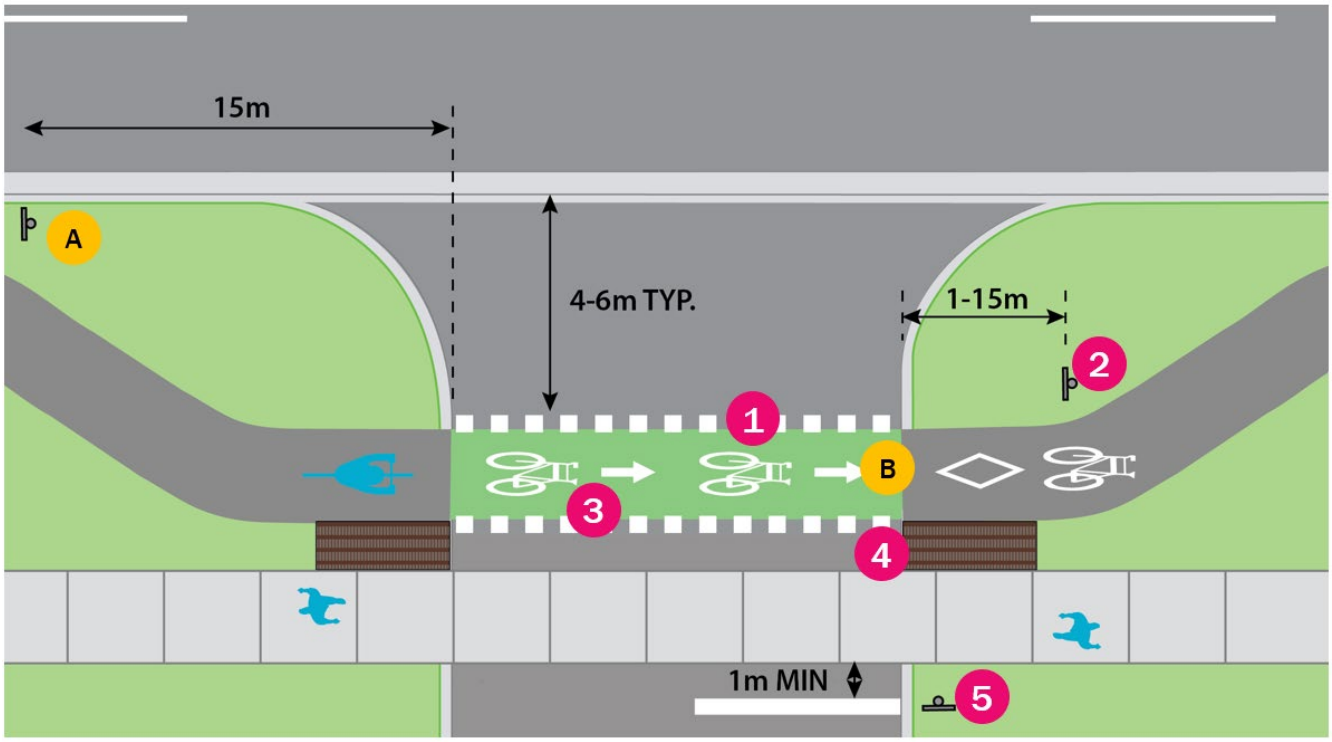
1. Crossride markings (elephant's feet). Green conflict zone markings may also be considered on a case-by-case basis.
2. Bike & diamond symbol with designated bike lane sign (Rb-84A) following the driveway. Where there are multiple consequent driveways within a short distance, consider installing the sign and markings once at the end of the row of driveways
3. Application of bike symbol and arrow across lanes of the driveway
4. Delineation of cycling and pedestrian space where the two facilities approach each other through the application of high contrast and/or texture material
5. Stop' sign (Ra-1 – OTM) and stop bar

Optional/Context-Sensitive Elements

A. Custom TAC RB-37 signage. Where there are multiple consequent driveways within a short distance, consider installing the sign once at the beginning of the row of driveways.

Cycle Track at Non-Residential, Higher Volume Driveway

Exhibit 5.7: Cycle Track at Non-Residential, Higher Volume Driveway



Required Elements

1. Crossride marking for cyclists with elephant's feet markings and bike with arrow to indicate direction of travel
2. Bike & diamond symbol with designated bike lane sign (Rb-84A) following the driveway. Where there are multiple consequent driveways within a short distance, consider installing the sign and markings once at the end of the row of driveways
3. Application of bike symbol and arrow across each lane of the driveway
4. Delineation of cycling and pedestrian space where the two facilities approach each other through the application of high contrast and/or texture material
5. 'Stop' sign (Ra-1 – OTM) and stop bar

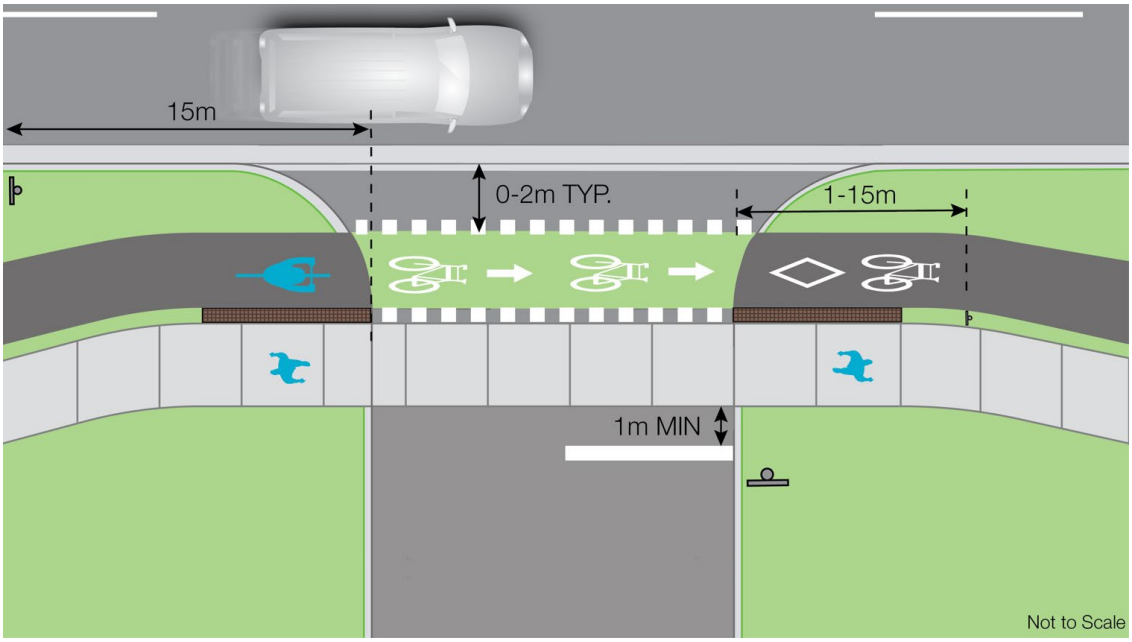
Optional/Context-Sensitive Elements

A. Custom TAC RB-37. Where there are multiple consequent driveways within a short distance, consider installing the sign once at the beginning of the row of driveways

B. Optional green conflict zone marking

As noted in Section 5.2, cycle tracks can also be 'bent-in' at multi-family residential and commercial driveways where it is not possible to bend-out (see example in Exhibit 5-8).

Exhibit 5.8: Alternate Bend-in Design for Cycle Track at Driveway



5.3.1 Raised Crossings

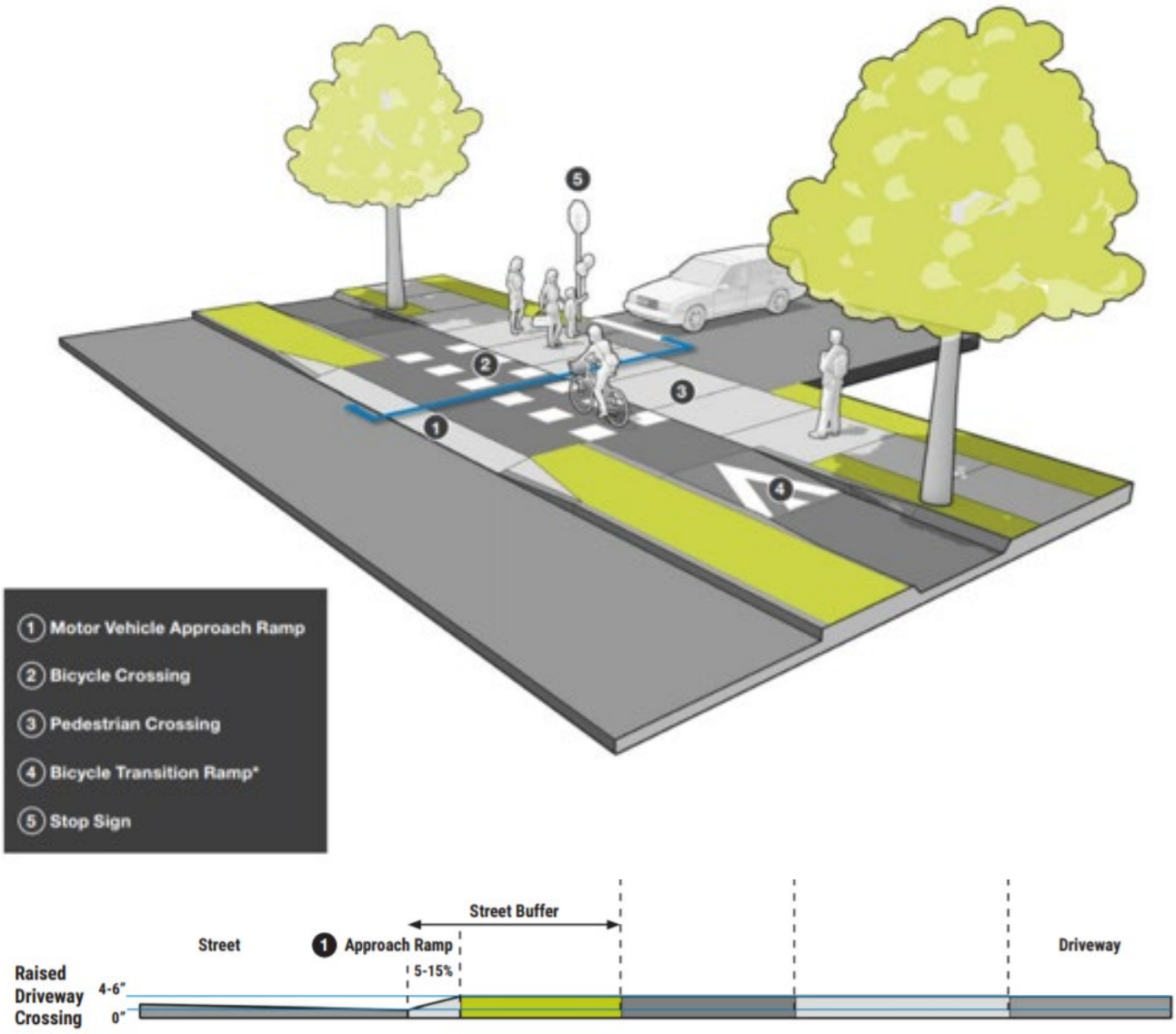
Raised crossings are an optional treatment at driveways that force vehicles to reduce speeds, increase the visibility of cyclists, and reinforce the requirement of drivers to yield to passing cyclists. In contexts with cycling facilities at sidewalk level and a high density of driveways, they also create a more comfortable, level cycling environment than the provision of many successive ramps to meet the driveway level. Any of the above design concepts would be enhanced through application of a raised crossing design.

The MassDOT Separated Bike Lane Planning and Design Guide provides detailed guidelines for raised crossings. Key design characteristics include the following:

- They should be elevated 10-15 cm above street level.
- Motor vehicle approach ramps should have a 5-15% slope at driveways.
- Yield lines or speed hump markings should be used on uncontrolled motor vehicle approaches.

An example raised driveway crossing is shown in Exhibit 5.9.

Exhibit 5.9: Sample Raised Driveway Crossing



Source: MassDOT Separated Bike Lane Planning & Design Guide

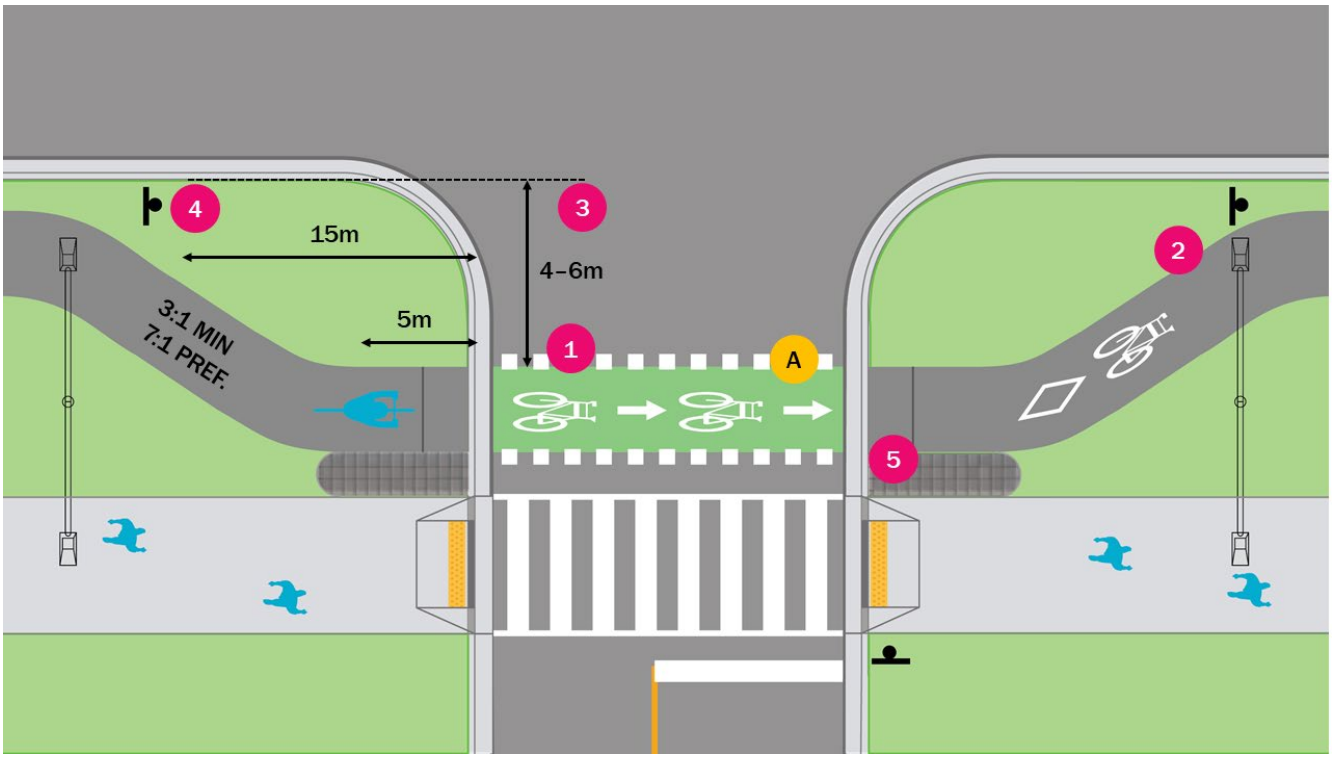
5.4 Side Street Crossing (Stop-Controlled)

Cyclists on a major roadway crossing a side street intersection that is stop controlled on the side street have right-of-way over the side street traffic. Pavement markings & signage should be used to alert drivers to crossing cyclists. With cycle tracks, a similar strategy of bend-in or bend-out geometric approaches should be used wherever possible to reduce and mitigate conflicts with right and left turning vehicles from the major road onto the side street.

An example of a side-street crossing is shown in Exhibit 5-9.

Cycle Track at Side Street Crossing (Minor Leg Stop-Controlled)

Exhibit 5.10: Cycle Track at Side Street Crossing



Required Elements

1. Crossride marking for cyclists with elephant's feet markings and bike with arrow to indicate direction of travel
2. Bike & diamond symbol with designated bike lane sign (Rb-84A) following the driveway. Where there are multiple consequent driveways within a short distance, consider installing the sign and markings once at the end of the row of driveways
3. Crossride should be set back from the major road 4-6m to allow a turning vehicle space to yield to crossing cyclists without risk of being rear-ended (or 0-2m for a bend-in design)
4. Custom TAC RB-37 to indicate to turning vehicles the right-of-way of through cyclists
5. Delineation of cycling and pedestrian space per Section 5.1.1

Optional/Context-Sensitive Elements

A. Green conflict zone marking in crossride

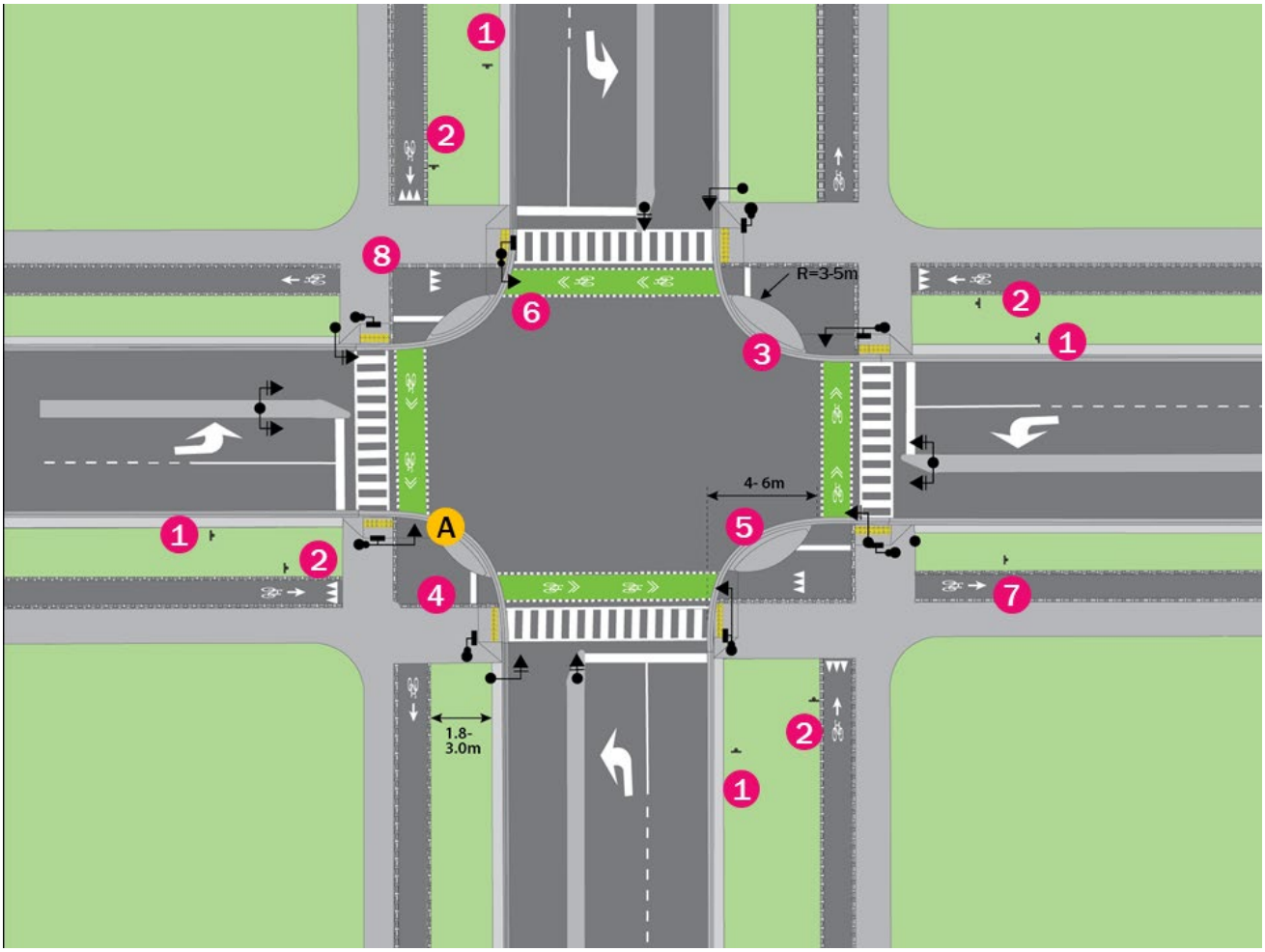
5.5 Intersection Crossing (Traffic Signal Controlled)

Through signalized intersections, every effort should be made to maintain a similar level of protection for cycle tracks as on the approach to the intersection.

One strategy for achieving a similar level of comfort and separation through a signalized intersection is to implement a protected intersection (refer to Exhibit 5-10).

Cycle Track Bend-Out (Protected Intersection)

Exhibit 5.11: Protected Intersection Concept



Required Elements

1 Customized 'Turning Vehicles Yield To Bicycles' (RB-37 – TAC) signage to alert turning drivers that they must yield to through cyclists

2 Yield markings alerting approaching cyclists of pedestrian priority should be applied to separated cycling facilities along with the use of 'Cyclists Yield to Pedestrians' signage (Rb-73-OTM)

3 Corner refuge island to provide physical protection to waiting pedestrians and cyclists

4 Bicycle queuing area must provide sufficient storage so that a waiting bicycle does not block or impede through pedestrian traffic. A stop bar for cyclists can be provided at the top of the ramp.

5 Motorist yield zone (minimum 4m) which allows turning drivers to yield to crossing pedestrians and cyclists without risk of being rear-ended by through vehicles

6 Intersection crossing of the cycle track should be designed as a crossride for cyclists with elephant's feet markings and sharrows to indicate direction of travel

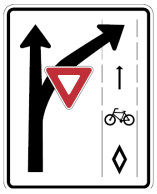
7 Bike & arrow with optional diamond symbol with designated bike lane sign (Rb-84A) following the intersection.

8 Cycle track and sidewalk crossing should be designed to emphasize pedestrian priority. Treatments may include carrying sidewalk material across cycle track or providing tactile plates on either side of cycle track crossing.

Optional/Context-Sensitive Elements

A Separate bicycle signals are preferred to provide consistency through the transition. Where phasing is identical to parallel vehicle heads, only one head is needed. Otherwise, two bicycle heads should be provided.

Signage Details:



RB-37 / Rb-18

Rb-73

Rb-84A

Exhibit 5.12: Example of a Protected Intersection Corner

Source: Google Streetview

5.5.1 Signal hardware considerations at signalized intersections

Requirements for signal hardware will vary based on intersection geometry and constraints. Refer to OTM Book 12A for further discussion on bicycle signals. Consider the following interventions for cyclists and pedestrians:

- Separate pedestrian pole with pushbutton for cyclists approaching on the right side of the multi-use path preferred to reduce conflicts with pedestrians and improve ease of crossing
- Separate bicycle signals are preferred to provide consistency along the corridor and to allow for leading phases. Where phasing is identical to parallel vehicle heads, only one head is needed. Otherwise, two bicycle heads should be provided.

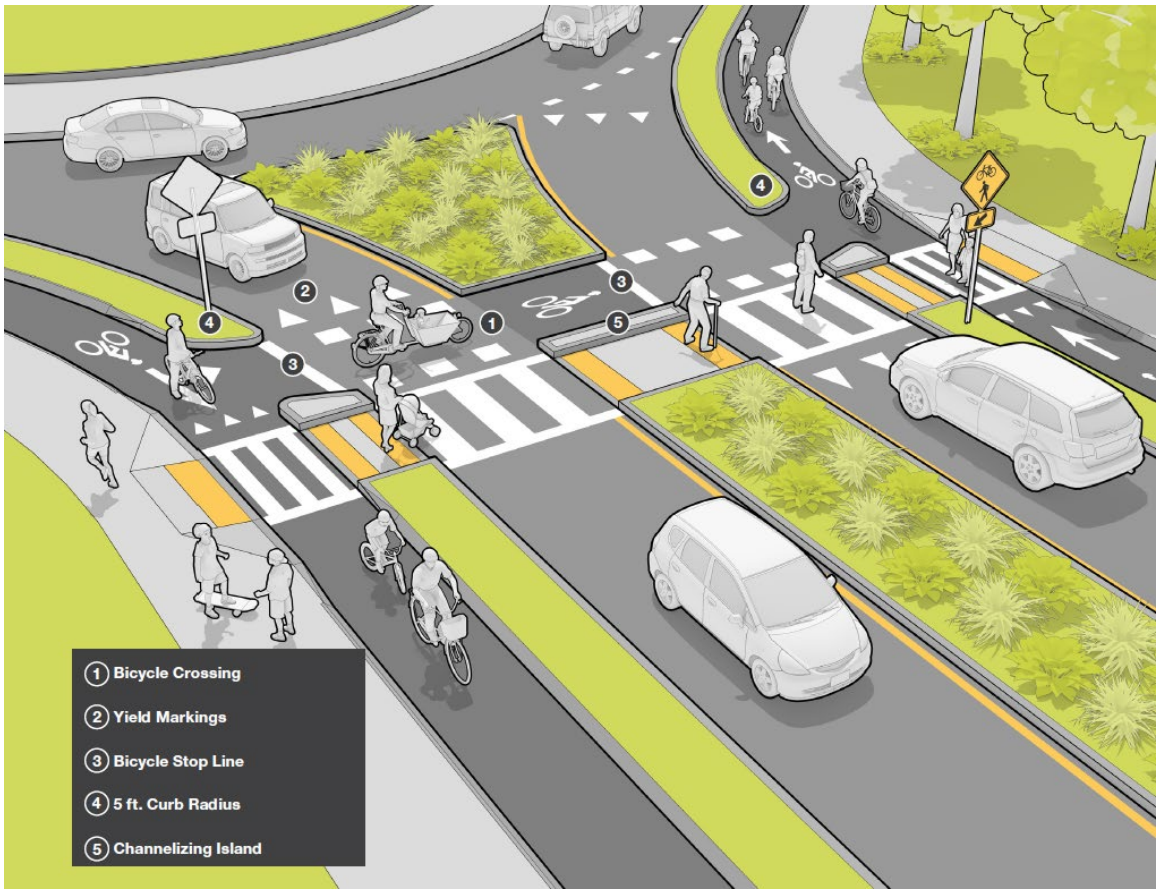
Phasing options to prioritize vulnerable road users through intersections such as leading and protected bicycle/pedestrian phases are discussed in York Region Pedestrian & Cycling Planning and Design Guidelines (Section 8.2), as well as OTM Book 18.

5.6 Roundabouts

While there are limited applications of single lane roundabouts in the City of Markham, they may be considered in new development areas as a method of traffic calming. Single lane roundabouts can have operational benefits for both cyclists and pedestrians as they tend to slow vehicular speeds, reduce delays for all users and have fewer conflict points than conventional signalized intersections. Despite these benefits, roundabouts can present crossing challenges for visually impaired pedestrians, can take up more space within the right-of-way, and may not be appropriate in all situations.

In most cases, cyclists can share the lane in single lane roundabouts as vehicular speeds are generally reduced to 30-40 km/hr through the roundabout. An enhanced alternative, where high volumes of both cyclists and pedestrians are anticipated and a roundabout is selected as the preferred intersection treatment, is to maintain the physical separation of cyclists and pedestrian through the intersection. An example application of this approach with fully separated streams from the MassDOT Separated Bike Lane Planning & Design Guide (2015) is shown in Exhibit 5.13.

Exhibit 5.13: Roundabout with Cycle Tracks



Source: MassDOT Separated Bike Lane Planning & Design Guidelines

6 Multi-use Paths

Multi-use paths are facilities shared between cyclists, pedestrians and other users such as rollerbladers, skateboarders etc. Multi-use paths appeal to a wide range of users, including a variety of cyclists with different skill levels. They are most likely to be implemented along collector or arterial roadways. *It is important to note that any multi-use path within the boulevard portion of the Regional right-of-way must comply with Pedestrian Planning Guidelines for York Region Pedestrian and Cycling Facilities. In addition, all crossings at intersections and driveways within the Regional right-of-way must follow Regional design standards and be approved by the Region.*

Since multi-use paths typically accommodate two-way travel for both pedestrians and cyclists, they can introduce design challenges at intersections and driveways, and are most appropriate on corridors with fewer intersections. As many multi-use paths are built on only one side of the street, this reduces access to destinations on the opposite side of the street. While riding along the path gives a sense of comfort, trying to access or leave the path from across the street is problematic, leading to mid-block crossings, and wrong-way riding on the road or sidewalk. Some of these concerns can be avoided or mitigated by providing multi-use paths on both side of the road as a preferred practice when multi-use paths are identified as an appropriate facility. Multi-use paths are generally not preferred where high volumes of cyclists or pedestrians are expected. TAC provides the following thresholds for separating cycling and pedestrian facilities:

- A high percentage of pedestrians (more than 20% of users) and total volumes greater than 33 persons per hour per metre of path width; or
- A low percentage of pedestrians (less than 20% of users) and total volumes greater than 50 persons per hour per metre of path width.

For the above reasons, effort should be made to implement and design boulevard multi-use paths with an understanding of their limitations and risks.

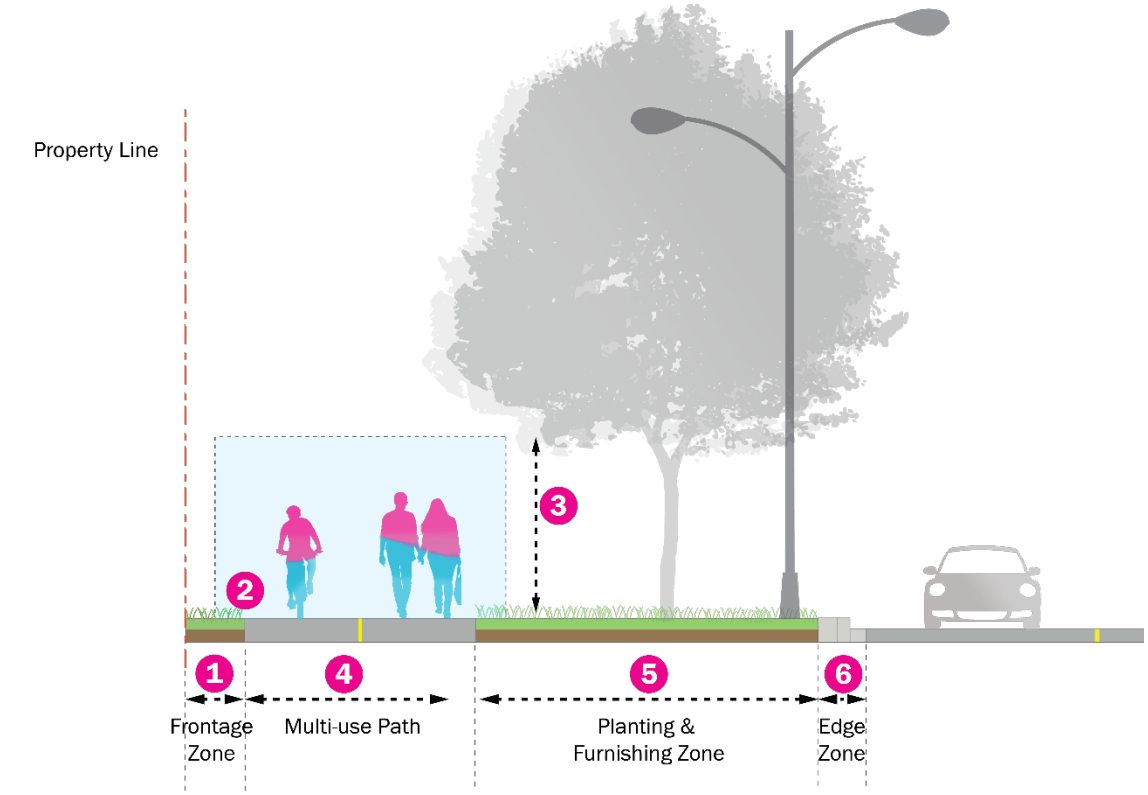
Exhibit 6.1: Example of a Boulevard Multi-use Path in Markham

6.1 Mid-block Design Elements

Typical midblock design guidance for a multi-use path is shown in Exhibit 6-2.

Exhibit 6.2: Boulevard Multi-use Path Midblock Elements

Boulevard Multi-use Path



#	Parameter	Minimum	Preferred
1	Frontage Zone	Varies; 0.3m minimum	
2	Lateral Clearance	0.6m	1.0m
3	Vertical Clearance	2.5m	3.0m
4	Width of Pathway	3.0m	4.0-5.0m+
5	Planting & Furnishing Zone	Varies; Typically .5m-2.5m+	
6	Edge Zone *(incl. curb & gutter)*	0.5m curb +0.6m buffer strip	1.5m+

Surface Type

Hard surfaces that provide a stable, slip-resistant and accessible surface are recommended for primary multi-use paths, generally anticipated to be either concrete or asphalt surfaces. The City's current standard is the application of concrete for multi-use paths and trails. However, it is noted that the use of asphalt or asphalt surfaces on a concrete base were noted as preferred during

the course of the development of the Active Transportation Master Plan, based on stakeholder and community input.

6.2 Driveways

The HTA requires that drivers entering a highway from a private road or driveway that is not controlled by a traffic control signal, yield the right-of-way to all traffic approaching on the highway so closely that to enter would constitute an immediate hazard. Since pedestrians and cyclists are traffic operating on a multi-use path within the right-of-way of a highway, drivers entering the highway are to yield the right-of-way where the path crosses the driveway.

It is common for drivers to pull up to the edge of the travel way of the roadway before entering a parallel road, thereby blocking the multi-use path in the boulevard. For this reason, it is desirable to consider opportunities to introduce a ‘bend out’ design for multi-use paths (refer to Section 5.2) at driveway approaches where heavy volumes of exiting vehicles are anticipated. Where visibility is of primary concern, and lower volumes of vehicles are anticipated (such as at a single-family residential driveway), a ‘bend-in’ design may be more appropriate. Raised driveway crossings can also be implemented to slow drivers and ensure the path is continuous and level for cyclists and pedestrians – see 5.4.1 for further details.

Pavement marking & signage may vary depending on the type of driveway (and motor vehicle volume). Driveway categories and corresponding treatments are summarized in Exhibit 6-3.

Exhibit 6.3: Required & Optional Elements along Multi-use Paths through Driveways

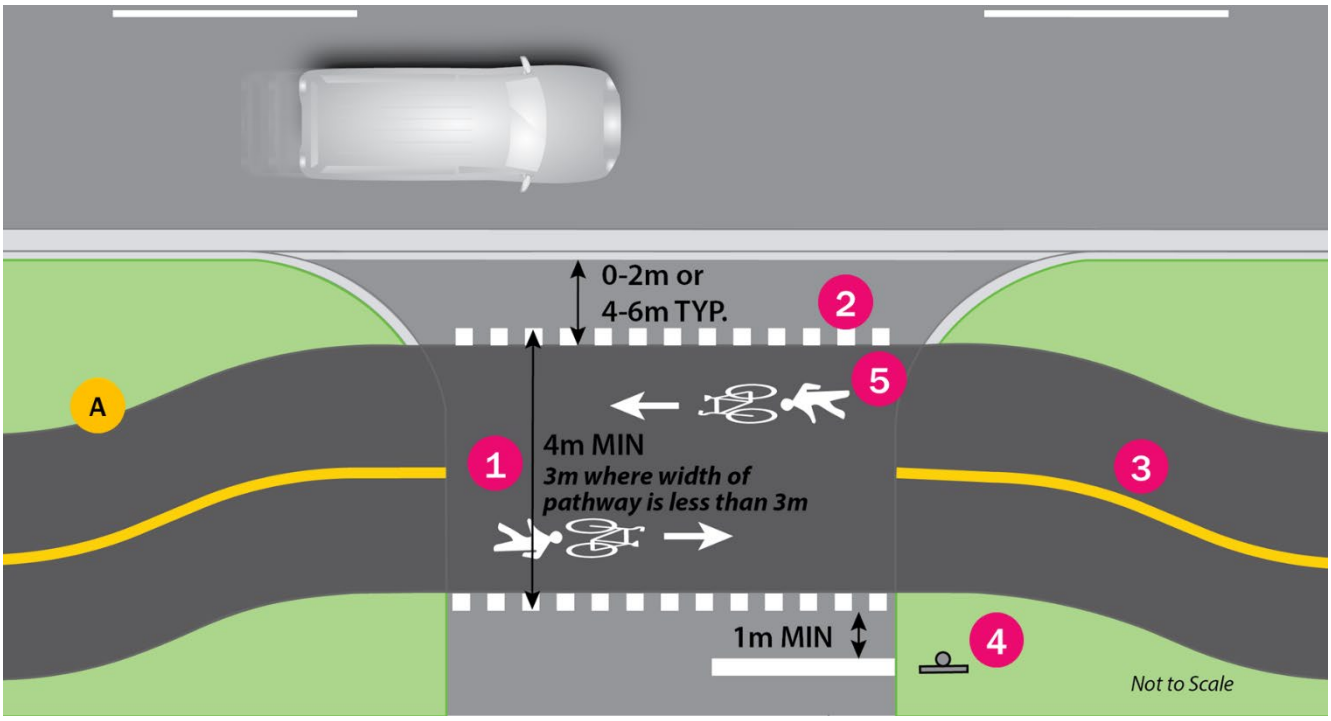
TYPE	FEATURE	REQUIRED ELEMENTS	OPTIONAL ELEMENTS
Multi-Family Residential	Signage	• TAC WC-44 + WC-44T • Stop sign for vehicles	• N/A
	Pavement Markings	• Elephant's feet • Bike symbol + arrow (i.e. mixed crossride) • Yellow dividing line on approach to driveway	• N/A
	Geometry	• N/A	• Consider bend-out design to avoid blockages of multi-use path or bend-in design to enhance visibility from parallel road
Non-Residential, Higher Volume Driveway	Signage	• TAC WC-44 + WC-44T • Stop sign for vehicles	• N/A
	Pavement Markings	• Mixed crossride • Yellow dividing line on approach to driveway	• Green surface treatment
	Geometry	• N/A	• Consider bend-out design to avoid blockages of multi-use path or bend-in design to enhance visibility from parallel road

Further details about these signs and pavement markings, including information on usage and locations, are provided in the City of Markham's *Multi-use Path Signage and Pavement Markings Guideline (2014).*

Treatments for a multi-family residential driveway are illustrated in Exhibit 6-4, with treatments for non-residential, higher volume driveways shown in Exhibit 6-5.

Multi-use Path at Multi-Family Residential Driveway

Exhibit 6.4: Multi-use Path at Multi-Family Residential Driveway



Required Elements

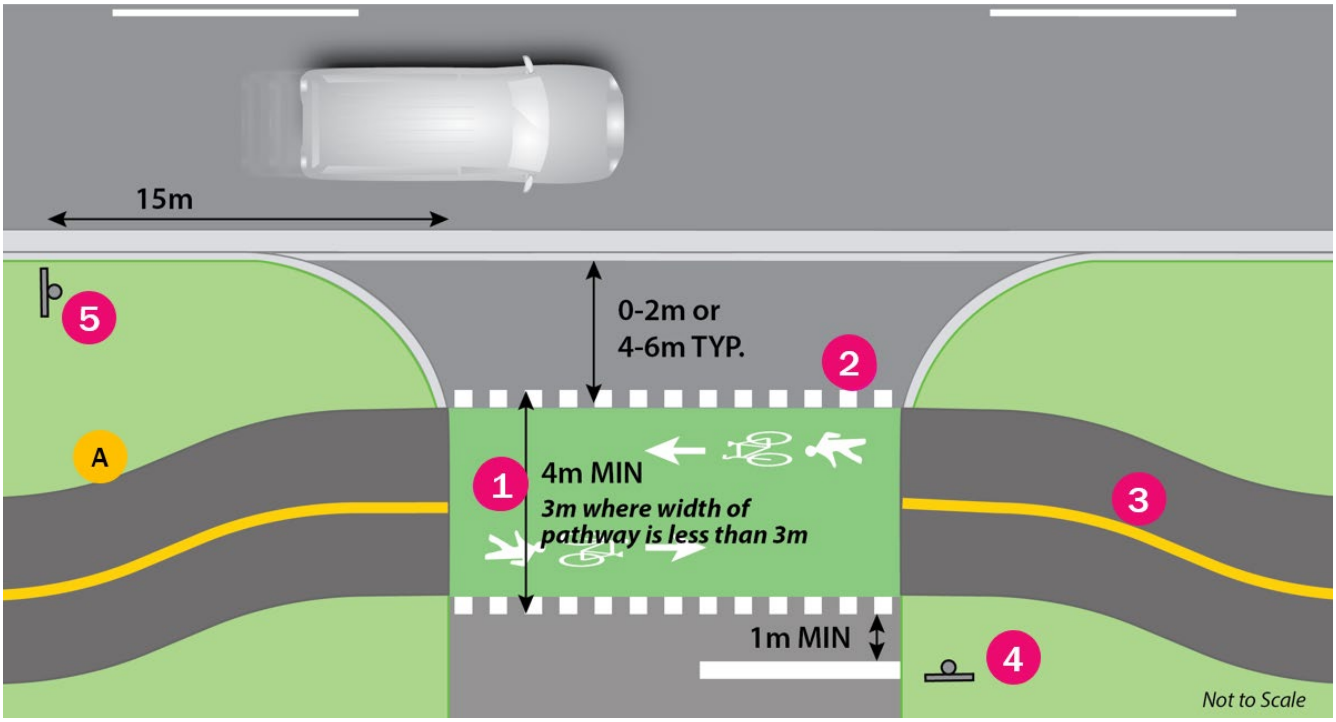
1. Facility surface material carried through driveway (concrete or asphalt)
2. Elephant's feet markings
3. Yellow dividing line on approach to driveway as needed to channelize users
4. Stop' sign (Ra-1 – OTM) and stop bar
5. Bike symbol + ped symbol + arrow markings

Optional/Context-Sensitive Elements

A. Gentle curve to bend-in or bend-out multi-use path on approach to driveway where feasible based on site conditions.

Multi-use Path at Non-Residential, Higher Volume Driveway

Exhibit 6.5: Multi-use Path at Non-Residential, Higher Volume Driveway



Required Elements

1. Facility surface material carried through driveway (concrete or asphalt)
2. Mixed crossride markings with green surface treatment
3. Yellow dividing line on approach to driveway as needed to channelize users
4. Stop' sign (Ra-1 – OTM) and stop bar
5. Bicycle Trail Crossing Side Street Sign' signage and optional 'Trail Crossing' tab (WC-44R + WC-44T – TAC) alerting drivers to the potential presence of cyclists crossing the intersecting street.

Optional/Context-Sensitive Elements

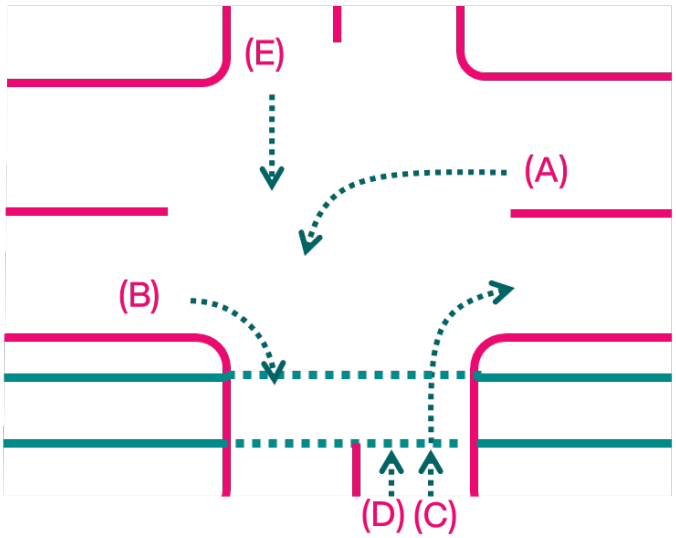
A. Gentle curve to bend-in or bend-out multi-use path on approach to driveway where feasible based on-site conditions

6.3 Side Street Crossing (Stop-Controlled)

Cyclists and pedestrians travelling on a multi-use path along a roadway have right-of-way over traffic approaching on a stop-controlled side street. As noted in Section 2.1.1, multi-use paths operating two-way can increase the risk to cyclists

compared to one-way facilities (refer to Exhibit 6-6). Therefore, it is important that geometric enhancements, pavement markings & signage are used to alert drivers to crossing cyclists. An example of a side-street crossing is shown in Exhibit 6-7.

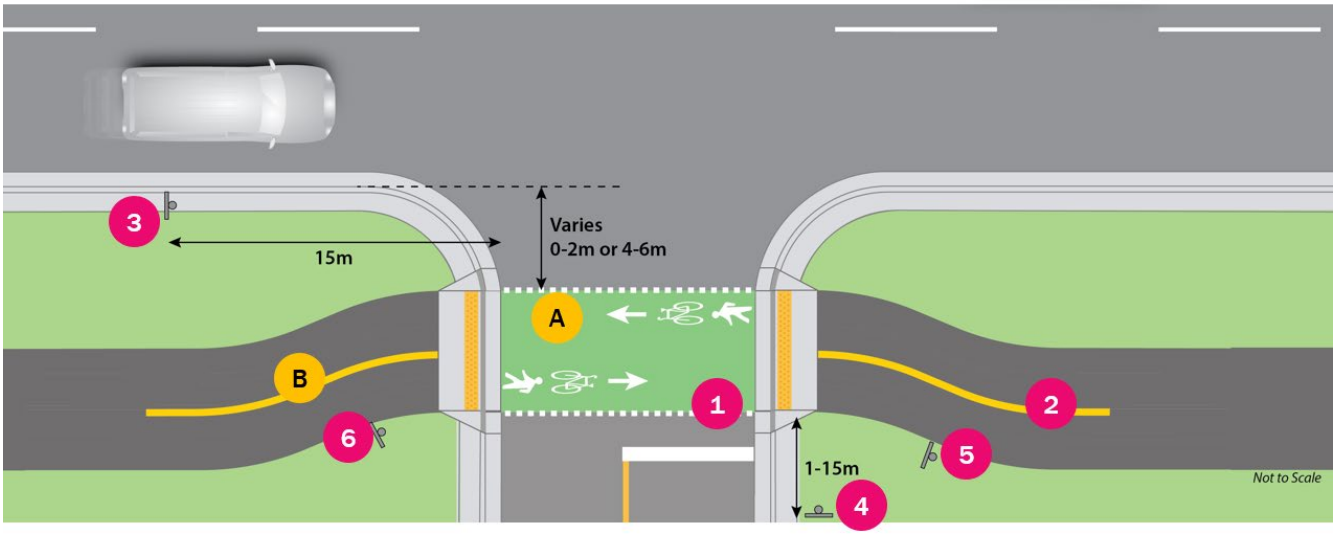
Exhibit 6.6: Crossing Dangers of Multi-use Paths at Intersections



A. Left-turning motorist is focused on gap selection. Accelerating through the turn, the driver is then faced with the unexpected path crossing. While the driver was waiting to make the turn, a fast-moving right-to-left cyclist outside the driver's field of view may overtake arriving in the crossing. Slowing or stopping for path users, this left turning motorist may interfere with through traffic on the parallel roadway.
B. Left-to-right path users are out of the field of view of higher speed right-turning motorists
C. Right-turning motorists are looking left while turning right; right-to-left path users are out of their field of view. They may also obstruct the path crossing.
D. Through motorists may obstruct the path crossing or obscure the view of right-turning motorists and of left-to-right path users.
E. Motorists crossing the road at a signal need a clearance interval that is long enough to allow them to cross the path before the signal changes providing the path right-of-way.

Multi-use Path at Side Street Crossing (Minor Leg Stop-Controlled)

Exhibit 6.7: Multi-use Path at Side Street Crossing



Required Elements

1. Mixed crossride markings including pedestrian and cyclist with an arrow aligned with vehicular lane
2. A yellow dividing line should be used approaching the intersection to reduce conflicts
3. 'Bicycle Trail Crossing Side Street' signage and tab (WC-44 - TAC & WC-44T - TAC) 15m (R) and 30m (L) in advance of intersection along major road
4. Contraflow Bike Lane Crossing warning sign (WC-43 TAC) should be placed on the cross-street approach (upstream of intersection stop sign)
5. 'Shared Pathway' signage (RB-93 - TAC) can be applied following the intersection for path users
6. Cyclists Yield to Pedestrians' (RB-73 – TAC) may be used remind cyclists that they are approaching a pedestrian zone.

Optional/Context-Sensitive Elements

A. Green surface treatment

B. Gentle curve in multi-use path may be used to slow cyclists approaching the intersection. Crossride should be set back from the major road 4-6m to allow a turning vehicle space to yield to path users (or 0-2m for a bend-in design)

6.4 Intersection Crossing (Traffic Signal Controlled)

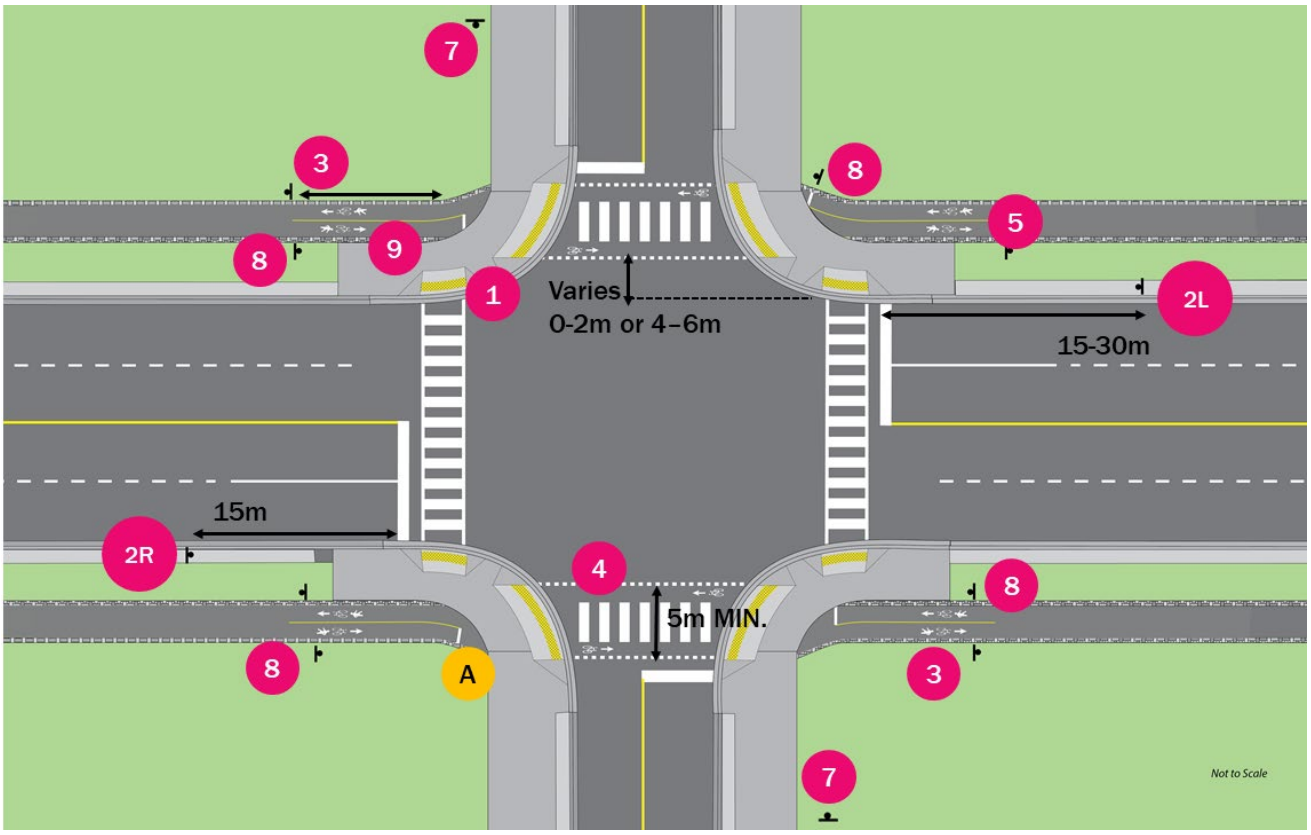
At signalized intersections with a multi-use path, there are several core objectives of the intersection design:

1) Alert drivers to crossing pedestrians and cyclists and emphasize the priority of vulnerable road users through the intersection;
2) Clarify pedestrian priority over cyclists on the approach to the intersection crossing; and
3) Provide features that improve the ease of intersection crossing for pedestrians and cyclists, including crossrides to enable cyclists to ride through intersections.

A typical intersection treatment for a multi-use path at a signalized intersection is shown in Exhibit 6-8.

Multi-use Path Signalized Intersection Treatment

Exhibit 6.8: Multi-use Path at Signalized Intersection



Required Elements

1. AODA – compliant curb ramps and tactile plates
2. 'Bicycle Trail Crossing Side Street Sign' signage and optional 'Trail Crossing' tab (WC-44 + WC-44T – TAC) alerting drivers to the potential presence of cyclists crossing the intersecting street. The right or left version of the sign should be used as appropriate. If the left version is used, the sign should be installed on both sides of the road/median so that it is clearly visible to left turning traffic.
3. 'Shared Pathway' signage (RB-93 – TAC) should be applied 5-30m downstream of the intersection.
4. Intersection crossing of the multi-use path should be designed as Combined Pedestrian and Cyclist Crossride. In some instances, cyclists may be likely to cross the road to use the multi-use path on the other side (for example, to reach a major destination). Where this is anticipated, a crossride may be added to the perpendicular legs of the intersection in addition to the parallel legs (refer to Section 0 for an illustration of an intersection with crossrides on all legs)
5. A yellow dividing line should be applied to the multi-use path approaching the intersection to reduce conflicts.
6. Multi-use paths should be bent-in (0.5-2m) or bent-out (4-6m) from parallel edge of roadway, depending on roadway context & right-of-way availability
7. Contraflow Bike Lane Crossing warning sign (WC-43 TAC) should be placed on the cross-street approach (upstream of intersection stop bar)
8. Cyclists Yield to Pedestrians' signage (Rb-73-OTM) can be applied where there are challenges with interactions between users
9. Pedestrian and bicycle markings following/approaching intersection

Optional/Context-Sensitive Elements

A. Optional stop bar for cyclists located at the top of the curb ramp.

Signage Details:

WC-44L

WC-44R

RB-93

RB-73

WC-73

6.4.1 Signal hardware considerations at signalized intersections

Requirements for signal hardware will vary based on intersection geometry and constraints. Refer to OTM Book 12A for further discussion on bicycle signals. Consider the following interventions for cyclists and pedestrians:

- Separate pedestrian pole with pushbutton for cyclists approaching on the right side of the multi-use path preferred to reduce conflicts with pedestrians and improve ease of crossing
- Separate bicycle signals are required for bi-directional cycling facilities in the boulevard to provide consistency along the corridor and to allow for leading phases for path users. Where phasing is identical to parallel vehicle heads, only one head is needed. Otherwise, two bicycle heads should be provided.

Phasing options to prioritize vulnerable road users through intersections such as leading and protected bicycle/pedestrian phases are discussed in York Region Pedestrian & Cycling Planning and Design Guidelines (Section 8.2), as well as OTM Book 18.

7 Off-Road Trails

Off-road trails consist of trails located outside of road rights-of-way, often through parks, open space or greenways. Trail conditions vary significantly along different trail classifications, and provide a different user experience. Trails can generally be grouped into the following categories.

- **Multi-use Trails** – These trails are intended to accommodate a wide variety of users, such as cyclists and pedestrians, and are used for both utilitarian and recreational trips. They can be further classified into secondary and primary multi-use trails.
  - **Primary Multi-use Trails** – Primary multi-use trails have a city-wide function, connecting neighbourhoods and providing access to key destinations across different parts of a city. These trails can accommodate a higher volume of users compared to secondary multi-use trails. An example of a primary multi-use trail in Markham would be the Rouge Valley Trail (although it is noted that sections of this trail pass through sensitive lands with elements of a greenway system trail).
  - **Secondary Multi-use Trails** – Secondary multi-use trails act as tributary branches to the larger primary multi-use trails. These trails provide community-level connections. These trails can accommodate a lower volume of users compared to primary multi-use trails. An example of a secondary multi-use trail in Markham would be the Berczy Park Trail system.
- **Greenway System Trails** – These are primarily recreational trails that provide circulation through the City's network of greenways. Due to the sensitive land uses in these areas, they require context-sensitive design. An example of a greenway system trail in Markham would be the various trails through Rouge National Urban Park.
- **Walking / Hiking Recreational Trails** – These recreational trails are intended to support walking and hiking. They are primarily located within natural areas and parks and generally have unpaved surfaces.

The focus of this guidance is multi-use trails which will play a role in the overall transportation network, given the focus of the Active Transportation Master Plan, however basic design guidance for greenway system trails is also provided in Section 7.1 for context. As walking/hiking recreational trails do not serve cyclists, they are not discussed further in these design guidelines.

7.1 Mid-block Design Elements

Design considerations for off-road trails are largely driven by the trail categorization (based on operating context). High-level concepts for various classes of trail are described in the following sections.

As each trail moves from the high-level network planning context of the Active Transportation Master Plan through subsequent planning, design and implementation stages, a site-specific review and site inventory, as well as consideration of the anticipated volume of users, should be used to confirm design criteria and the appropriate categorization for any section of the trail system.

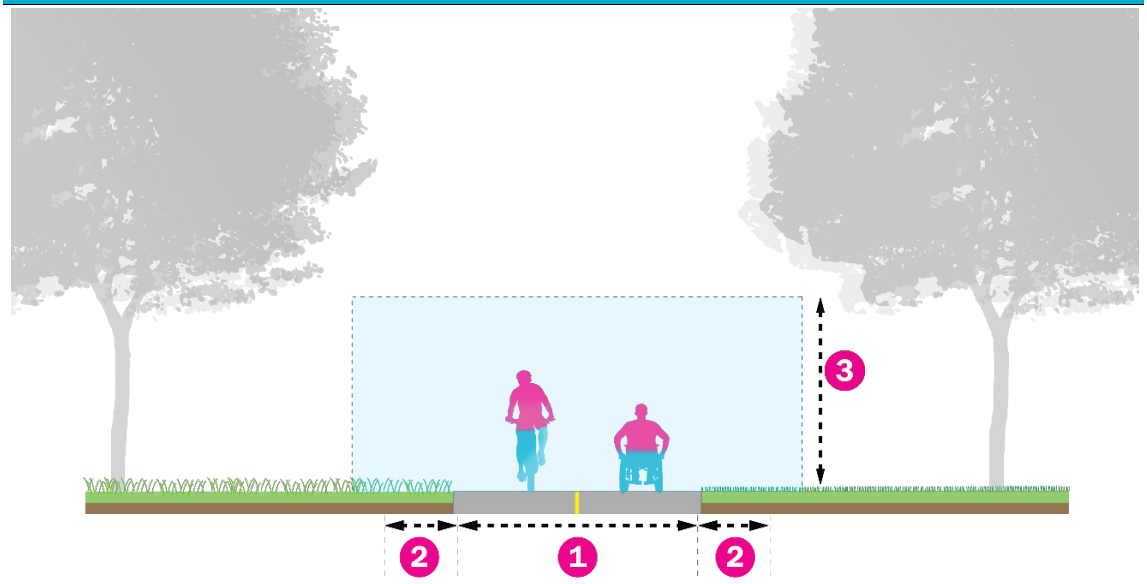
7.1.1 Multi-use Trail: Primary

Primary multi-use trails make up the spine network for trail across Markham. These are major off-road commuting routes, with high anticipated usage. Often, these trails are located along utility and transportation corridors. Primary trails are intended to accommodate a variety of users, including cyclists, pedestrians, roller skaters and skateboarders.

Design guidance for primary multi-use trails is shown in Exhibit 7-1.

Exhibit 7.1: Primary Multi-use Trail Cross-Section

Primary Multi-use Trail



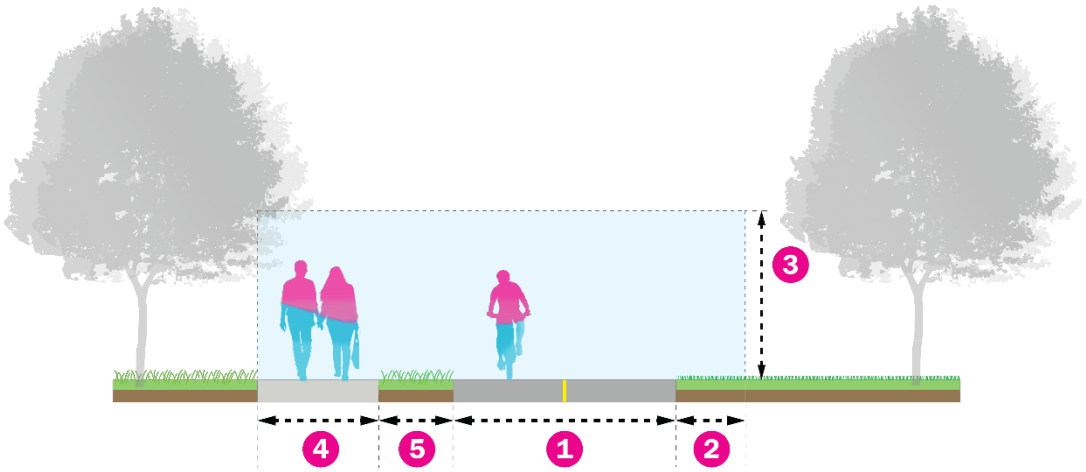
#	Parameter	Minimum	Preferred
1	Width	3.0m	4.0-5.0m+
2	Lateral Clearance	0.6m	1.0m
3	Vertical Clearance	2.5m	3.0m

Where feasible, an alternate configuration for primary multi-use trails is to construct separate pedestrian and cycling routes, as shown in Exhibit 7-2. This configuration can help resolve conflicts between pedestrians and other faster moving trail users (such as people on bikes, scooters or electric mobility devices). As this is a costlier configuration requiring more right-of-way,

application of this concept is anticipated to be limited to trail segments with very heavy usage or anticipated demand.

Exhibit 7.2: Primary Multi-use Trail – Alternate High-Capacity Configuration Cross-Section

Primary Multi-use Trail - Alternate High-Capacity Configuration



#	Parameter	Minimum	Preferred
1	Multi-use Path Width	3.0m	4.0m
2	Lateral Clearance	0.6m	1.0m
3	Vertical Clearance	2.5m	3.0m
4	Pedestrian Path Width	1.8m	2.0m+
5	Pedestrian / Cycling Buffer Zone	0.6m	1.0m

Note that the pedestrian area does not require a lateral clearance zone due to lower operating speeds.

Regulatory Pavement Markings & Signage

Primary multi-use trails should be marked and signed in accordance with the City of Markham's *Signage & Pavement Marking Guidelines for Multi-use Paths (2016).*

In the alternate high-capacity configuration, signage or pavement markings to designate the pedestrian-only area are discretionary. Usage patterns may be monitored prior to implementing these signs and markings.

Lighting

The decision to include lighting on a trail depends on its intended use and volumes. Providing adequate lighting on multi-use trails increases the level of comfort experienced by trail users, thereby increasing trail usage during the nighttime, and is strongly recommended for primary multi-use trails.

If lighting is to be provided, the following criteria may be used to evaluate the illumination of the trail:

- **Horizontal Illumination** – allows trail users to see pavement markings, and any potential obstacles; measured at surface level
- **Vertical Illumination** – allows users to view road signs and other trail users; measured 1.5m above the surface
- **Uniformity Ratio** – a measure of the consistency of lighting; the ratio between average and minimum illumination

Suggested illumination levels for different levels of usage from OTM Book 18 are provided in Exhibit 7-3.

Exhibit 7.3: Multi-use Trail Illumination Targets

LEVEL OF PEDESTRIAN OR CYCLING ACTIVITY	MAINTAINED AVERAGE HORIZONTAL ILLUMINANCE (LUX)	MAXIMUM HORIZONTAL UNIFORMITY RATIO	MINIMUM MAINTAINED VERTICAL ILLUMINANCE (LUX)
High (> 50 / hour)	20.0	4:1	10.0
Medium (10 to 50 / hour)	5.0	4:1	2.0
Low (< 10 / hour)	3.0	6:1	0.8

Source: OTM Book 18, from the TAC Guide for the Design of Roadway Lighting, 2006

Special consideration is required at intersections between off-road trails and streets. If the street is unlit, the trail must be illuminated at the prescribed level for 25 metres on either side of the intersection and the roadway must provide transitional drafting. If the street is lit, the trail must be lit to the same illumination level as the street for a distance of 25 metres on either side of the intersection. This ensures that trail users are clearly visible to motorists.

Surface Type

Hard surfaces that provide a stable, slip-resistant and accessible surface are recommended for primary multi-use trails, generally anticipated to be either concrete or asphalt surfaces.

Additional Innovative Design Elements

Depending on the context of primary multi-use trails, additional innovative design features may be considered and applied, including many of the elements envisioned for the Markham Centre trail network, such as:

- Heated trails to reduce snow-clearing requirements;
- Digital wayfinding features;
- Internet and connectivity along trails; and

- Within-pavement lighting (consideration needed to meet dark sky compliance).

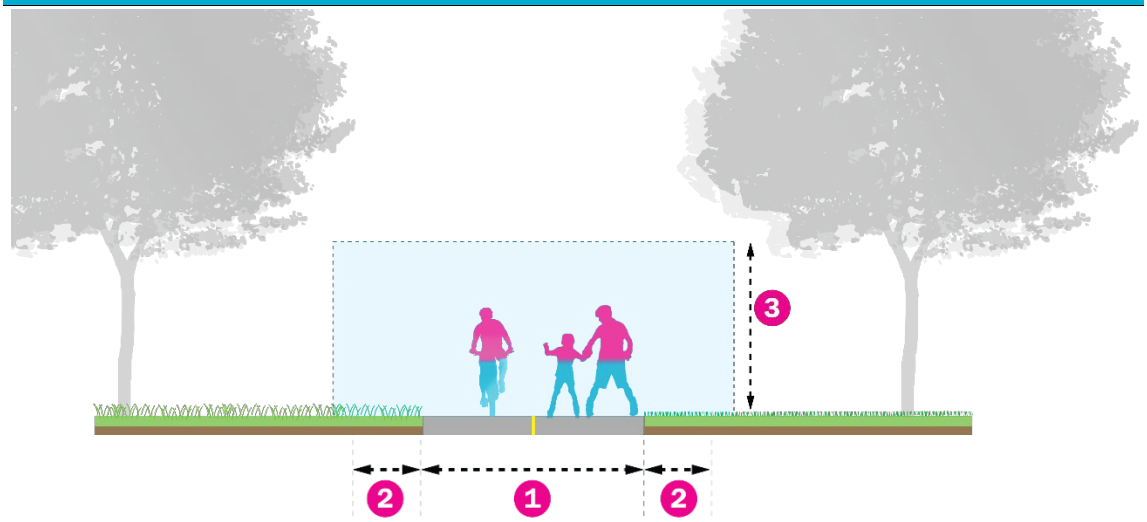
7.1.2 Multi-use Trail: Secondary

Secondary multi-use trails act as tributary branches to the larger primary multi-use trails. These trails attract a lower volume of users compared to primary multi-use trails, but still accommodate a variety of user types, including cyclists, pedestrians, roller skaters and skateboarders.

Design guidance for a secondary multi-use trail is shown in Exhibit 7-1.

Exhibit 7.4: Secondary Multi-use Trail Cross-Section

Secondary Multi-use Trail



#	Parameter	Minimum	Preferred
1	Width	3.0m	3.5m
2	Lateral Clearance	0.25m	0.5m
3	Vertical Clearance	2.5m	3.0m

Regulatory Pavement Markings & Signage

Secondary multi-use trails should be marked and signed in accordance with the City of Markham's *Signage & Pavement Marking Guidelines for Multi-use Paths (2016).*

Lighting

The decision to include lighting on a trail depends on its intended use and volumes. Providing adequate lighting on multi-use trails increases the level of comfort experienced by trail users, thereby increasing trail usage during the nighttime, and is recommended for secondary multi-use trails. Special consideration is required at intersections between off-road trails and streets. If

the street is unlit, the trail must be illuminated at the prescribed level for 25 metres on either side of the intersection and the roadway must provide transitional drafting. If the street is lit, the trail must be lit to the same illumination level as the street for a distance of 25 metres on either side of the intersection. This ensures that trail users are clearly visible to motorists.

If lighting is to be provided, suggested illumination levels for different levels of usage from OTM Book 18 are provided in Exhibit 7-3.

Surface Type

Hard surfaces that provide a stable, slip-resistant and accessible surface are recommended for secondary multi-use trails, generally either concrete or asphalt surfaces. Granular surfaces can be considered in some contexts, as they can provide similar slip resistance; however, they are not preferred for all users and cannot be maintained year-round. Boardwalk-style surfaces can provide a suitable alternative for wet or environmentally-sensitive contexts, but there can be challenges related to accessibility for all users.

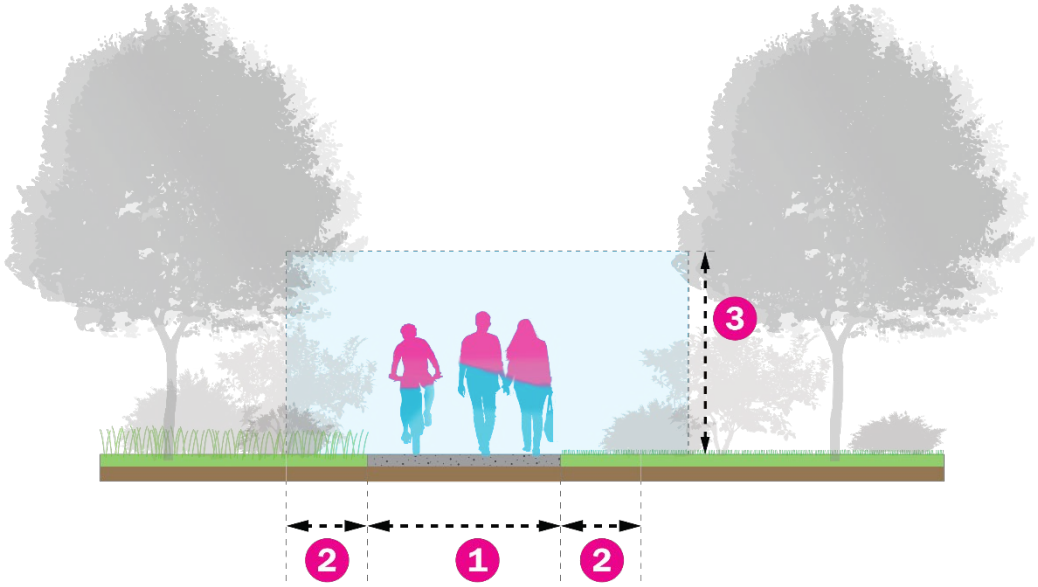
7.1.3 Greenway System Trails

Greenway systems trails generally follow the network of greenways identified in the City of Markham's Official Plan. It is important that trails through the greenways minimize impacts and footprint. Greenway System Trails and Walking / Hiking Recreational Trails work together to provide public access to the City's valley systems and natural areas.

By definition, the development of greenway system trails requires a balanced approach to design - trails can help to manage encroachment and impacts on the greenway system, but they also interrupt continuity of the system itself. On this basis, trails will generally be narrower and lower-impact than most multi-use paths. High-level design guidance for a greenway system trail is shown in Exhibit 7-5.

Exhibit 7.5: Greenway System Trail Cross-Section

Greenway System Trail



#	Parameter	Minimum	Preferred
1	Width	2.4m	3.0m (maximum)
2	Lateral Clearance	0.25m	.5m
3	Vertical Clearance	2.5m	-

Additional Planning Requirements for Greenway System Trails

Due to the sensitive nature of the land use, new greenway system trails may be subject to additional steps in the trail planning and design process, including completion of an Environmental Impact Study to assess and mitigate impacts to natural heritage and hydrologic features.

Additional Design Requirements for Greenway System Trails

In addition to the design parameters shown in Exhibit 7-5, it is further recommended that greenway system trails:

a) be located on the outer edge of the Greenway and outside of the vegetation protection zones (VPZ) of features. This is to minimize fragmentation of wildlife habitat and to support wildlife movement. MUP's are not permitted to locate in the VPZ of features without the completion of an Environmental Impact Study; In areas where the Greenway System comprises only the features and the required vegetation protection zones, additional lands could be secured adjacent the Greenway System for trail usage.

b) generally be constructed of pervious (granular, mulch/dirt, permeable pavers/paving) materials. Asphalt and other hard surface pavements shall

typically only be considered in areas subject to erosion, flooding or other exceptional circumstances as demonstrated through a technical justification;

c) incorporate enhanced buffering and planting adjacent to trails in the Greenway to ensure cyclists and other users do not venture into the protected natural heritage areas or disturb residential property owners.

Lighting will generally not be provided along with greenway system trails, except where the trail approaches a road crossing, unless a strong rationale is provided for the provision of lighting (e.g. for a short stretch of trail that connects to a school site, with minimal anticipated impact and appropriate mitigation measures as assessed through an Environmental Impact Study).

7.2 Multi-use Trail Crossings

7.2.1 Types of Road Crossings

In general, the type and scale of intervention for a midblock trail crossing treatment will vary depending on the road to be crossed and the level of trail priority and usage.

The hierarchy for crossing treatments for cycling facilities is provided in OTM Book 18 and includes:

- **Uncontrolled Crossings:** Trail users do not have the right-of-way over oncoming motorists
- **Controlled Crossings:** Trail users have the right-of-way over oncoming motorists. Types of controlled crossings include:
  - Stop or Yield Control
  - Pedestrian Crossovers
  - Traffic Signals
    - Intersection Pedestrian Signal
    - Mid-block Signal
    - Full Intersection Signal
- **Grade Separated Crossings:** Trail users bypass the road crossing by overpass or underpass

7.2.2 At-Grade Road Crossings

For primary and secondary multi-use trails, crossings of the road network require special consideration and intentional design approaches to prioritize trail users. Controlled crossing types are generally preferred to uncontrolled crossing types wherever possible, since they provide right-of-way to trail users.

The process for evaluating the appropriate type of crossing is documented in OTM Book 21, Section 6.8.2. and includes the following steps:

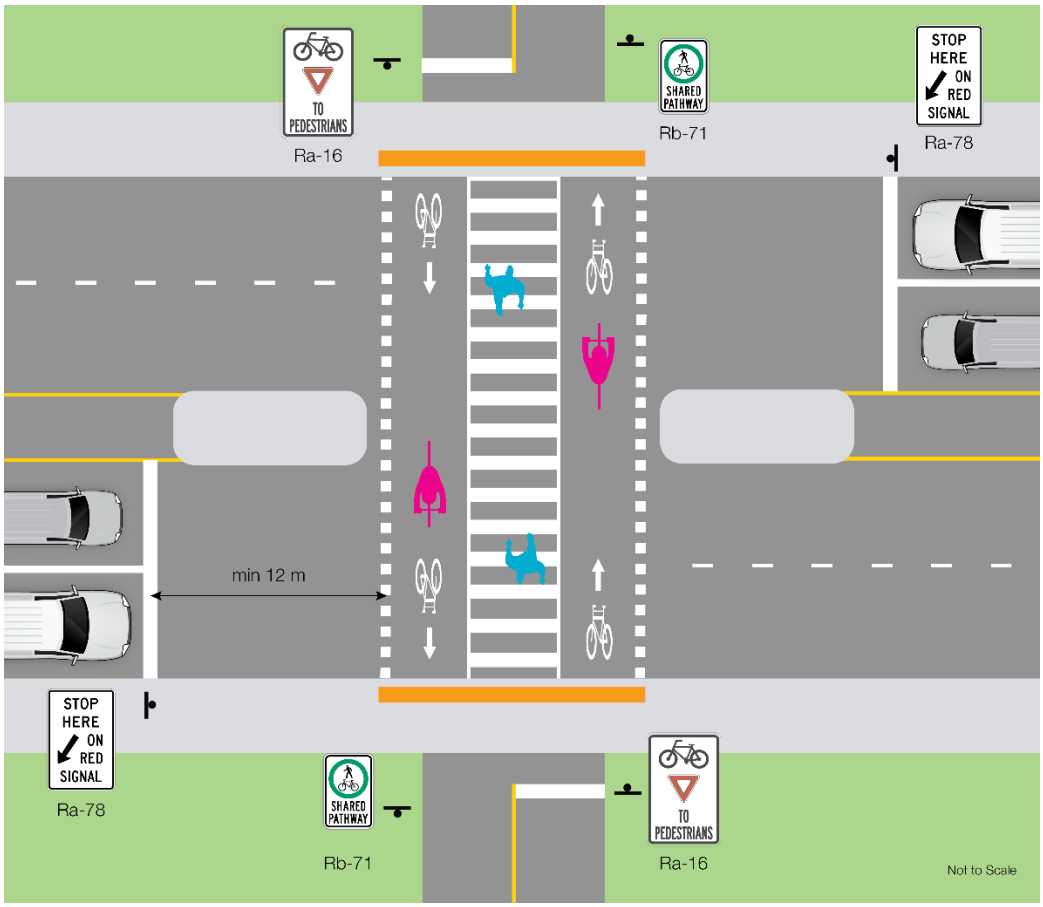
- **Step 1:** Determining whether a traffic signal is warranted

- **Step 2:** Assessing whether an unsignalized crossing is warranted; typically based on meeting at least two of the three following conditions:
  - A crossing is required to provide network connectivity or access to a destination.
  - The crossing site is more than 200 m from the nearest traffic control device. This threshold may be reduced to 100 m in urban environments with a high density of destinations on both sides of the street.
  - There is an average latent crossing demand of 15 or more users per hour of pedestrians and cyclists combined. The latent demand may be assessed by counting the actual number of pedestrians or cyclists crossing the roadway in the absence of a formal crossing treatment and estimating the projected demand.
- **Step 3:** Determining whether an uncontrolled crossing is appropriate
- **Step 4:** Assessing alternative options

The following concepts illustrate typical trail crossings for consideration:

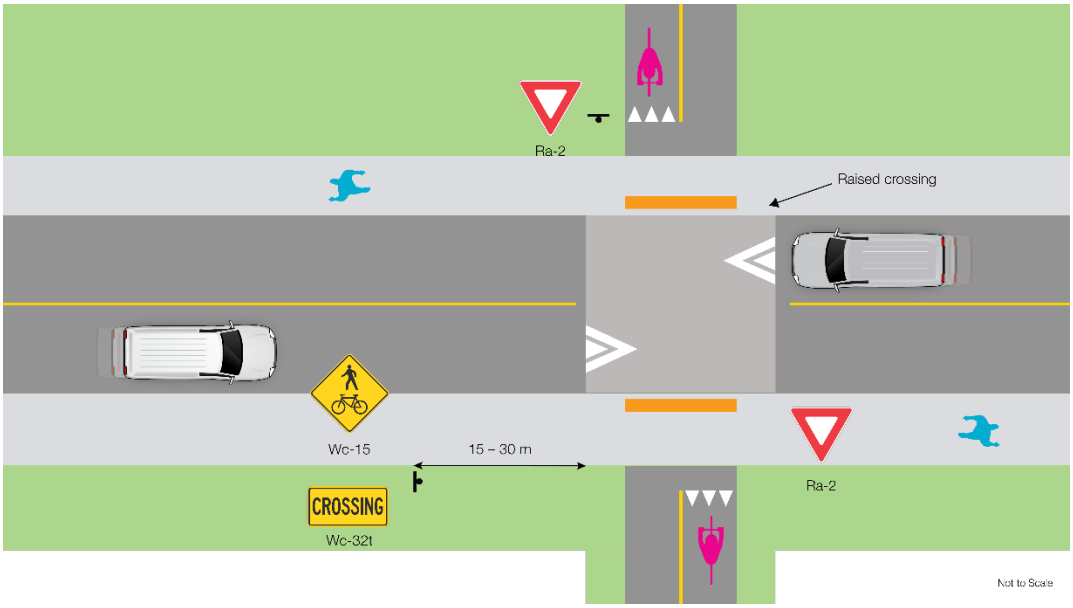
- **Primary or secondary multi-use trail – midblock crossing of higher volume (collector or Regional) roadway**: Wherever possible, crossings of higher order roadways should be signalized. Exhibit 7.6 depicts a signalized midblock trail crossing. Warrants for signalized crossings must be evaluated in accordance with OTM Book 12 / OTM Book 15.
- **Primary or secondary multi-use trail – midblock crossing of local road**: Along local roads, it is less likely that a signalized crossing or controlled crossing will be warranted. An uncontrolled crossing may be considered, pending evaluation of the above process. A typical uncontrolled crossing with raised crossing to mitigate the risk of conflicts is illustrated in Exhibit 7.7.

Exhibit 7.6: Midblock Trail Crossing (Midblock Pedestrian Signal)



Adapted from OTM Book 18

Exhibit 7.7: Midblock Trail Crossing (Uncontrolled Crossing)



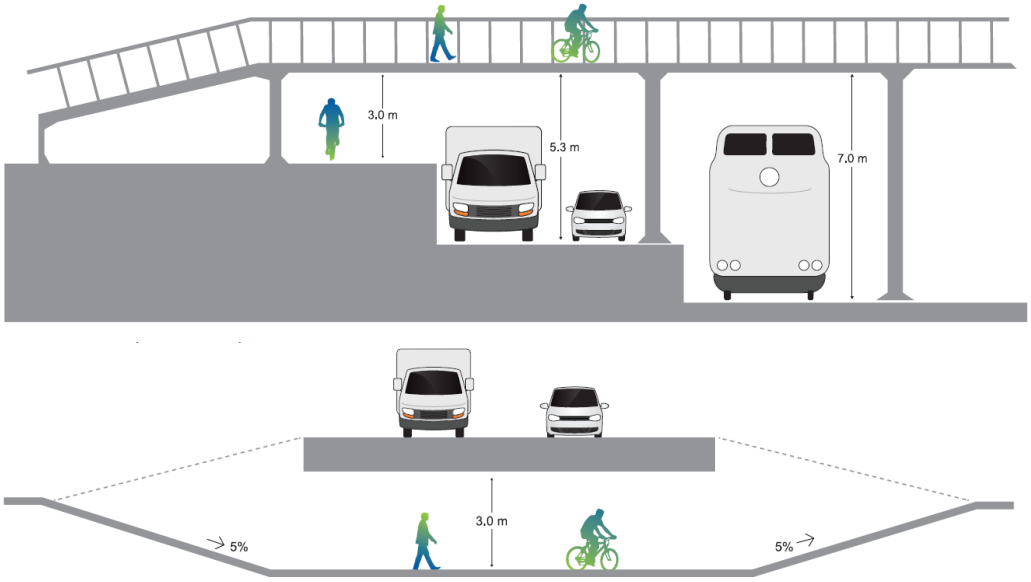
Adapted from OTM Book 18

7.2.3 Grade Separated Crossings

Multi-use trails may require grade-separated crossings. For example, bridges may be needed to cross a natural feature such as a watercourse, or an underpass or overpass may be used to cross major road corridors. In their absence, trail users may be forced to make long detours to cross a barrier.

Considerations for the design of bridges, overpasses and underpasses are provided in York Region's *Pedestrian & Cycling Planning and Design Guidelines*, Section 5.7

Exhibit 7.8: Example Configurations for Overpasses & Underpasses



Source: York Region Pedestrian & Cycling Planning and Design Guidelines

7.3 Additional Trail Design Elements

These guidelines do not provide comprehensive design guidelines for all elements of off-road trails. Information on design elements such as fencing requirements, rail crossings, slopes and drop-offs, access stairs, low-impact development, wayfinding, trailheads and amenities etc. can be referenced in industry standard documents, including:

- City of Toronto. (2014). Toronto Multi-use Trail Design Guidelines (2015): https://www.toronto.ca/wp-content/uploads/2017/11/96a5-TORONTO_TRAIL_DESIGN_GUIDELINES.pdf
- MTO. (2014). Bikeway Design Manual: https://www.library.mto.gov.on.ca/SydneyPLUS/Sydney/Portal/default.aspx?component=AAAAIY&record=2123efe9-b107-4fcc-9d3b-1bde607bdf7b
- TAC Geometric Design Guide for Canadian Roads. (2017). Chapter 5 – Bicycle Integrated Design. (Available for purchase)

8 Facility Transitions & Intersections

Facility transitions, occurring where different active transportation facilities intersect or terminate, require special design interventions to ensure connectivity and clarity for vulnerable road users and drivers alike.

In most cases, it is recommended that facility transitions occur at signalized intersections or other controlled crossings, rather than at uncontrolled intersections or midblock locations. The examples in the following sections illustrate common transitions anticipated to occur at signalized intersections as the City of Markham continues to expand their network of separated cycling facilities and multi-use paths.

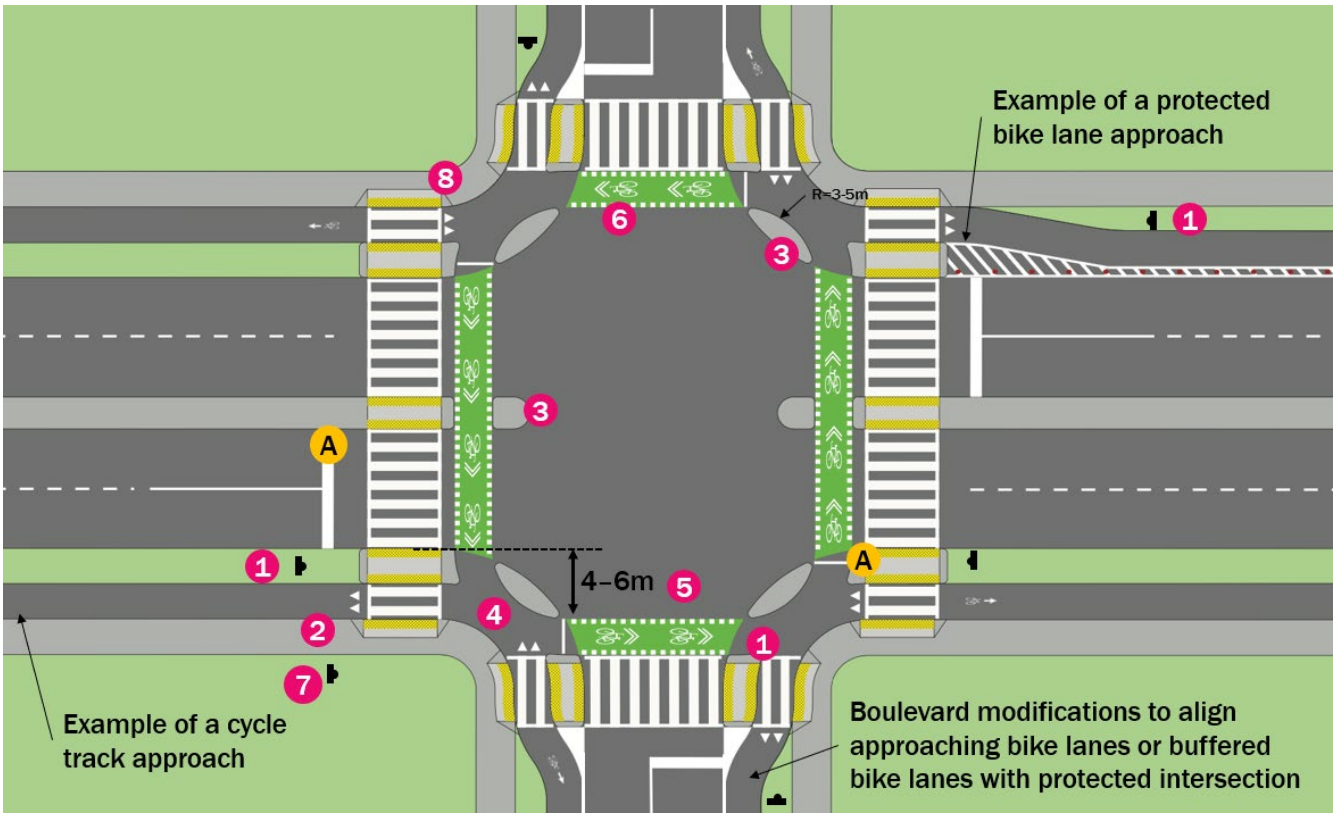
Additional examples of transitions are included in the latest OTM Book 18 (2021), which can be referenced for the latest guidance.

8.1 Separated Bikeway Intersecting Bike Lanes

Where on-road cycling facilities (such as bike lanes) intersect cycle tracks or protected bike lanes, a preferred treatment is to transition all facilities into the boulevard on the intersection approach and circulate all facilities through a protected intersection design (refer to Exhibit 8-1). This approach may only be feasible when larger civil works / intersection improvements are planned.

Separated Bikeway Intersecting Bike Lanes or Buffered Bike Lanes

Exhibit 8.1: Facility Intersection: Separated Bike Lanes & Bike Lanes / Buffered Bike Lanes



Required Elements

1. Customized 'Turning Vehicles Yield To Bicycles' (RB-37 – TAC) signage to alert turning drivers that they must yield to through cyclists
2. Yield markings alerting approaching cyclists of pedestrian priority should be applied to separated cycling facilities
3. Corner refuge island and median islands to provide physical protection to waiting pedestrians and cyclists
4. Bicycle queuing area must provide sufficient storage so that a waiting bicycle does not block or impede through pedestrian traffic
5. Motorist yield zone (minimum 4m) which allows turning drivers to yield to crossing pedestrians and cyclists without risk of being rear-ended by through vehicles
6. Intersection crossing of the cycle track should be designed as a crossride for cyclists with elephant's feet markings and sharrows to indicate direction of travel
7. Cyclists Yield to Pedestrians' signage (Rb-73-OTM) can be applied where there are challenges with interactions between users
8. Treatments at pedestrian crossings should emphasize pedestrian priority. Consideration maybe given to additional higher-order treatments (i.e. tactile plates or crosswalk markings).

Optional/Context-Sensitive Elements

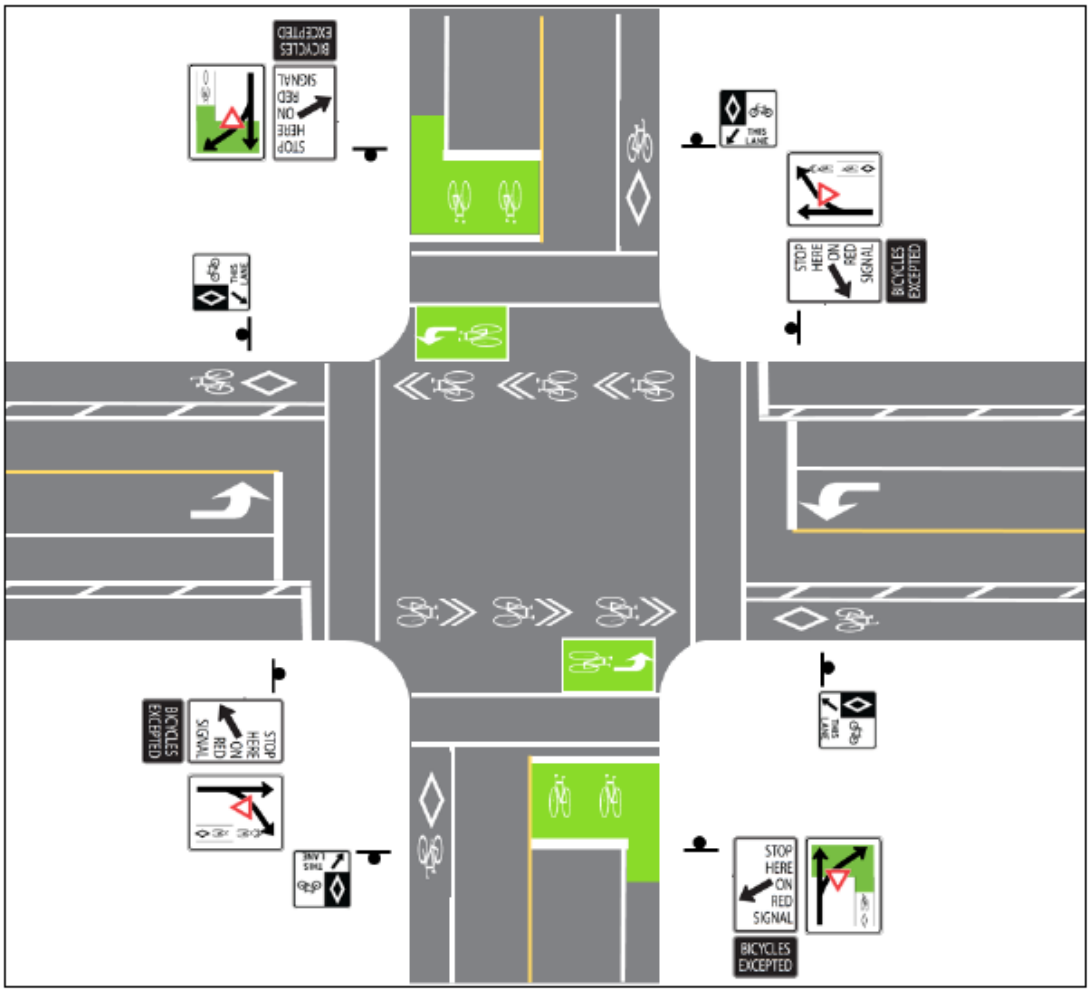
A. Optional stop bar for cyclists located at the top of the curb ramp.

Note that through transitions it is particularly important to distinguish cycling facilities from pedestrian facilities. Per OTM Book 18, "using asphalt for cycling facilities and concrete for pedestrian facilities is an example of a practical strategy to consistently communicate intended use of space" (p. 67). A similar contrasting effect could also be achieved using coloured or impressed concrete. Where this approach is not possible, other strategies for providing delineation

between pedestrian and cycling space include vertical separation (mid-height, detectable curbs) or horizontal/tactile separation (i.e. detectable tactile buffer strip, sod or landscaping zones, railings).

Where the facility transition is not bundled with a larger intersection improvement, a retrofit-style transition may be considered between a protected bike lane and a conventional bike lane to provide at least some connectivity between intersecting facilities. An example of a retrofit-style facility transition is shown in Exhibit 8-2. For more information on this treatment, refer to the *Signage & Pavement Marking Guidelines for On-Road Cycling Facilities (2019).*

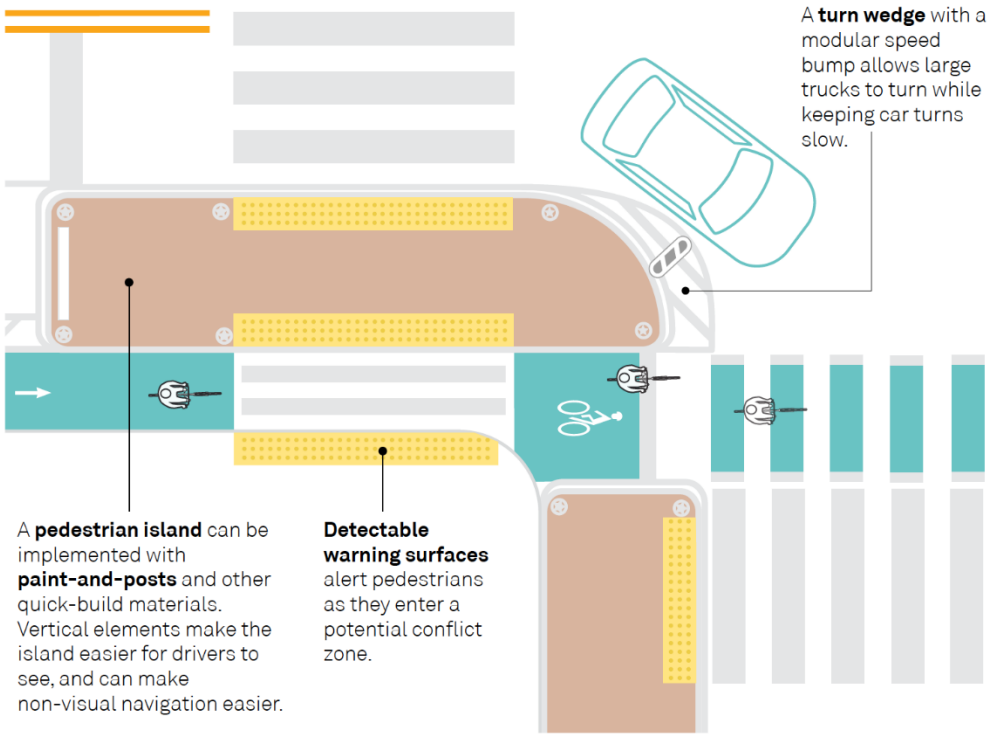
Exhibit 8.2: Retrofit-Style Intersection: Protected Bike Lanes on Major Road & Bike Lanes



Source: City of Markham Signage & Pavement Marking Guidelines for On-Road Cycling Facilities (2019)

A hybrid design, based on the geometry of the protected intersection, but installed using relatively inexpensive materials, could be considered on a project-specific basis. An example of a rapid-implementation protected intersection is shown in Exhibit 8-3.

Exhibit 8.3: Example of Interim / Retrofit-Style Protected Intersection Designs



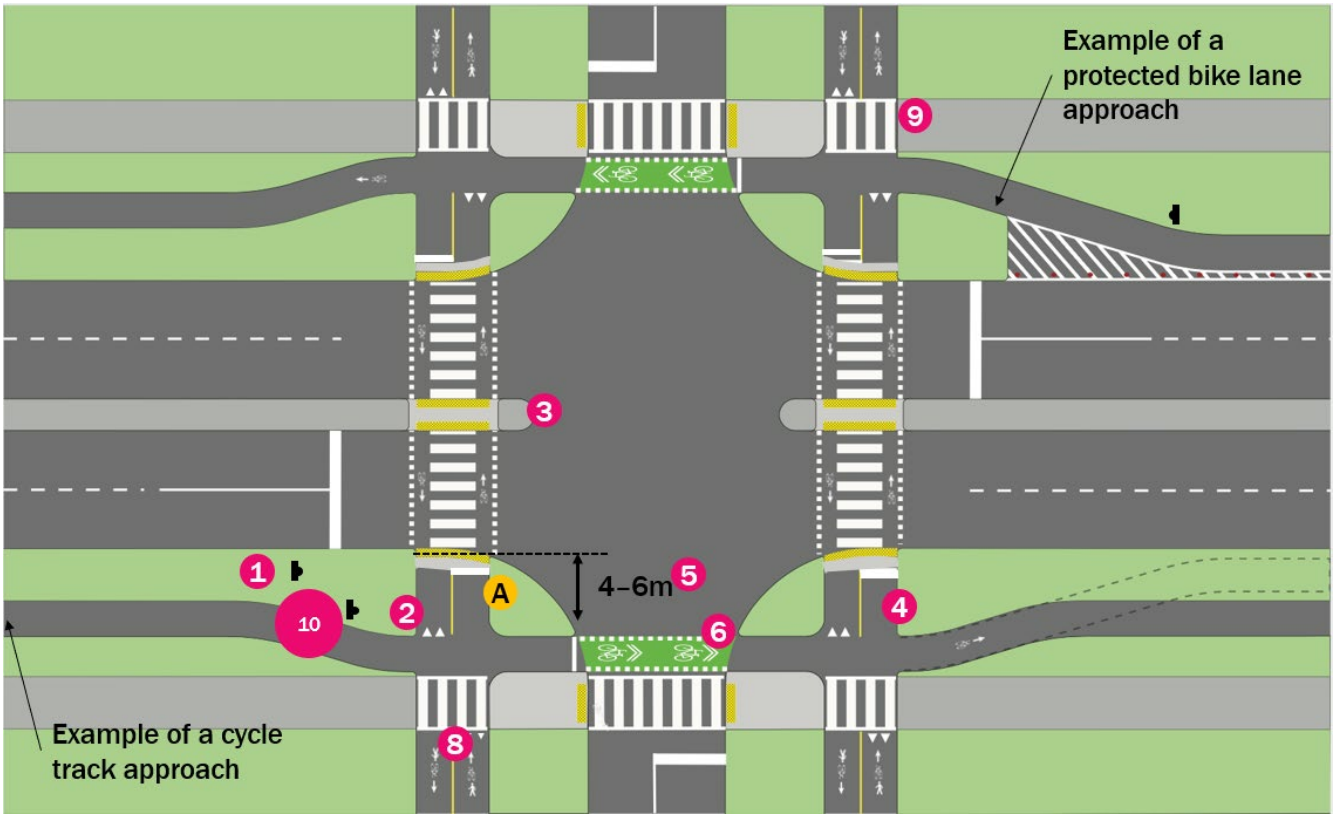
Images Source: NACTO Don't Give up at the Intersection: Designing All Ages & Abilities Bicycle Crossings (2019)

8.2 Separated Bikeway on Major Road intersecting a Multi-use Path

Where a sidewalk and separated bikeway intersects a multi-use path, it is important to clarify pedestrian priority through a combination of wayfinding, signage and pavement markings. A sample transition at a signalized intersection is shown in Exhibit 8-4.

Separated Bikeway Intersecting a Multi-use Path

Exhibit 8.4: Facility Intersection: Separated Bikeway & Multi-use Path



Required Elements

1. Customized 'Turning Vehicles Yield To Bicycles' (RB-37 – TAC) signage to alert turning drivers that they must yield to through cyclists
2. Yield markings alerting approaching cyclists of pedestrian priority should be applied to separated cycling facilities
3. Median islands wherever possible
4. Bicycle queuing area must provide sufficient storage so that a waiting bicycle does not block or impede through pedestrian traffic
5. Motorist yield zone (minimum 4m) which allows turning drivers to yield to crossing pedestrians and cyclists without risk of being rear-ended by through vehicles

6 Intersection crossing of the cycle track should be designed as a crossride for cyclists with elephant's feet markings and sharrows to indicate direction of travel

7 Intersection crossing of the multi-use path should be designed as Combined Pedestrian and Cyclist Crossride

8 A yellow dividing line should be applied to the multi-use path approaching the intersection to reduce conflicts.

9 Pedestrian priority should be emphasized where sidewalk crosses multi-use path through pavement markings and signage.

10 Cyclists Yield to Pedestrians' signage (Rb-73-OTM) can be applied where there are challenges with interactions between users

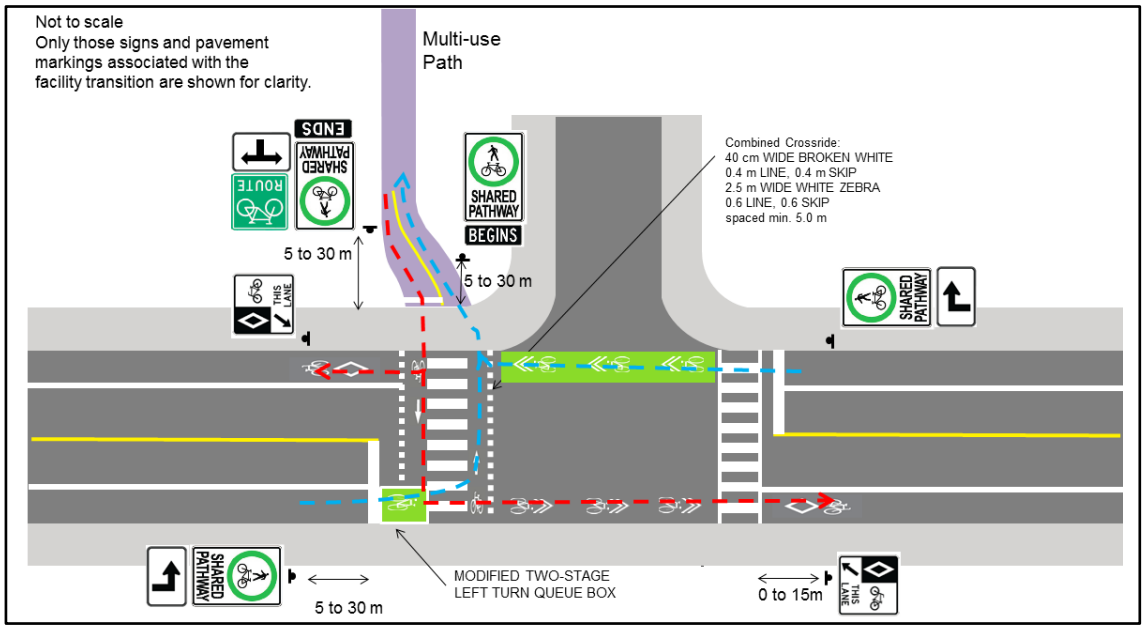
Optional/Context-Sensitive Elements

A Optional stop bar for cyclists located at the top of the curb ramp.

Per OTM Book 18, "using asphalt for cycling facilities and concrete for pedestrian facilities is an example of a practical strategy to consistently communicate intended use of space" (p. 67). A similar contrasting effect could also be achieved using coloured or impressed concrete. Where this approach is not possible, other strategies for providing delineation between pedestrian and cycling space include vertical separation (mid-height, detectable curbs) or horizontal/tactile separation (i.e. detectable tactile buffer strip, sod or landscaping zones, railings).

Note that this transition may require significant civil works / signal upgrades. A retrofit treatment could be adapted from the transition shown in Exhibit 8-5 for protected bike lanes. For details, please refer to the City of Markham's *Signage & Pavement Marking Guidelines for Multi-use Paths (2015).*

Exhibit 8.5: Retrofit-style Intersection: On-Road Cycling Facilities and Multi-use Path



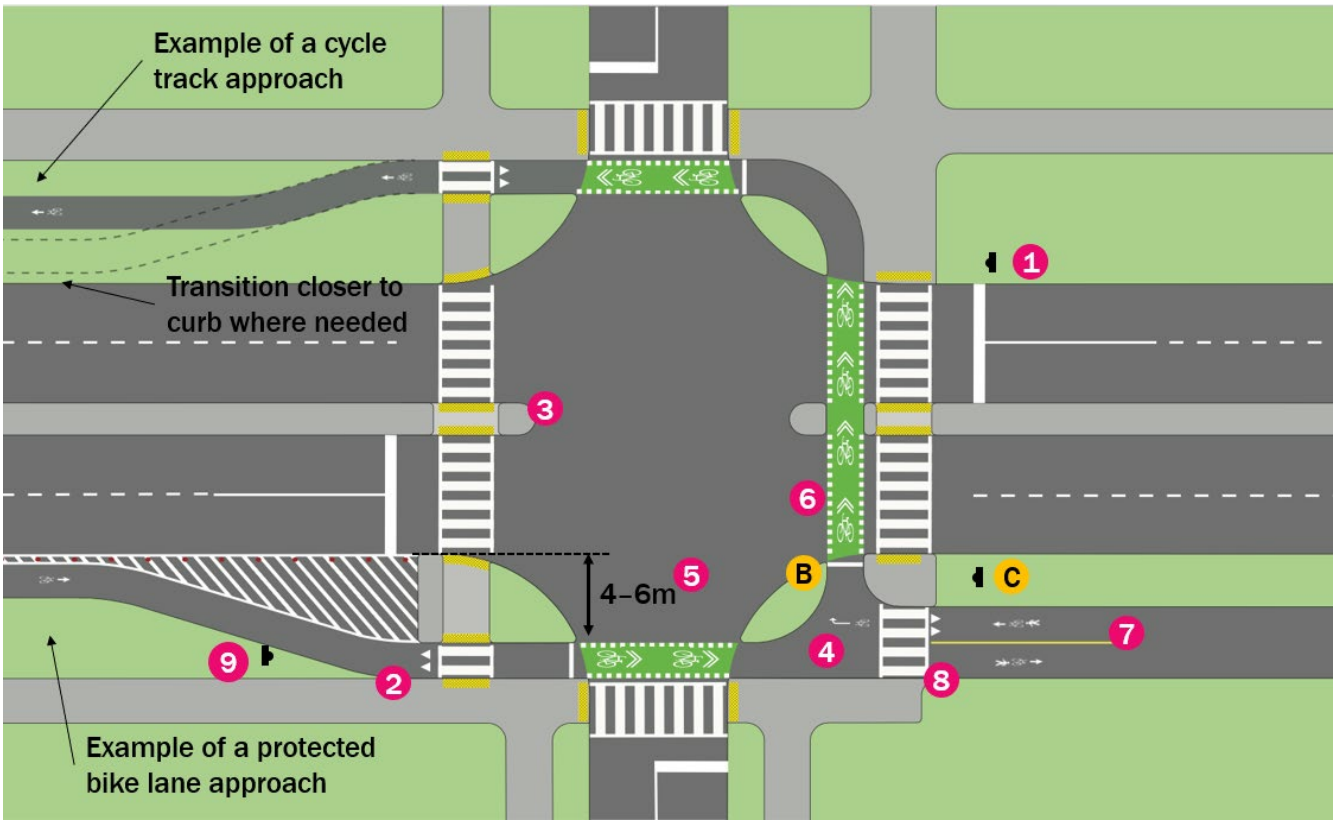
Source: City of Markham Signage & Pavement Marking Guidelines for Multi-use Paths (2015)

8.3 Separated Bikeway Transitioning to a Multi-use Path

Locations where bi-directional facilities such as multi-use paths transition to uni-directional facilities such as cycle tracks are complex for cyclists and drivers alike. In these cases, it is important to provide clear directional paths for cyclist movements. These treatments are likely to occur at transitions from urban centres to lower-density surrounding neighbourhoods. A sample transition at a signalized intersection is shown in Exhibit 8-6.

Separated Bikeway Transitioning to a Multi-use Path

Exhibit 8.6: Facility Transition: Separated Bikeway to Multi-use Path



Required Elements

1. Customized 'Turning Vehicles Yield To Bicycles' (RB-37 – TAC) signage to alert turning drivers that they must yield to through cyclists
2. Yield markings alerting approaching cyclists of pedestrian priority should be applied to separated cycling facilities
3. Median islands wherever possible
4. Bicycle queuing area must provide sufficient storage so that a waiting bicycle does not block or impede through pedestrian traffic
5. Motorist yield zone (minimum 4m) which allows turning drivers to yield to crossing pedestrians and cyclists without risk of being rear-ended by through vehicles

6 Intersection crossing should be designed as a crossride for cyclists with elephant's feet markings and sharrows to indicate direction of travel

7 A yellow dividing line should be applied to the multi-use path approaching the intersection to reduce conflicts.

8 Pedestrians should be prioritized through crossing through crosswalk markings, tactile plates and/or signage.

9 Cyclists Yield to Pedestrians' signage (Rb-73-OTM) can be applied where there are challenges with interactions between users

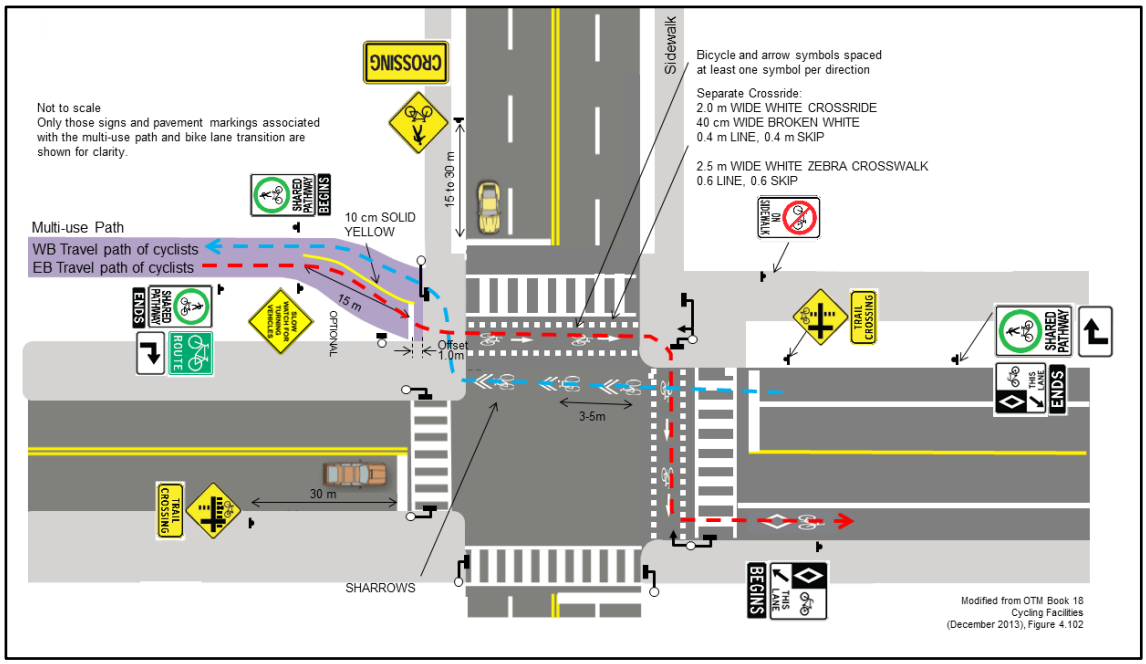
Optional/Context-Sensitive Elements

A Optional stop bar for cyclists

B Wayfinding signage should be considered indicating that cyclists wishing to continue to along the major roadway must turn right. Possible signage includes: 'Bicycle Route' marker signage (IB-23 TAC) combined with right turn signage (IS-5R) and custom street signage (C-1)

Note that this transition may require significant civil works / signal upgrades. A retrofit transition from on-road cycling infrastructure (i.e. protected bike lanes) to a multi-use path could be adapted from the transition identified in Exhibit 8-7. For details, please refer to the City of Markham's *Signage & Pavement Marking Guidelines for Multi-use Paths (2015).*

Exhibit 8.7: Retrofit-style Transition: Bike Lanes and Multi-use Path



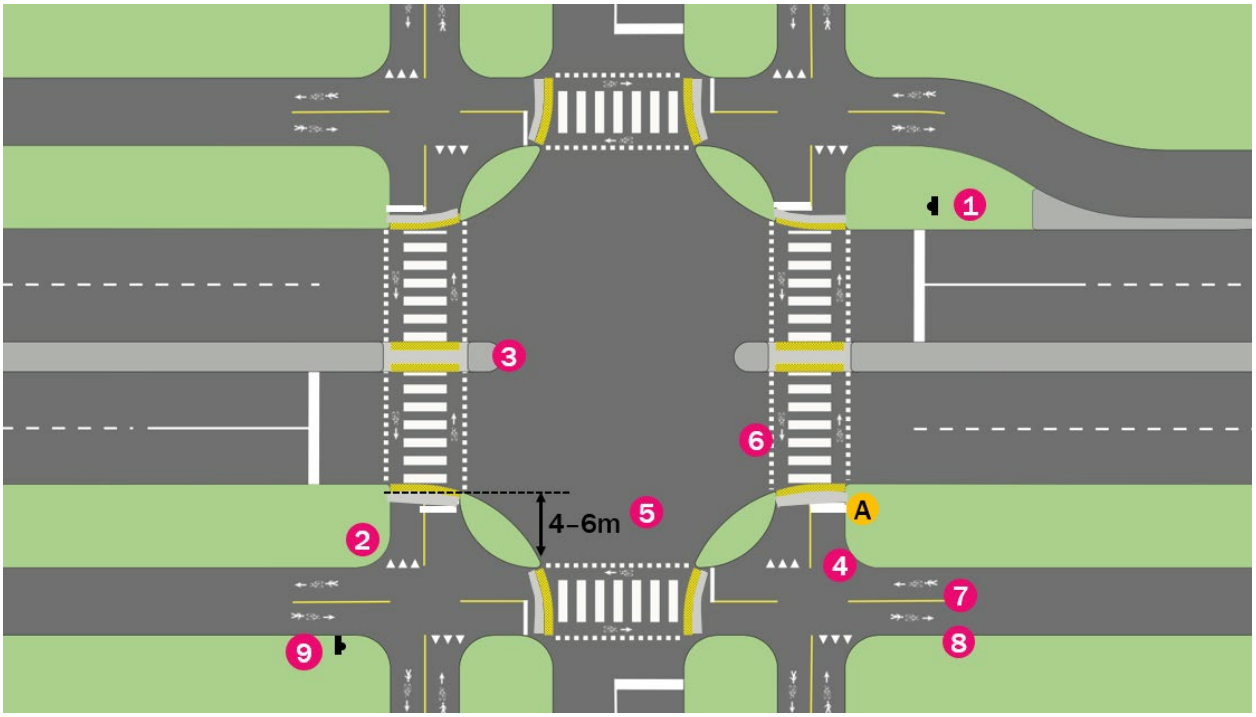
Source: City of Markham Signage & Pavement Marking Guidelines for Multi-use Paths (2015)

8.4 Multi-use Path on Major Road Intersecting a Multi-use Path

In the cases where two multi-use paths intersect, it is important to reiterate pedestrian priority within the shared space at the intersection. A sample transition at a signalized intersection is shown in Exhibit 8-8.

Multi-use Path Intersecting a Multi-use Path

Exhibit 8.8: Facility Intersection: Multi-use Path & Multi-use Path



Required Elements

1. Customized 'Turning Vehicles Yield To Bicycles' (RB-37 – TAC) signage to alert turning drivers that they must yield to through cyclists
2. Yield markings alerting approaching cyclists of pedestrian priority should be applied to separated cycling facilities
3. Median islands wherever possible
4. Queuing area must provide sufficient storage so that a waiting bicycle does not block or impede through pedestrian traffic
5. Motorist yield zone (minimum 4m) which allows turning drivers to yield to crossing pedestrians and cyclists without risk of being rear-ended by through vehicles
6. Intersection crossing of the multi-use path should be designed as Combined Pedestrian and Cyclist Crossride
7. A yellow dividing line should be applied to the multi-use path approaching the intersection to reduce conflicts.
8. Cyclists Yield to Pedestrians' signage (Rb-73-OTM) to ensure pedestrian priority
9. Optional pedestrian and bicycle markings following/approaching intersection

Optional/Context-Sensitive Elements

A. Optional stop bar for cyclists

9 Maintenance

Typical maintenance activities to be considered with respect to separated cycling facilities, multi-use paths and trails include:

- Year-Round & Seasonal Maintenance Activities:
  - **Inspection & Patrol** - Routine inspection and patrolling to ensure that facilities are in a state of good repair
  - **Pothole & Surface Discontinuity Repair** – Ensuring a smooth walkable / rideable surface free of major cracks and/or discontinuities
  - **Pavement Markings & Signage** – Ensuring visibility of signage and pavement markings and refreshing pavement markings following winter months
  - **Sweeping** – Clean-up of leaves, debris and dirt that accumulate along active transportation facilities.
  - **Vegetation Trimming** – Ensuring grass and other plantings do not impact the surface through regularly cutting and trimming
- Winter Maintenance Activities:
  - **Snow Clearing & Snow Removal; Prevention of Ice Formation** – All of the winter maintenance activities that help to create a navigable active transportation facility year-round.
  - **Removal of Barriers** – in some cases, temporary physical barriers (i.e. Flexi posts) may be removed seasonally to facilitate snow removal.
- As-needed Activities:
  - **Litter collection** – Removing / collecting garbage accumulated in boulevards and through open spaces

Maintenance practices for separated cycling facilities, multi-use paths and trails are largely outside of the scope of this document. However, it is recognized that a growing adoption and implementation of these facilities will have maintenance implications over time.

Wherever possible, integration and coordination between the City of Markham, York Region and adjacent municipalities is preferred to provide a consistent user experience. Winter clearing activities should also be coordinated with school boards where active transportation facilities adjoin school properties. Further information on maintenance is provided in *York Region's Pedestrian & Cycling Planning and Design Guidelines (Chapter 10).*