



Design Guidelines for Bikeways



	<u>Page No.</u>
CHAPTER ONE	
1.0 INTRODUCTION	1
CHAPTER TWO	
2.0 CLASSIFICATION OF BIKEWAYS	2
2.1 <i>Shared Roadway</i>	2
2.1.1 Wide Outside Lane	2
2.1.2 Bicycle Boulevard	2
2.2 <i>Shoulder Bikeway</i>	2
2.3 <i>Bicycle Lane</i>	2
2.3.1 Bus/Bicycle Lane	5
2.3.2 Contra-flow Bicycle Lane	5
2.4 <i>Multi-use Path</i>	5
2.5 <i>Bikeway Type Selection Criteria</i>	5
CHAPTER THREE	
3.0 ALIGNMENT ELEMENTS	6
3.1 <i>Design Vehicle</i>	6
3.2 <i>Design Speed</i>	7
3.3 <i>Stopping Sight Distance</i>	7
3.4 <i>Horizontal Alignment</i>	8
3.5 <i>Vertical Alignment</i>	8
CHAPTER FOUR	
4.0 CROSS-SECTION ELEMENTS	10
4.1 <i>Lane Widths</i>	10
4.2 <i>Horizontal/Vertical Clearances</i>	12
4.3 <i>Cross Slope</i>	12
CHAPTER FIVE	
5.0 INTERSECTION TREATMENTS	13
5.1 <i>Intersection with Bicycle Lanes</i>	13
5.2 <i>Path Crossings</i>	13

CHAPTER SIX

6.0 DESIGN DETAILS	14
6.1 <i>Pavement Surfaces</i>	14
6.2 <i>Drainage Grates/Manhole Covers</i>	14
6.3 <i>Railway/Streetcar Tracks</i>	15
6.4 <i>Delineators</i>	15
6.5 <i>Bikeway Ramps/Curb Cuts</i>	15
6.6 <i>Bollards and Gates</i>	15
6.7 <i>Fences</i>	16
6.8 <i>Staircases</i>	16
6.9 <i>Detours</i>	17
6.10 <i>Lighting</i>	17
6.11 <i>Landscaping</i>	17
6.12 <i>Rest Areas</i>	17
6.13 <i>Parking</i>	17

CHAPTER SEVEN

7.0 TRAFFIC CONTROL DEVICES	18
7.1 <i>Signing and Marking</i>	18
7.2 <i>Traffic Signals</i>	22

REFERENCES	23
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LIST OF FIGURES

1.	<i>Types of Bikeways</i>	3
2.	<i>Typical Bicycle Boulevard</i>	4
3.	<i>Design Vehicle</i>	6
4.	<i>Bicycle Friendly Stairs</i>	16
5.	<i>Standard Bike Route Symbol</i>	18
6.	<i>Destination Information Signs</i>	18
7.	<i>Special Information Signs</i>	19
8.	<i>Share the Path Sign</i>	19
9.	<i>Bike Lane (Combined Through/Right Turns)</i>	20
10.	<i>Jug Handle Intersection</i>	20
11.	<i>Contra-Flow Bicycle Lane</i>	21
12.	<i>Bicycle Lane at Diverging Ramp Facility</i>	21
13.	<i>Interchange with Jug Handle Path for Right Turns</i>	22
14.	<i>Shared Lane Pavement Marking</i>	22

LIST OF TABLES

1.	<i>Bikeway Type Criteria</i>	5
2.	<i>Stopping Sight Distances for Down Grades</i>	7
3.	<i>Minimum Radii for Paved Bikeways</i>	8
4.	<i>Lateral Clearances for Stopping Sight Distance</i>	9
5.	<i>Bikeway Widths</i>	10
6.	<i>Horizontal & Vertical Clearances</i>	12
7.	<i>Minimum Sight Distance for Path Crossings</i>	13
8.	<i>Typical Pavement Designs</i>	14

1.0. INTRODUCTION

In 1993, Regional Council adopted the Vision 2020 reports as a guide for future planning in the Region. Since then, policy changes have been incorporated in the Region's Official Plan and in the Regional Transportation Review report. The new policies aim at, among others, a more balanced transportation system with greater emphasis on transit, cycling and walking. Initiatives taken to encourage cycling include the construction of on-street and off-street bikeways.

The purpose of this guide is to present recommended guidelines for the uniform design of bikeways throughout the Region. The guide has adopted basic bikeway guidelines, recommended by the Transportation Association of Canada, Ontario Ministry of Transportation and other agencies, modified to suit local circumstances. These publications contain bikeway design guidelines. The guide contains a list of references for more detailed information.

The information contained in this guide is to be used carefully. As in engineering design for motor vehicles, good engineering judgement will still be required in the design of specific bikeway projects.

2.0 CLASSIFICATION OF BIKEWAYS

Bicycles are vehicles under the Ontario Highway Traffic Act; they can be ridden on all streets and highways except for freeways. Therefore, on-street bikeways must be designed to allow cyclists to ride in a manner consistent with motor vehicle operation. There are three basic types of bikeways: shared roadways with or without wider curb lanes or shoulders, bicycle lanes and multi-use paths (see Fig. 1).

2.1 Shared Roadway

Cyclists and motorists share the same travel lanes. Motorists usually cross over into the adjacent lanes to pass. Some shared roadways are signed bicycle routes as they are preferred routes and provide continuity with other bikeways. Treatments enhancing road sharing are:

2.1.1 Wide outside lane

A wide outside lane allows a motorist and cyclist to operate adjacent to one another.

2.1.2 Paved Shoulder

A smooth paved shoulder provide a suitable area for cycling, with few conflicts with faster moving motor vehicle traffic.

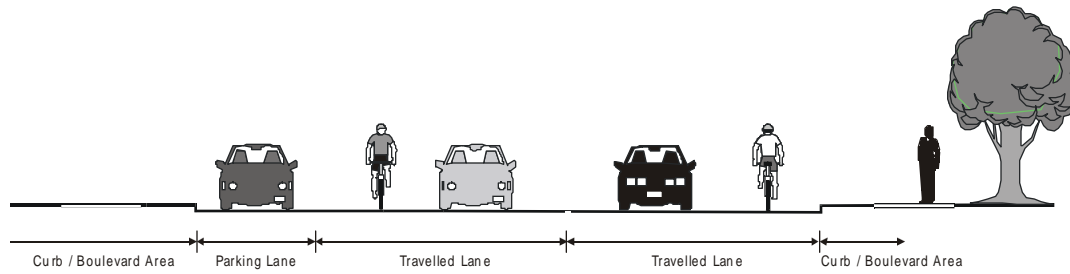
2.1.3 Bicycle Boulevard

Modification of the operation of local streets to function as a through street for bicycles, while maintaining local access for motor vehicles. Traffic calming devices control traffic speeds and discourage through trips by motor vehicles. Traffic control devices reduce potential conflicts and give priority to through bicycle traffic. Figure 2 illustrates a typical bicycle boulevard.

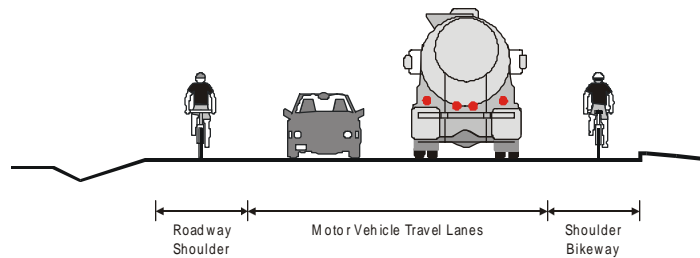
2.2 Bicycle Lane

A bicycle lane is a portion of the roadway or shoulder which is designated by signing, pavement markings and/or physical barriers. Even though only bicycles are permitted within these lanes, motor vehicles are allowed to cross into the lanes when performing turning movements. Two special types of bicycle lanes are Bus/Bicycle lanes and Contra-Flow bicycle lanes.

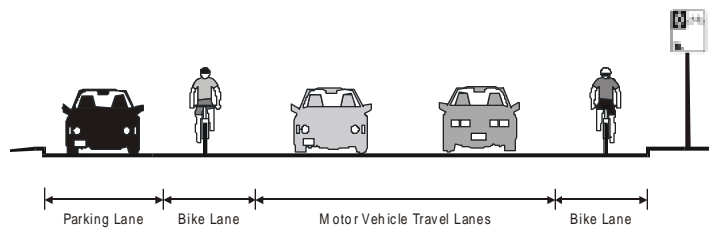
Figure 1: Types of Bikeways



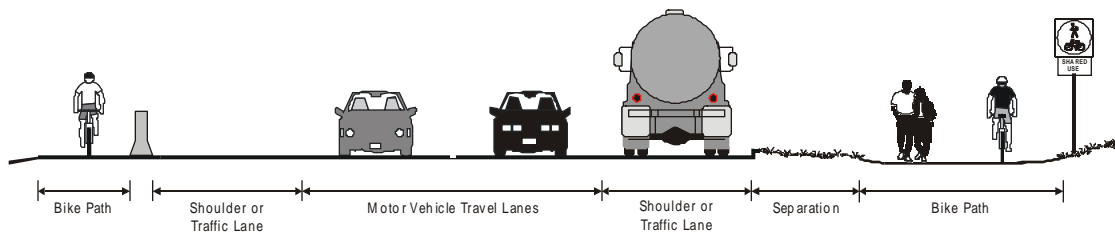
SHARED ROADWAY WITH WIDE CURB LANES



SHARED ROADWAY WITH SHOULDERS

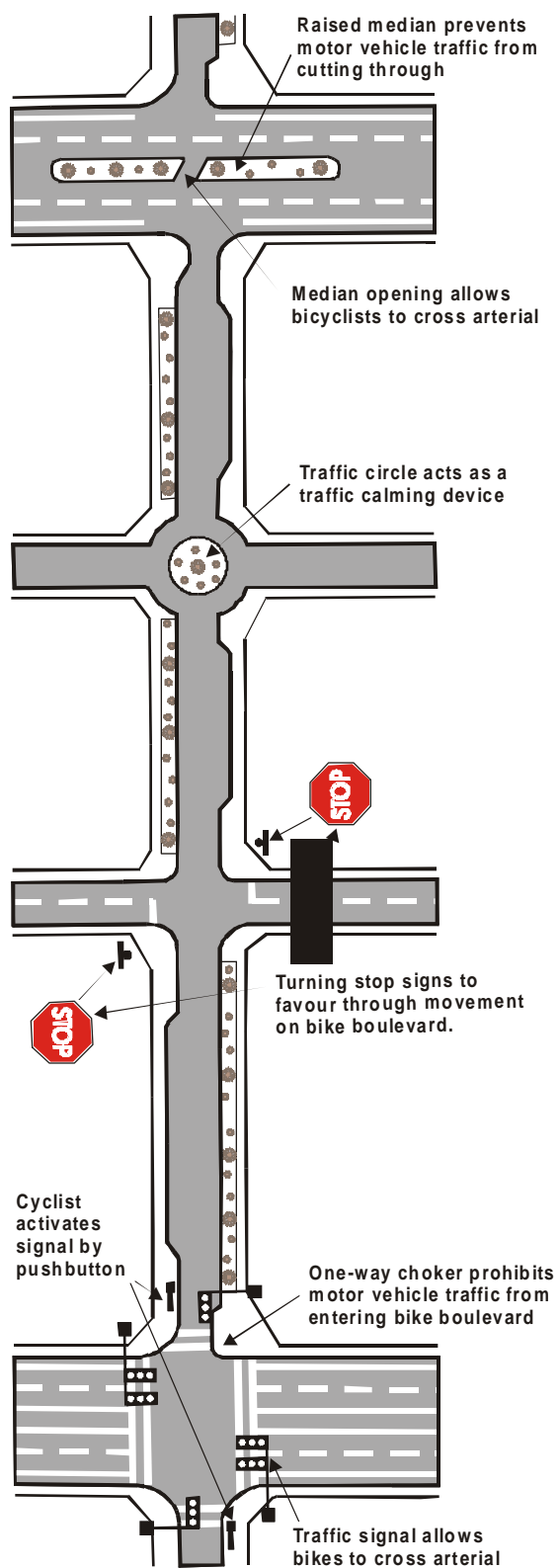


BICYCLE LANE



MULTI-USE PATH

Figure 2: Typical Bicycle Boulevard



2.3.1 Bus/Bicycle Lane

In recent years, the use of High Occupancy Vehicle (HOV) lanes has increased. These lanes are also useful for bicycles in low traffic volume conditions. No HOV lanes currently exist in the Region of Hamilton-Wentworth.

2.3.2 Contra-flow Bicycle Lane

To provide a critical connection in a cycling network, a contra-flow bicycle lane is sometimes installed in the opposite direction of the motor vehicle flow on a one-way street. The contra-flow bicycle lane should be clear of any stopped or parked vehicles.

2.4 Multi-Use Path

A multi-use path is physically separated from the travel portion of a roadway by an open space, barrier or separate right-of-way. Paths can be designated for cyclists only, but most paths are multi-use paths available to other users including pedestrians, in-line skaters and joggers.

2.5 Bikeway Type Selection Criteria

The selection of the type of bikeway is related to four factors: motor vehicle traffic volume (AADT per lane), average motor vehicle operating speed (km/hour), traffic mix (number of heavy vehicles per hour) and the presence of on-street parking. Table 1 illustrates the type of bikeway by traffic volume and speed. The affect of the presence of heavy vehicles and on-street parking should be considered prior to the final selection of the bikeway. The information was derived from Reference 7 and modified to account for local experience.

Table 1: Bikeway Type Criteria

Average Motor Vehicle Operating Speed (km/h)	AADT (per lane)		
	<3,000	3,000 - 5,000	>5,000
<30	SL	WCL	N/A
30 - 50	WCL	WCL or BL	WCL or BL
50 - 70	WCL or BL	BL	BL
>70	N/A	BL	BL or MP
SL = Shared Use Lane WCL = Wide Curb Lane BL = Bike Lane MP = Multi-Use Path N/A = Not Applicable AADT = Annual Average Daily Traffic			
Notes * for all rural sections, use paved shoulders * where WCL or BL, select BL if high truck % and/or parking			

3.0 ALIGNMENT ELEMENTS

3.1 Design Vehicle

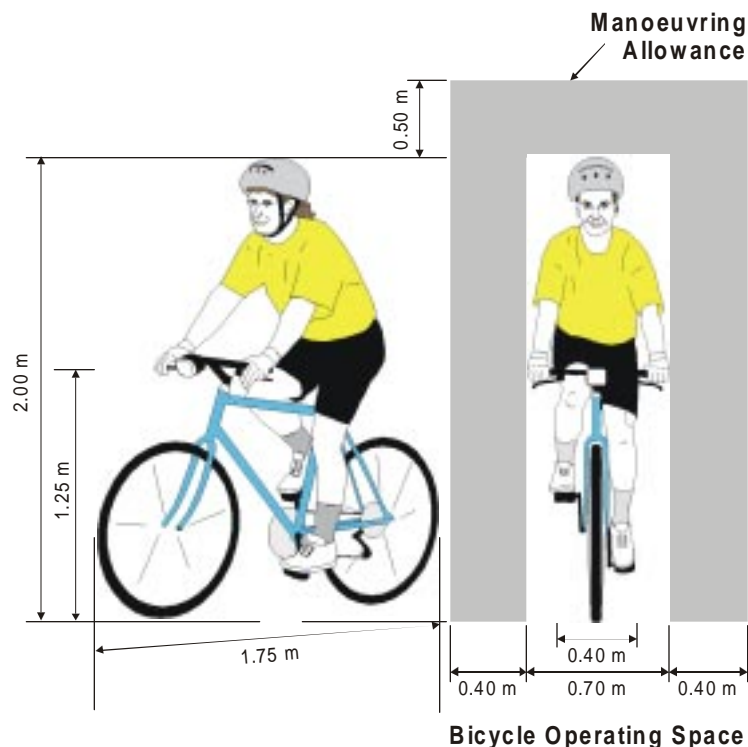
To ensure the safety and comfort of cyclists, it is important to take into account typical bicycle dimensions. Figure 3 illustrates the design vehicle. The recommended dimensions are as follows:

The widest part of a bicycle is its handlebars. The average width of a set of handle bars is 0.60 m with some of the newer mountain bikes being as wide as 0.80 m. Cyclists need at least 0.20 m on either side for essential manoeuvring space but it is preferable to provide 0.40 m on either side. The extra manoeuvring space will also ensure that bicycles with handlebars 0.80 m wide will have adequate clearance. Therefore, the total amount of space required for a cyclist to ride comfortably is 1.5 m.

The height of a bicycle is taken as the height of the handlebars, which can vary from 0.75 m, to 1.25 m. For safety reasons, the highest possible height of 1.25 m should be used for the design vehicle. With bicycles being 1.25 m high, bicycle and person can reach 2.0 m. A minimum vertical clearance of 2.5 m should be used to allow the cyclist to feel safe and comfortable.

The average length of most bicycles is 1.75 m.

Figure 3: Design Vehicle (Ref. 1)



3.2 Design Speed

Most cyclists travel at 15 - 25 km/hr assuming normal conditions (no wind, flat terrain, asphalt pavement). Cyclists can however reach higher speeds, and therefore, it is recommended that a design speed of at least 30 km/h be used. The design speed should be higher for routes exposed to prevailing winds or containing steep down grades.

3.3 Stopping Sight Distance

Stopping Sight Distance is the distance required by a cyclist to come to a complete stop upon spotting an obstacle. It is a function of perception and reaction time, tire/surface friction coefficient, grade, cyclist speed and the braking capabilities of the bicycle. Table 2 sets out stopping sight distance for down grades for various design speeds. Stopping sight distances for other conditions can be calculated using the formula.

Table 2: Stopping Sight Distances for Downgrades (Ref. 6)

Design Speed km/hr	Stopping plus reaction distance (m)		
	Percent Grade		
	0	-5	-10
15	14	15	16
20	20	22	25
30	35	40	45
40	55	60	70
50	75	85	100

$$S = 0.694V + \frac{V^2}{255(f + G/100)}$$

Where: **S** = stopping sight distance, m
V = speed, km/hr
f = coefficient of friction
G = grade, % (upgrade is positive and downgrade is negative)

3.4 Horizontal Alignment

The minimum radius of a circular curve for a bikeway is a function of bicycle speed, superelevation and coefficient of friction between the tires and the riding surface. Table 3 shows minimum radii for paved bikeways. Table 4 gives the lateral clearance to an obstruction for a range of radii and stopping sight distances.

Table 3: Minimum Radii for Paved Bikeways (Ref. 6)

Design Speed	Radius
10	4
15	8
20	10
25	15
30	25
35	35
40	45
45	65
50	80

* e = 2%

$$R = \frac{V^2}{127(e + f)}$$

Where: **R** = radius, m
V = speed, km/hr
e = superelevation, m/m
f = coefficient of lateral friction

This relationship is used to determine the minimum design radius for given design speeds. For most applications and conditions, the superelevation rate will range from 0.02 to 0.05 m/m. The coefficient of lateral friction used for design of paved bikeways varies from 0.30 at 25 km/hr to 0.22 at 50 km/hr.

3.5 Vertical Alignment

Grades on multi-use paths should be kept to a minimum, especially on long inclines. Grades greater than 5 percent for paved surfaces and 3 percent for unpaved surfaces (e.g. crushed stone), are undesirable because the ascents are difficult for many cyclists to climb and the descents cause some cyclists to exceed the speeds at which they are competent. However, terrain dictates, grades over 5 percent and less than 150 m long are acceptable when a higher design is used and additional width is provided. It is recommended that a minimum of 0.5 percent be used for proper drainage. Routes with steep grades should be assessed by the designer to ensure that the prevailing conditions fit the type of cyclists expected.

Crest curves control the distance that a cyclist can see ahead. The longer the curve, the farther a cyclist can see. The minimum length required is a function of the sight distance and algebraic difference between grades on either side of the crest. For information on crest and sag vertical curves, see references 4 or 6.

Table 4: Lateral Clearances for Stopping Sight Distance (Ref. 4)

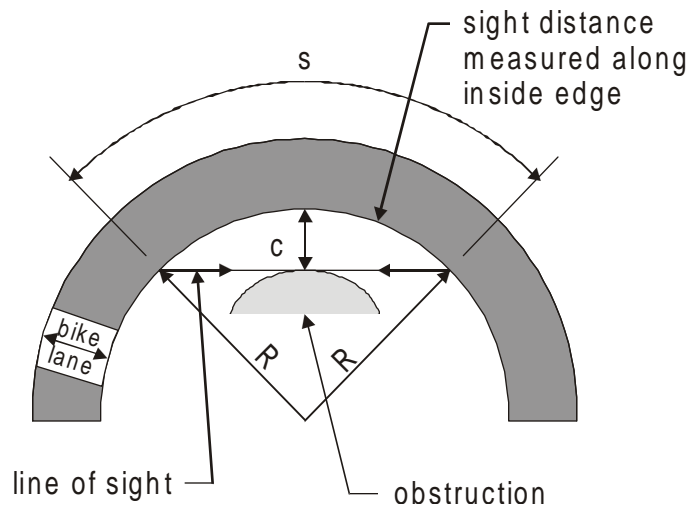
$$c = R \left(1 - \cos 28.65 \frac{S}{R} \right)$$

s = stopping sight distance (m)

R = radius of inside lane (m)

c = clearance required from inside lane (m)

Note: Formula applies only when $S \leq$ length of circular curve



Clearance, c (m)										
radius (m)	Stopping Sight Distance (m)									
	10	20	30	40	50	60	70	80	90	100
10	1.2	4.6	9.3	-	-	-	-	-	-	-
15	0.8	3.2	6.9	11.5	-	-	-	-	-	-
20	0.6	2.4	5.4	9.2	13.7	18.6	-	-	-	-
25	0.5	2.0	4.4	7.6	11.5	15.9	20.8	-	-	-
30	0.4	1.7	3.7	6.4	9.8	13.8	18.2	22.9	27.9	-
35	0.4	1.4	3.2	5.6	8.6	12.1	16.1	20.5	25.2	30.0
40	0.3	1.2	2.8	4.9	7.6	10.7	14.4	18.4	22.8	27.4
45	0.3	1.1	2.5	4.4	6.8	9.6	12.9	16.6	20.7	25.0
50	0.2	1.0	2.2	3.9	6.1	8.7	11.8	15.2	18.9	23.0
55	0.2	0.9	2.0	3.6	5.6	8.0	10.8	13.9	17.4	21.2
60	0.2	0.8	1.9	3.3	5.1	7.3	9.9	12.8	16.1	19.7
65	0.2	0.8	1.7	3.1	4.7	6.8	9.2	11.9	15.0	18.3
70	0.2	0.7	1.6	2.8	4.4	6.3	8.2	11.1	14.0	17.1
75	0.2	0.7	1.5	2.7	4.1	5.9	8.0	10.4	13.1	16.1
80	0.2	0.6	1.4	2.5	3.9	5.6	7.5	9.8	10.8	15.1

4.0 Cross Section Elements

4.1 Lane Widths

For on-street bikeways, lane widths are measured from the edge of the gutter pan to the edge of lane markings. Wheels of heavy vehicles tend to cause rutting along the outer road edges lowering the actual travel space available. Extra width should be provided on roads with heavy vehicle traffic to ensure proper travel space for cyclists. Widths of multi-use paths are intended as the actual travelled portion of the path. Table 5 summarizes suggested lane widths for Hamilton-Wentworth based on numbers found throughout the literature review.

Table 5: Bikeway Widths

	Lane Width (m)					
	Wide Curb Lane	Bicycle Lane	Lane & Parking Stalls	Contra-Flow Lane	HOV / Bus	Multi - Use Path
Absolute Minimum	4.0	1.2	4.0	1.5	4.3	2.5
Minimum	4.3	1.5	4.0	1.8	4.5	3.0
Desirable	4.5	1.8	4.5	2.0	4.8	4.0

a) Wide Curb Lane

Wide curb lanes can be achieved by widening the roadway or restriping the lane markings outside the gutter pan. The minimum recommended curb lane is 4.0 m with 4.3 m being the most desirable. Lane widths greater than 4.5 m should be avoided as this may result in two vehicles moving abreast in the lane. A lane width 5.5 m or greater should include a bike lane (minimum width 1.5m).

b) Bicycle Lane

The recommended width for a cycle lane is 1.5 m (absolute minimum 1.2 m) as this is the amount of space a cyclist needs to be comfortable outside the gutter pan. Due to the aerodynamic impact of vehicles on cyclists, 1.8 m should be provided for bike lanes on roads within the following conditions:

1. Adjacent vehicles travelling at speeds greater or equal to 70 km/h; and
2. High percentage of buses and/or trucks.

For more information on aerodynamic impact, see reference 1.

c) Bicycle Lane adjacent to parking stalls

When a bike lane is located adjacent to parking stalls, a minimum width of 4.0 m is recommended (assuming a 2.4 m parking bay). This is enough space to ensure that a cyclist will not be hit by a motorist opening the car door. Providing a width of 4.5 m is desirable as it will provide space for cyclists to move into when vehicles are entering/exiting the parking spaces. A lane width greater than 4.5 m should be avoided as it may result in vehicles travelling along side parked cars, causing a hazard to cyclists.

d) Bus / Bicycle Lane (HOV)

A minimum width of 4.3 m is recommended. However, it is desirable to provide a 4.5 m width to accommodate buses and interaction with other vehicles. Problems arise when a bus makes frequent stops, requiring the bus driver and cyclists to pass each other several times. Certain rules should be set out to solve this problem. For example, buses should not pass a cyclist unless there is sufficient time to merge safely. Cyclists should only pass on the left and allow buses to merge. These lanes should not be applied on narrow and/or high speed routes. In this situation, the cycle lane should be located between the HOV lane and adjacent motorized vehicle lane.

e) Contra-flow Lane

Recommended width is 2.0m. For safety reasons, a contra-flow bicycle lane needs to be marked with a solid "NO PASSING" line. Delineators and/or medians should preferably be used to prevent vehicles from travelling into oncoming cyclists. Snow should be removed and stored in such a way that it does not block the entrance/exit points of bicycle lane.

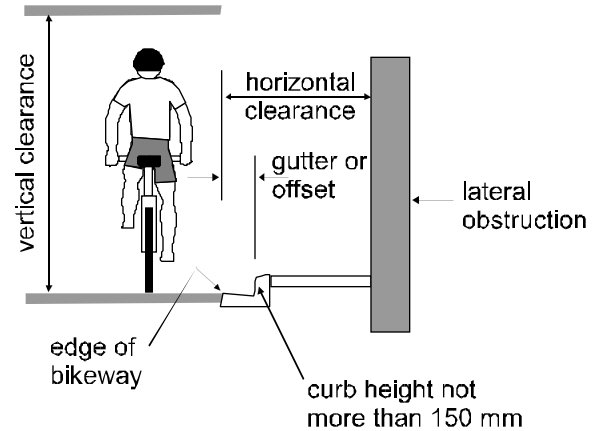
f) Multi-Use Path

The width of a path depends on the expected number of users. A minimum width of 3.0 m is recommended with 4.0 m preferable. This width will allow for the presence of pedestrians and in-line skaters. A minimum 0.5 m wide graded area should be maintained adjacent to both sides of the path. One-way facilities are not recommended due to the difficulty of obtaining compliance.

4.2 Horizontal/Vertical Clearances

Table 6: Horizontal and Vertical Clearances

Clearances (m)		
Type	Minimum	Desirable
Horizontal	0.5	1.0
Vertical	2.5	3.5
Railing or Parapet Height	1.4	1.8



a) Horizontal Clearance

A minimum horizontal clearance of 0.5 m is recommended with a preferable clearance of 1.0 m for obstructions such as poles, trees, fences etc. A curb with a height greater than 150 mm is considered a lateral obstruction as measured from the bikeway edge. Fences/ barriers should have a lateral clearance of 1.0 m from the edge of the path. If this is not possible, the edges should curve back so that they are at least 1.0 m away. This distance will prevent the cyclist's handlebars from clipping the edge of the barrier and falling.

b) Vertical Clearance

A minimum vertical clearance of 2.5 m should be used with 3.5 m preferable. The 2.5 m will allow just enough comfort space for a cyclist. A minimum of 3.5 m should be used for tunnels and underpasses. Overhanging foliage should also be trimmed to this height. Fence railings should be a minimum of 1.4 m high to prevent cyclists from falling over the top. This height will allow cyclists to maintain proper visibility.

4.3 Cross Slope

Multi-use paths should have a crowned section for drainage. Cross slopes should not exceed 4% for cyclists to keep their balance at lower speeds.

5.0 INTERSECTION TREATMENTS

Most conflicts between road users occur at intersections. Good intersection design minimizes confusion for motorists, cyclists and pedestrians, and, encourages all users to operate according to the normal rules of the road. Cyclists' movements should be predictable. Only in rare cases, should cyclists be required to proceed through intersections as pedestrians.

5.1 Intersection with Bicycle Lanes

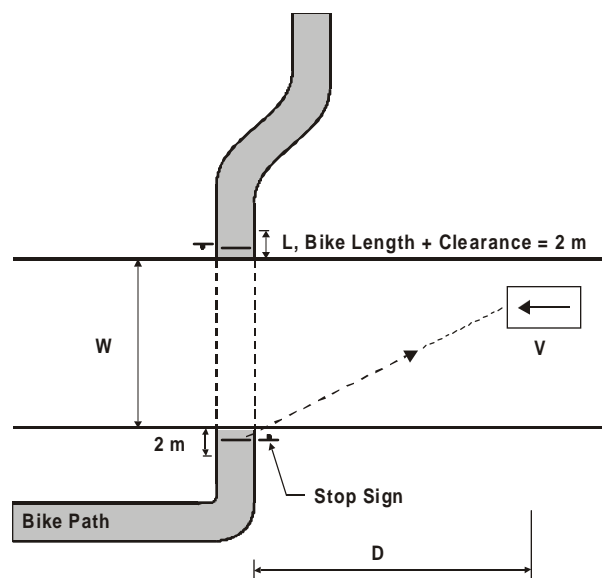
Intersection with bicycle lanes should be marked according to the new TAC guidelines (see Chapter 7). For more details, see Reference 5.

5.2 Path Crossings

Mid-block path crossings with busy streets are discouraged since motorists are often not prepared for cyclists crossing the street at mid-block. Advanced alignment (horizontal and/or vertical) changes should be applied to reduce cyclists' speed for a stop or yield. Proper sight distances to cross the roadway are required (see Table 7). For more information, see references 4 and 6.

Table 7: Minimum Sight Distance for Path Crossings

Minimum Sight Distance (D) to Approaching Vehicle, m				
Width of Roadway (W), m	Roadway Design Speed km/hr			
	50	60	70	80
7.0	130	150	180	200
10.5	170	200	230	270
14.0	210	250	290	330
17.5	250	300	350	400
21.0	290	350	410	460



$$D = \frac{V(W + 4)}{4.32}$$

- Where: **D** = sight distance, m
V = roadway design speed, km/hr
W = roadway width, m
L = (bike length + clearance) taken to be 2m

6.0 DESIGN DETAILS

6.1 Pavement Surfaces

Pavement surfaces should be uniform and free of potential hazards to provide a smooth and safe ride. Required maintenance includes filling in potholes, adjusting utility covers/drainage grates, and keeping the edges free of debris. Table 8 presents typical pavement designs.

Table 8: Typical Pavement Designs

ON-STREET BIKEWAY
<ul style="list-style-type: none"> • 80 mm HL3 or thickness of driving lane
MULTI-USE PATH
<ul style="list-style-type: none"> • 50 mm HL3 150 mm Granular 'A' 150 to 300 mm Granular 'B' as required • 100 mm portland cement concrete 100 mm Granular 'A' • 75 mm limestone screening 100 mm Granular 'A' 150 to 300 mm Granular 'B' as required • 2 aggregate lifts on surface treatment binder 100 mm Granular 'A' 150 to 300 mm Granular 'B' as required

6.2 Drainage Grates/Manhole Covers

Drainage grates and manhole covers are potential hazards as they are:

- slippery when wet
- not always flush with roadway surface
- a prime location for the formation of potholes
- a trap for bicycle tires

Texturing can reduce the slippery quality of drainage grates and manhole covers. Potholes can be prevented by offsetting the grates so that they are not directly on the travelled roadway. Drainage grates should always be perpendicular to prevent bicycle tires from getting caught. Collars can be placed on recessed drainage grates to bring them flush with the roadway. For more information, see reference 4.

6.3 Railway/Streetcar Tracks

Railway/streetcar tracks are potential hazards to cyclists, because they

- are slippery when wet
- may not always be flush with the roadway
- may have gaps on either side of the rail that can trap wheels

Bikeways should cross railway tracks at a right angle. The greater the angle deviates from this angle, the greater the potential for a bicycle front wheel to become trapped in the tracks. This could cause a loss of steering control. Preferably bikeways should be widened to allow more room for cyclists to cross at a right angle. Commercial fillers, such as rubber track guards, should be used to enhance safety. For more information, see reference 6.

6.4 Delineators

Delineators can come in many forms including vertical tubular markers, bollards, and tubular/concave posts. They are used to:

- separate a bicycle lane from a motor vehicle lane
- prevent motor vehicles from entering a bicycle path
- indicate the presence of obstacles
- provide additional protection for cyclists on traffic islands
- protect bicycle parking areas
- increase visibility of curbs

Delineators should be spring loaded and anchored by solid, high quality footings to ensure safety. It is suggested that they be removable for snow maintenance requirements. For more information, see references 1 and 4.

6.5 Bikeway Ramps/Curb Cuts

Bikeway ramps or curb cuts are typically installed to help the transition between paths and roadways. The curb cut should always be the same width as the bike path to encourage uniformity for cyclists. For information, see references 1 and 7.

6.6 Bollards and Gates

An odd number of bollards (preferably one only) should be installed to prevent motor vehicles entering a path. Gates should be avoided as they impede cyclists and distract their attention to cross-traffic. For more information, see reference 1.

6.7 Fences

Fences should only be installed when there is a real danger to cyclists. Bikeway designers should avoid installing fences in safe conditions as fences are considered to be a hazard to cyclists. Fences are necessary in the following situations:

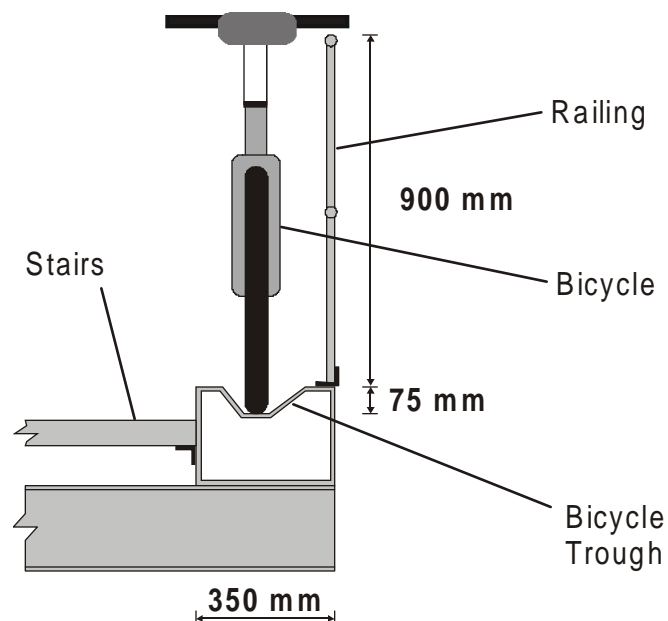
- next to a waterway with steep banks
- near a steep ravine or slope
- on bridges and culverts

Fence design must take into consideration the characteristics of the bicycle, in particular, the position of the rider, and the height of the handlebars. For more information on fences, see reference 1 and 6.

6.8 Staircases

Staircases pose a problem as cyclists must carry their bicycles up or down. A solution is to build concave ramps along the staircases. The ramps need to be built on both sides of a staircase to avoid conflicts between cyclists going up and down. The ramp width should be minimum 150 mm, preferably 350 mm. Figure 4 illustrates a typical example of existing stairs with ramps in Hamilton.

Figure 4: Bicycle Friendly Stairs



6.9 Detours

When an existing bikeway is affected by construction a detour is required. A detour should have:

- the same width as the bikeway
- smooth pavement and acceptable grades
- adequate signing

6.10 Lighting

See references 2 and 6.

6.11 Landscaping

See reference 1.

6.12 Rest Areas

See references 1 and 6.

6.13 Parking

Bicycle racks must secure the bicycle in unprotected parking locations. Racks which support the wheel and frame are preferred e.g. (“lock and lean”). Single racks are useful at locations with low demand or limited space. Multiple racks include wheel racks, which supports wheel only, and ribbon racks which allows frame locking. Racks should be firmly attached to the ground to avoid theft. For more information, see references 6 and 8.

7.0 Traffic Control Devices

7.1 Signing and Marking

Signing and marking of bikeways must be uniform and consistent to direct motor vehicle and bicycle traffic safely. Bicycle route signing and marking is currently up to the discretion of the individual municipality. The Region follows the TAC **Bikeway Traffic Control Guidelines** (1998). Figure 5 shows the standard bike route symbol.

Figure 5: Standard Bike Route Symbol



The purpose of designating bicycle routes on streets and trails is to help cyclists find their way; on-street signs may also alert motorists of the presence of cyclists. Destination and distance signs will benefit cyclists even more (see Figure 6).

Figure 6: Destination Information Signs



Special signs may be erected to inform cyclists where they can find the access to a trail or stairs with bicycle ramps (see Figure 7). Trail etiquette signs may be installed to promote sharing of multi-use paths by pedestrians and cyclists (see Figure 8).

Figure 7: Special Information Signs

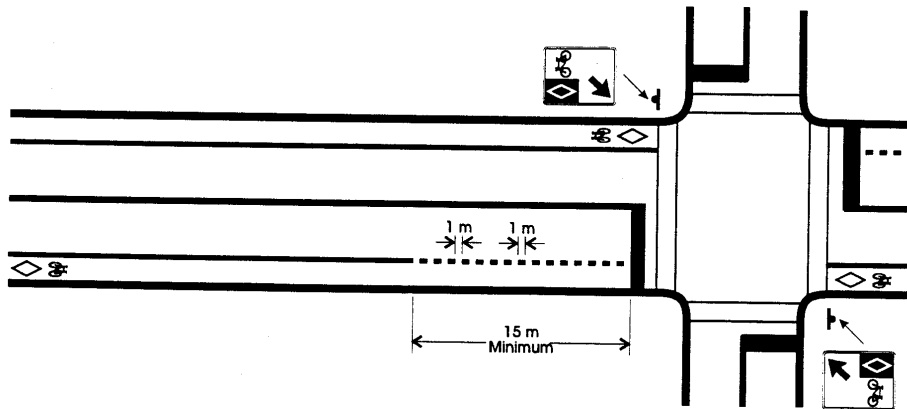


Figure 8: Share the Path Sign



At intersection approaches, solid paint lines for bicycle lanes should either be discontinued or dashed before each intersection (Figure 9). This will decrease the chances of collisions as it allows motorists to merge when there is a gap in bicycle traffic up to the intersection. Otherwise motorists are forced to cross the bike lane to make a right turn.

Figure 9: Bike Lane (Combined Through/Right Turns)



Where traffic is heavy at a “T” intersection, a jug handle configuration may be considered. Cyclists will follow a path to arrive at the intersection at a right angle (Figure 10).

Figure 10: Jug Handle Intersection

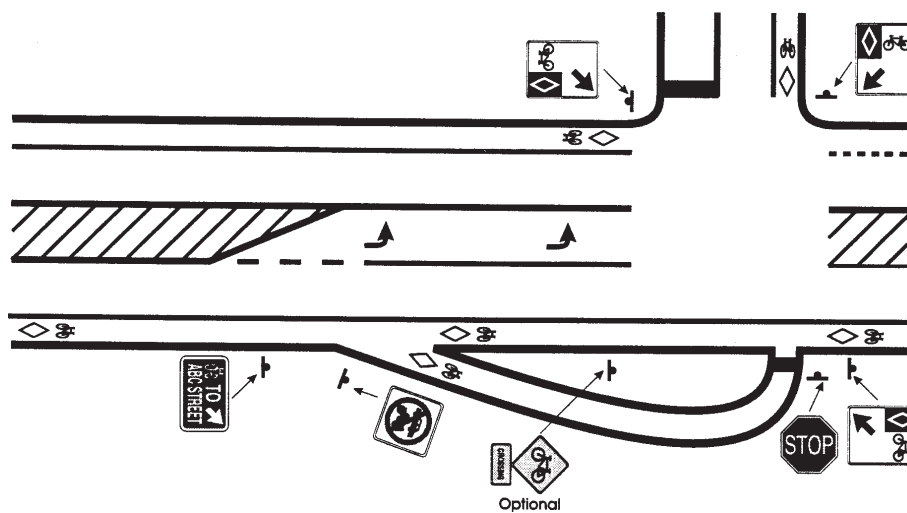
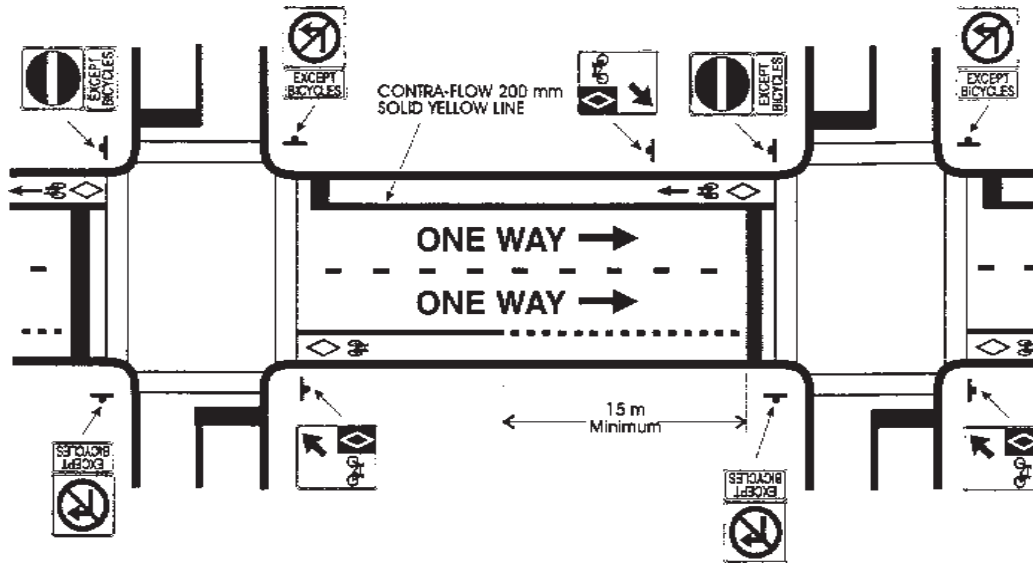


Figure 11 illustrates signs and markings for a contra-flow bicycle lane.

Figure 11: Contra-Flow Bicycle Lane



In the vicinity of interchanges, bike lanes should be marked to conform to the rules of the road (Figure 12). Where traffic volumes entering the ramp are high, the extension of bike lane into a jug handle may be considered (Figure 13).

Figure 12: Bicycle Lane at Diverging Ramp Facility

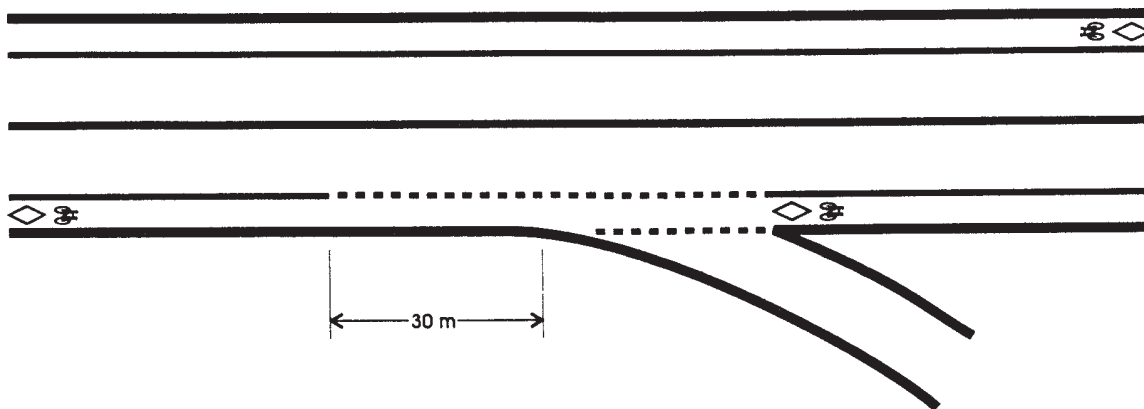
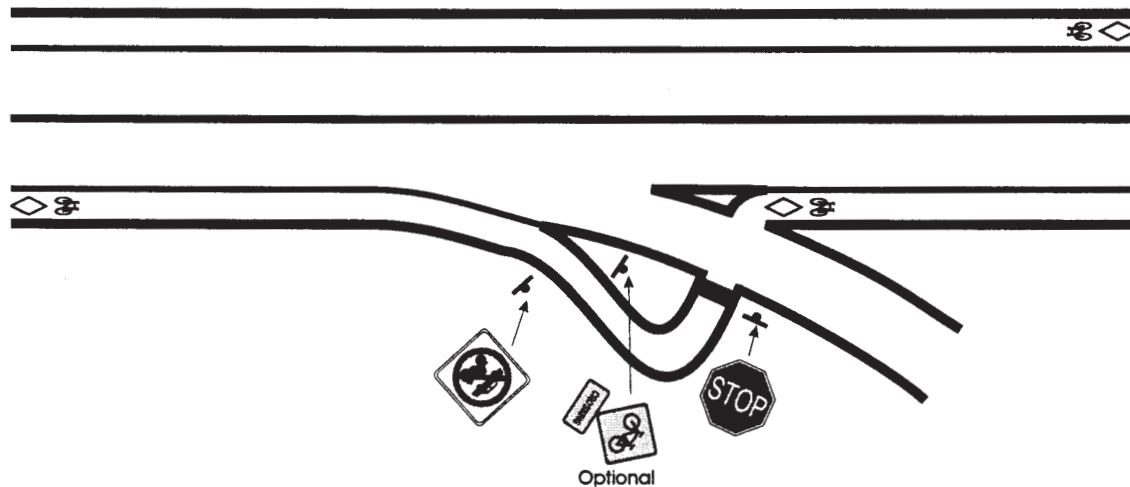


Figure 13: Interchange with Jug Handle Path for Right-Turns

Where bicycle lanes cannot be installed due to restricted road width, 'shared lane' symbols on the pavement may be considered to alert motorists and cyclists to share the road space (Figure 14).

Figure 14: Shared Lane Pavement Marking

7.2 Traffic Signals

Bicycles can use the same signal timing as motor vehicles. Short green intervals are to be avoided, since bicycles take longer to move from a stopped position and travel at slower speeds than motorized vehicles. Clearance intervals are defined by the Ontario Traffic Manual (Book 12). Special bicycle traffic signal heads may have merit in certain circumstances, but are currently not legal in Ontario.

Induction loops that can detect bicycles along with cars are currently available for actuated and semi-actuated signalized intersections. Alternately, infra-red, microwave or radar detection can be used. Pedestrian push buttons may be, positioned to serve both cyclists and pedestrians.

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