5 Toolbox

The construction of Windsor's cycling network should be designed to consistent and safe standards.

The following provides general design guidelines for the construction of the cycling network and supporting facilities including site specific applications in the Windsor context.

5.1 Design Guidelines

The following design guidelines are based on best practices, provincial guidelines, other accepted guidelines and practices and the expertise of the consulting team. Key reference manuals include:

- Transportation Association of Canada, 1998. *Bikeway Traffic Control Guidelines*;
- Transportation Association of Canada, 1999. *Geometric Design Guideline for Canadian Roads*;
- Ministry of Transportation of Ontario, 1996. *Ontario Bikeways Planning and Design Guidelines*;
- American Association of State Highway and Transportation Officials, 1999. *Guide for the Development of Bicycle Facilities*;
- Vélo Quebec, 1992. *Technical Handbook of Bikeway Design*; and
- Canadian Institute of Planners, 1990. *Community Cycling Manual – A Planning and Design Guide*.

Types of Cyclists

A successful bicycle facility should provide a comfortable environment for the anticipated users. It is, therefore, important to identify the target group for whom the bicycle facility is being designed. According to Fitness Canada's Campbell Inquiry (1988), over 40% of all adult Canadians describe themselves as cyclists. Within

Photo: Windsor, Ontario

Recreational cyclists on an off-road multi-use trail.

this group, however, there is wide range of skill levels and considerable variation in typical trip length and purpose.

From a planning perspective, cyclists can generally be grouped according to cycling purpose, age and skill level.

Cycling Purpose

Recreational cyclists are individuals who use a bicycle for trip enjoyment, and usually take relatively short trips at lower speeds. An ultimate destination is of secondary importance.

Recreational Cyclists

Photo: Windsor, Ontario

Utilitarian cyclists are individuals who use a bicycle primarily for travel to and from specific destinations such as work, school, shops or recreation centres. Often, utilitarian cyclists do not own or use a personal automobile. In inclement or severe weather, or for longer distances, utilitarian cyclists may combine cycling trips with transit. They generally have good bike handling skills and a commitment to use their bicycle whenever possible. Research indicates that younger adults are more likely to cycle for utilitarian purposes as are male cyclists.

Age

Adult cyclists constitute the main group of bicycle infrastructure users. Their skill levels vary based on their experience and age. Trips range from casual recreational riding around the local neighbourhood, to utilitarian cycling over short and long distances each day for work, shopping or fitness purposes.

Child cyclists, especially those under the age of 13, often ride their bikes on residential streets, pathways and sidewalks to get to the corner store, school, friends' homes and recreational areas. Their motor skills and physical size are not always fully developed. This makes them less visible and prone to unpredictable behaviour, which may offset their ability to react to hazardous situations. Young cyclists must be educated on the rules of the road and safe cycling techniques. Bikeway designers must consider child cyclists as a key user group. Children should be encouraged to use their bicycle for utilitarian purposes. The child cyclist of today who cycles to school, the corner store and school can become the utilitarian and commuter cyclist of tomorrow.

Skill Level

Casual cyclists typically ride occasionally, and usually within their local neighbourhood or to local community destinations. They have reasonably good cycling skills, usually avoid roads with moderate to high traffic volumes and generally obey the rules of the road that they understand. They become easily discouraged by unfavourable cycling conditions, and typically prefer residential streets, trails and roads with bike lanes, but they usually ride on the latter type of facility only during the off-peak or times of lower traffic volumes. Ideal off-road conditions for casual cyclists are typically wide, flat routes, which do not require a high level of skill or a significant degree of attention to bicycle handling and control.

Experienced cyclists ride frequently and do so for both recreational and utilitarian purposes including leisure, sport and commuting purposes. They generally have good bike handling skills, and are not often discouraged by traffic or adverse cycling conditions. Utilitarian cyclists tend to prefer wide shared curb lanes and on-street bike lanes in urban areas, and paved shoulders on low volume roads in rural areas. As for off-road conditions, they prefer a wide range of trail types, and often prefer challenging trails with a variety in topography and surface conditions.

Barriers to Commuting

Distance, unsafe traffic conditions and lack of proper facilities are often cited as the major obstacles that discourage recreational cyclists from becoming utilitarian cyclists. This group also cites incompatibility with work clothes, lack of shower, change room and parking facilities, plus a perceived difficulty in carrying personal belongings on their bicycles as barriers to cycling.

It should be noted that as standards for work dress have become more casual, the incompatibility with work clothes has become less of an issue.

Bicycle Characteristics and Design Criteria

Dimensions

Bicycles are distinct from all other modes of transportation. They are the lightest and smallest vehicles on the road network.

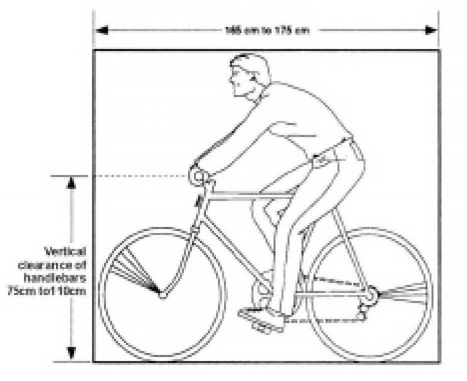
To assure safety and comfort, the design of bicycle facilities should account for the dynamic envelope required by a moving cyclist. The envelope consists of:

- the actual space occupied by a bicycle and cyclist (typically 0.6 m wide by 2.0 m high);
- an operating space allowance to accommodate the natural side-to-side

movement of a cyclist plus variations in bicycle tracking (0.2 m each side); and

- an additional clearance envelope to provide separation from lateral and overhead obstacles (0.25 m lateral and 0.5 m overhead).

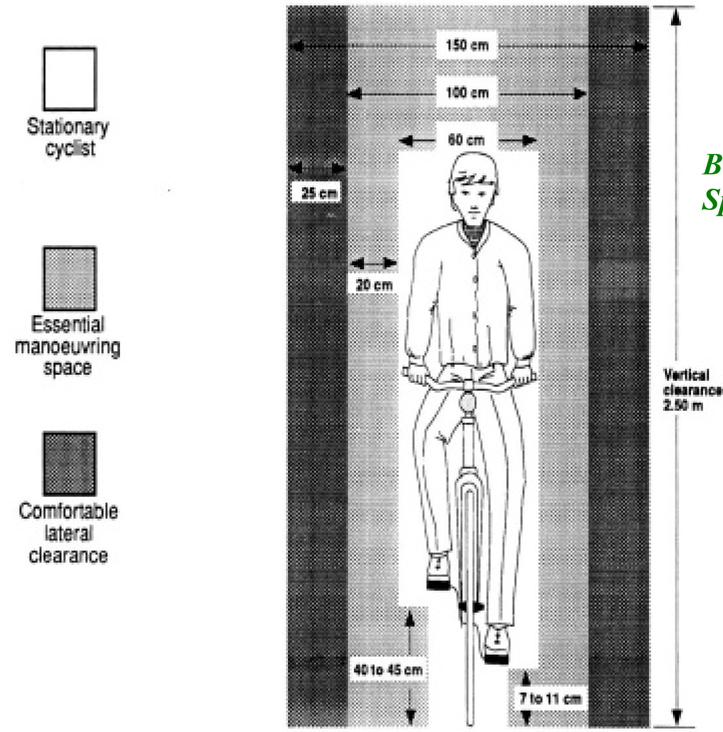
Bicycle Operating Space



Source: MTO, 1996 Ontario Bikeways Planning and Design Guidelines

Total design dimensions of 1.75 m (length), 2.5 m (height) and 1.5 m (width) should be assumed for the bicycle.

Bicycle Operating Space

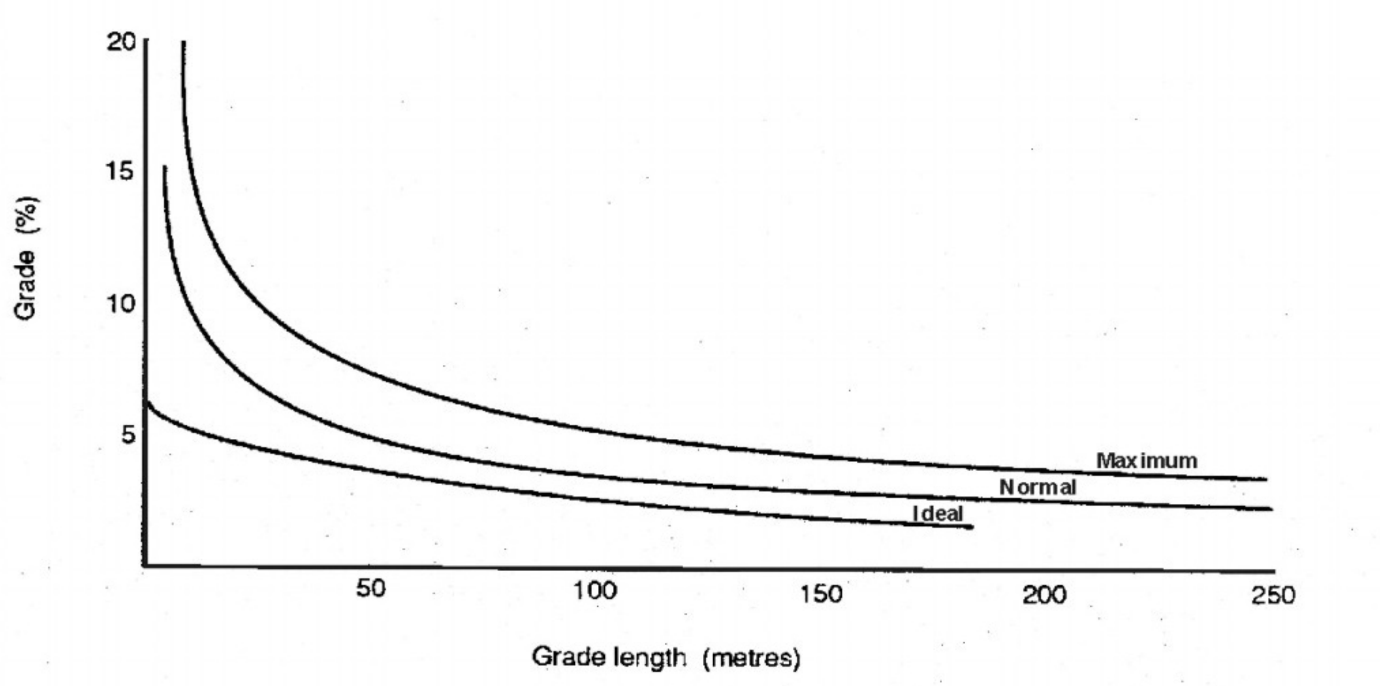


Source: MTO, 1996 Ontario Bikeways Planning and Design Guidelines

Design Speed

Most recreational cyclists can maintain a speed of 20 to 25 km/h, while utilitarian and fitness cyclists usually travel at higher speeds. In order to ensure that the bikeway system is safe for all users, a minimum design speed of 40 km/h should be provided. On descents with steeper grades (exceeding 4 %), the design speed should be increased to 60 km/h. It should be noted that since on-street bikeway systems utilize existing roadways which are generally constructed to a design speed of at least 50 km/h (for motorized vehicles), sight distances and curvatures should, in most cases, exceed the minimum bikeway design parameters. In the majority of cases, the cyclist's eye height is above that of the driver in a typical car, therefore the cyclist will actually be able to observe hazards at a greater distance.

Acceptable Ascent Grades for Design Purposes



Source: Balshone, L. Bruce, 1993. Bicycle Transit: Its Planning and Design

Maximum Grades

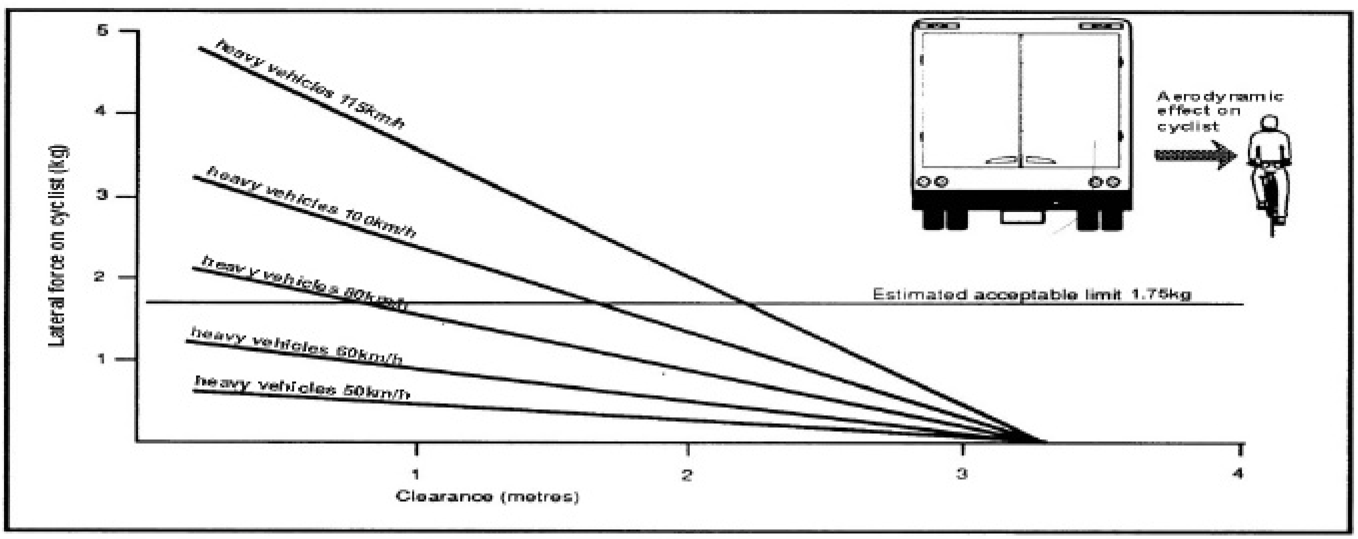
There are two major considerations when designing grades: the effort to ascend or climb, and conditions required for safe descent.

For a cyclist riding on a bike without a transmission system, it is almost impossible to climb a 50 metre long 10% grade. Bicycles equipped with a simple transmission system allow almost every cyclist to climb a 50 metre 15% grade. However, grades greater than 5% should normally be avoided, and desirable conditions, especially for long uphill grades, should not exceed 3%. Where possible, on long steep grades it is desirable to introduce relatively flat rest areas approximately every 100 metres of horizontal distance. The advent of the electric or electric assisted bicycle will require a future review of these standards.

Where one-way bicycle operation is proposed and cyclists will be travelling in a downhill direction, steeper and/or longer grades are not as much of a concern. It should be recognized, however, that speeds and stopping distances increase when travelling downhill, and that the available sight distances must be checked accordingly.

Effect of Motor Vehicle Speed on Cyclists

The space that is available between cyclists and vehicular traffic is an important safety issue. Motorized vehicles that pass with significant



The Aerodynamic Effect of Truck Passing

Source: MTO, 1996. Ontario Bikeways Planning and Design Guidelines travel speeds cause an aerodynamic force, which pushes the cyclist away or off of the roadway. It is estimated that a force of 1.75 kg is acceptable from a comfort and safety point of view.

Stopping Sight Distances

The minimum stopping site distance for bicycles is the distance required to bring a bicycle to a full controlled stop upon spotting an obstacle. It is a function of the cyclists' perception and reaction time prior to breaking, the initial speed of the bicycle, the coefficient of friction between the tires and the bikeway surface, and the braking capacity of the bicycle.

Stopping sight distance is given by the formula:

$$S = 0.694V + V^2 / 255 (f + G/100)$$

Where: S = stopping sight distance (m)

V = speed (km/h)

F = coefficient of friction

G = grade (%) (upgrade positive, downgrade negative)

Table 5.1 Minimum Stopping Sight Distances For Bicycles

Grade[1] (%)	Design speed (km/h)								
	10	15	20	25	30	35	40	45	50
	Minimum Stopping Sight Distance (m)								
+12	8	13	18	-	-	-	-	-	-
+10	8	13	18	24	-	-	-	-	-
+8	8	13	19	25	32	-	-	-	-
+6	8	13	19	25	32	40	-	-	-
+4	8	13	19	26	33	41	49	-	-
+2	8	14	20	26	34	42	51	61	-
0	9	14	20	27	35	44	53	63	74
-2	9	14	21	28	36	45	55	66	77
-4	9	15	21	29	38	47	58	69	81
-6	9	15	22	30	39	50	61	73	86
-8	9	16	23	32	42	53	65	68	92
-10	10	16	24	34	44	56	70	84	100
-12	10	17	26	36	48	61	76	92	110

Source: TAC, 1999. Geometric Design Guide for Canadian Roads

[1]Note: A positive grade is uphill, and a negative grade is downhill

Table 5.1 illustrates minimum stopping sight distances for a range of speeds and grades. It is based on 2.5 seconds of perception-reaction time and a coefficient of friction (f) of 0.25 that accounts for paved surfaces during wet weather and typical braking characteristics of bicycles.

The coefficient of lateral friction for unpaved surfaces should be reduced to 50% of those for paved surfaces.

Alignment Elements

The following provides information on horizontal, vertical and cross slope alignments.

Horizontal Alignment

The minimum radius of a curve depends on the bicycle speed, super-elevation and coefficient of friction between the bicycle tires and the bikeway surface. The following formula should be used to determine the minimum radius of horizontal curves:

$$R=V^2 / (127 * (e + f))$$

Where: R = radius (m)
V = speed (km/h)
e = super-elevation (m/m)
f = coefficient of lateral friction

For most applications and conditions, the coefficient of lateral friction varies from 0.3 at 25 km/h to 0.22 at 50 km/h, and for unpaved surfaces is reduced to 50% of those of paved surfaces. **Table 5.2** provides the coefficient of lateral friction and minimum radius for a range of design speeds and super-elevation rates.

Table 5.2 Minimum Radii for Paved Bikeways

Design speed (km/h)	Coefficient of lateral friction	Minimum radius (m)	
		e=0.02 (m/m)	e=0.05 (m/m)
25	0.30	15	14
30	0.28	24	21
35	0.27	33	30
40	0.25	47	42
45	0.23	64	57
50	0.22	82	73

Source: TAC, 1999. Geometric Design Guide for Canadian Roads

Refer to **Table 5.6** for typical cross slopes for bikeways. It should be noted that a combination of steep grade and high super-elevation might cause discomfort for slow moving cyclists.

Horizontal curves must be of sufficiently large radius to ensure that cyclists can safely negotiate the curve at the design speed. When horizontal curves are of very small radius, bikeway widening should be considered to compensate for the tendency of cyclists to track toward the inside of the curve. Widenings are not necessary for curves over a 32m radius, and will therefore not usually be a consideration for on-street routes. **Table 5.3** shows the recommended widening of the riding surface on curves.

Table 5.3 Widening of the Riding Curve Surface on Curves

Radius of Curvature (m)	Extra width required (grade 0 to 3%)
24 to 32	**250 mm**
16 to 24	**500 mm**
8 to 16	**750 mm**
0 to 8	**1,000 mm**

Source: Vélo Quebec, 1992. Technical Handbook of Bikeway Design

Horizontal curves must also be checked to ensure that there are no obstructions located on the inside of the curve, which could block the cyclists' line of sight and reduce stopping sight distance.

Vertical Alignment

Maximum gradients have been previously discussed. The minimum gradient for bicycles is 0.6%, however, this can be reduced to 0% when drainage is provided by adequate cross slope (1% to 2%).

The minimum length of crest vertical curves depends on the minimum stopping sight distance for the design speed of the facility. This is calculated to satisfy the safety requirements of bringing a bicycle from full speed to a full stop when an obstacle is spotted on the bikeway surface. **Table 5.4** shows vertical curve lengths for different design conditions for paved surfaces under wet conditions. Stopping sight distance for unpaved surfaces should be adjusted accordingly to satisfy reduced lateral friction conditions equal to 50% of those for paved surfaces.

Table 5.4 Vertical Curve Lengths

Minimum curve length (m)									
Change of grade (%)	**Design speed (km/h)**								
	10	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
2	-	-	-	-	-	-	-	-	**11**
5	-	-	-	-	**15**	**32**	**51**	**71**	**100**
10	-	-	**13**	**27**	**44**	**69**	**102**	**145**	**199**
15	-	**10**	**22**	**40**	**67**	**104**	**153**	-	-
20	**3**	**14**	**30**	**54**	-	-	-	-	-
25	**6**	**18**	**37**	-	-	-	-	-	-

Source: TAC, 1999. Geometric Design Guide for Canadian Roads

The following formula should be used to determine the stopping sight distances when they are greater than the curve length above the line:

$L = 2S - 274/A$

Where: L = minimum curve length
S = minimum stopping sight distance from Table 5.4
A = algebraic difference in grades (%)

Below the line, stopping sight distances are less than the curve length and $L = AS^2/274$.

The criterion for bicycles on sag curves is comfort, which is expressed in terms of a vertical maximum radial acceleration of 0.3 m/s^2. However, it is important to consider non-illuminated bicycle paths, which might be used by cyclists after dark, by providing them with longer vertical curves. **Table 5.5** provides K values corresponding to different design speeds. The following formula should be used to determine the minimum sag curvature:

$K = V^2/390$

Where: V = speed in km/h.

Table 5.5 Sag Vertical Curves for Bicycles

Design Speed (km/h)	Minimum Sag Curvature (m)
25	1.5
30	2.5
35	3
40	4
45	5
50	6

Source: TAC, 1999. Geometric Design Guide for Canadian Roads

It is recommended that bikeways with steep grades be widened to allow cyclists the extra space needed to either make corrections to their trajectory at higher speeds going downhill, or to maintain balance at lower speeds heading uphill. It is not necessary to widen bikeways on grades shorter than 75 m or shallower than 6%. **Table 5.6** summarizes the extra bikeway width required on grades as a function of steepness and length.

Table 5.6 Extra Bikeway Width Required on Grades

Grade (%)	Length (m)		
	25-75	75-150	150+
3-6	-	20 cm	30 cm
6-9	20 cm	30 cm	40 cm
9+	30 cm	40 cm	50 cm

Source: Vélo Quebec, 1992. Technical Handbook of Bikeway Design

Horizontal and Vertical Clearance

For on-road bicycle facilities, a minimum horizontal clearance of 600 mm should be maintained between the bikeway and any obstruction having height in excess of 150 mm including signs, lighting poles, trees and curbs. For off-road facilities, a minimum clearance of 600 m should be maintained between the trail and any obstructions such as signs, trees, shrubs, fences, barriers and trailside furnishings.

A minimum vertical clearance of 2.5 m should be maintained to the underside of all overhead structures.

Additional clearance may be required over that which is identified above to accommodate service vehicles and other users such as equestrians on off-road rural trails.

Cross Slope

A bikeway may have a crown or continuous cross slope. It is preferable to use a balanced cross slope on two-way bikeways for drainage purposes, and also to direct cyclists to the right side of the bikeway. Typical cross slopes depend on the surface type. **Table 5.7** summarizes typical cross slopes for different surface materials.

Table 5.7 Typical Cross Slopes

Surface	Range of cross Slope (%)
Concrete	1.5% to 2%
Asphalt	2% to 4%
Gravel, crushed stone, earth	2% to 4%

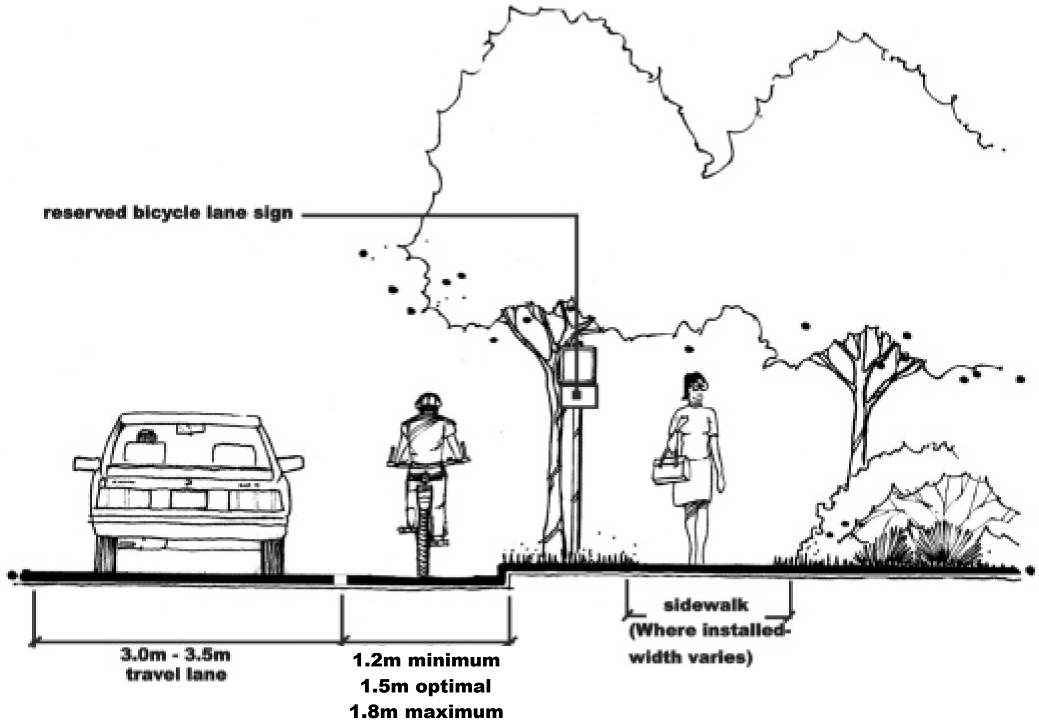
Source: TAC, 1999. Geometric Design Guide for Canadian Roads

Bikeway Design

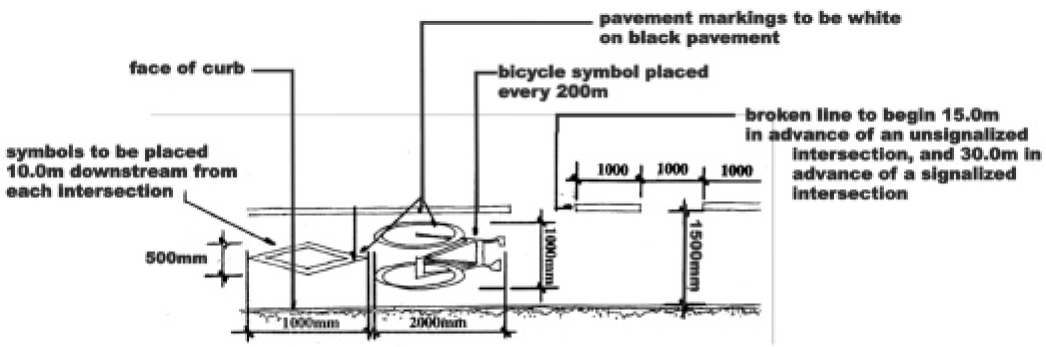
Bike Lanes

Bike lanes on urban roads consist of a designated space between the edge of the vehicular lane and the curb. Pavement markings, symbols and

Typical Bike Lane Cross Section



plan: n.t.s.



signage are used to designate this space for exclusive bicycle use. Bike lanes have several advantages over wide shared lanes. Some of these include exclusive space, and the perception of a higher level of safety. Bike lanes are therefore attractive to less skilled cyclists and may encourage more people to cycle. The optimum recommended bike lane width is 1.5 m (1.2 m minimum to 1.8 m maximum), enabling cyclists to travel in single file. Lane widths greater than 1.8 m are not recommended since they may encourage use by automobile drivers for passing other vehicles on the right, or for stopping and parking.

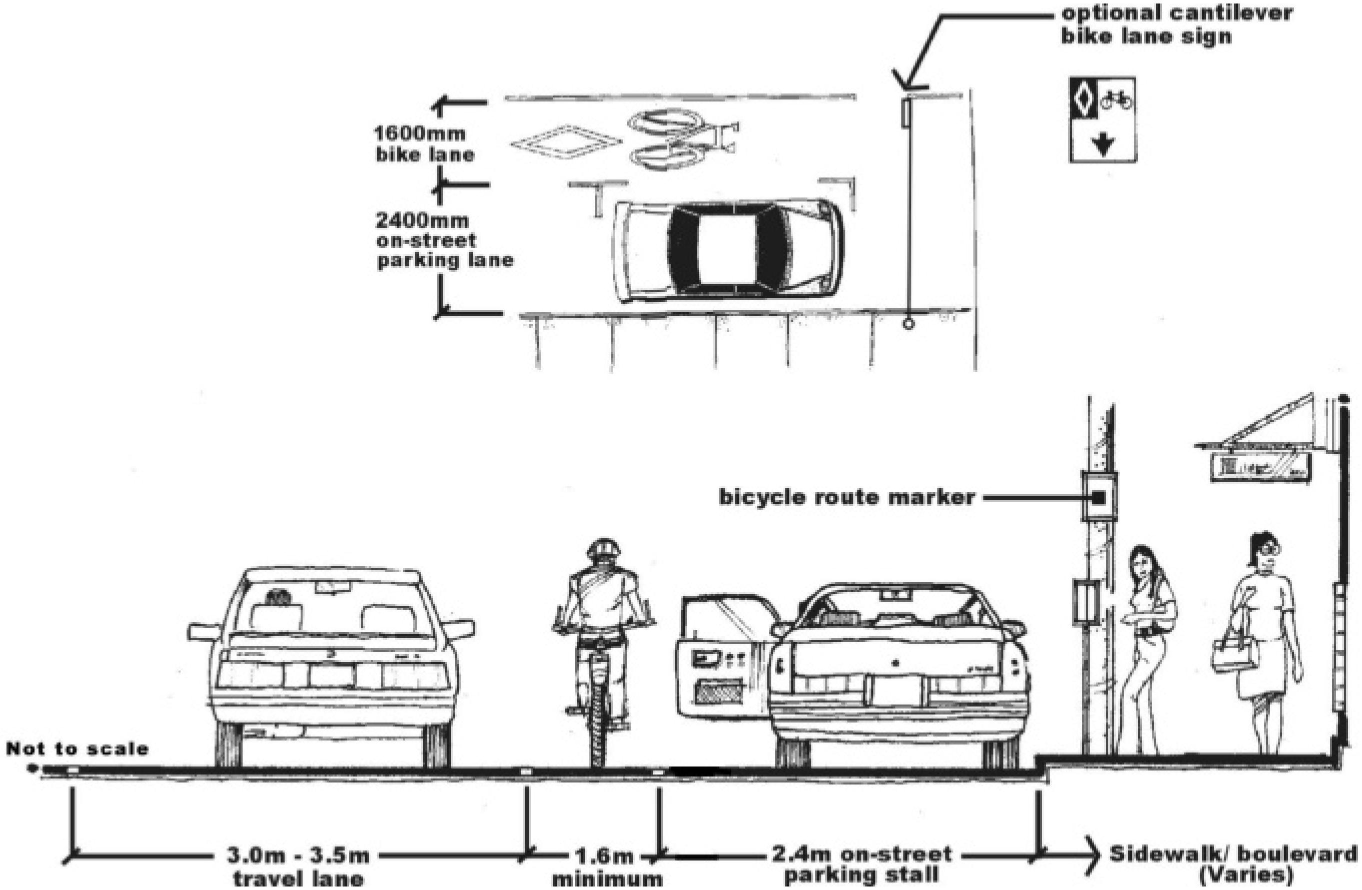
Photo: Toronto, Ontario

Bike Lanes with On-Street Parking

Bike lanes on roads with on-street parking should be considered in commercial and residential areas where the demand for and turnover of parking is high, or where commercial and residential property owners may not accept the reduction or prohibition of on-street parking. Bike lanes on roads with on-street parking are located immediately adjacent to the left of parked vehicles along the curb. Designing this type of bikeway facility must take into consideration the potential hazard to cyclists of vehicle doors opening into the travelled portion of the roadway.

In order to allow clearance for vehicle doors, and to minimize collisions with cyclists, the combined bicycle/parking lane should be a minimum of 4.0 m wide. This width allows for a 1.6 m bike lane and a 2.4 m wide curbside parking stall. The extra 0.4 m added to the typical 2.0 m wide curbside parking stall provides space for the opening of vehicle doors, and encourages cyclists to travel at a safe distance away from parked vehicles.

Typical Bike lane with On Street Parking



On Street Signed Routes

Standard

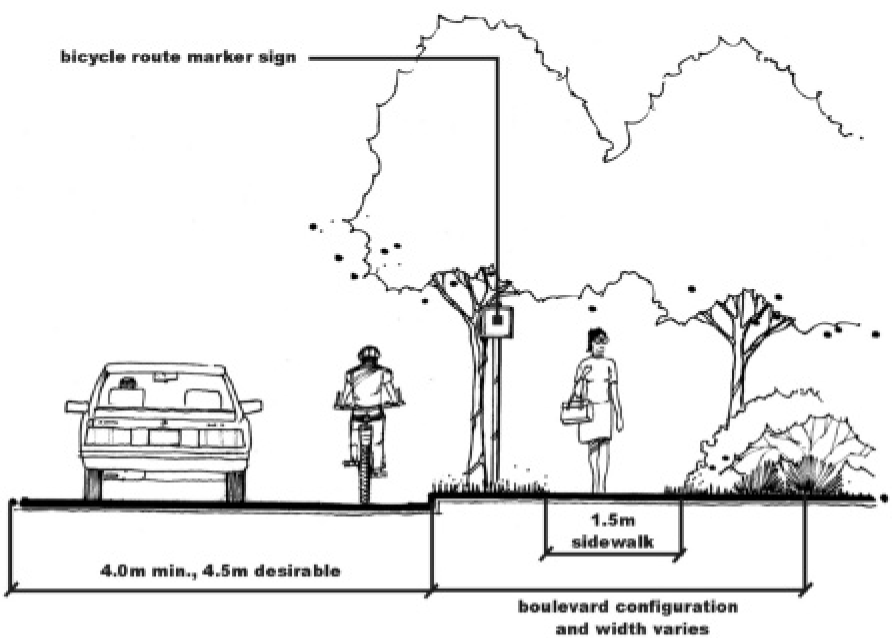
On-street signed bike routes are typically found on local and collector roads, although they can be implemented on arterial roads to form a connection or link in a cycling network. On-street signed routes should only be implemented where wide curb lanes exist or can be provided, or where traffic volumes are low. Wide curb lanes should have sufficient width to allow motorists to pass cyclists without encroaching on an adjacent travel lane. Wide curb lanes should be encouraged for all road class types to provide bicycle friendly streets, whether a designated bikeway or not.

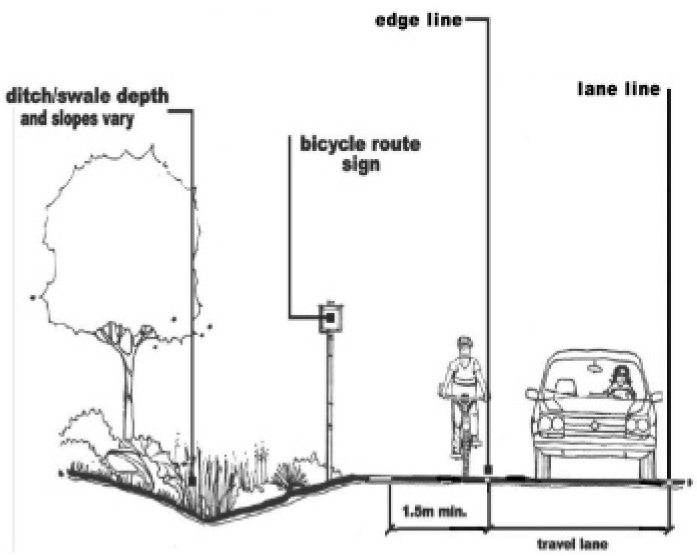
The preferred width for a curb lane is 4.5m, with an acceptable range from 4.0m to 5.0m.

An on-street signed route can form part of a cycling network when the addition of bike lanes is not possible. In some cases bike lanes are inappropriate, such as in residential neighbourhoods where traffic volume is low, or impossible in the short term due to limited pavement or right-of-way widths and/or because of on-street parking.

In addition to bicycle route marker signs for on-street signed routes, consideration should be given to shared-use pavement markings and/or signs in accordance with accepted standards (e.g. *Bikeway Traffic Control Guidelines*, Transportation Association of Canada, 1998).

Wide Shared Lane





Paved Shoulders

A relatively easy way to provide for cyclists on roads with granular shoulders is to pave a 1.5 m wide section of the shoulder. Paved shoulders can be considered for on-road routes along rural sections with no curb or gutter edge, and a speed limit at or below 80 km/h. Paved shoulders offer other advantages:

- reduced maintenance costs associated with the grading of gravel shoulders;
- extended life of the vehicle lanes; and
- reduced run-off-the-road collisions.

However, it should be noted that paved shoulders are not ideal for year round cycling since they often are used, whether intentionally or not, for snow storage during winter months.

Multi-Use Trails

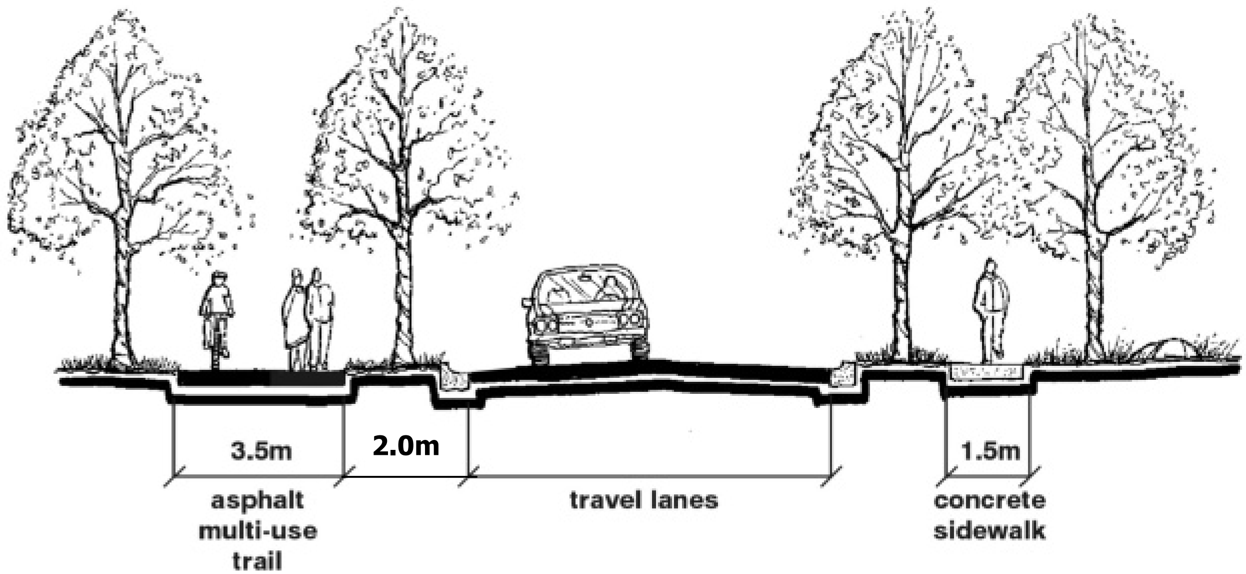
Bi-Directional

Multi use trails should be designed to accommodate a variety of user groups. Design standards vary depending upon the trail's location, the anticipated number of users and permitted uses.

The minimum width is typically 3.0 m, which allows for bi-directional flow. On popular, heavily travelled multi-use trails, widths of up to 4.0 m are recommended to allow for a wider variety and greater number of users, and a centre line should be provided to organize traffic.

Recommended multi-use trail surfaces include granular ('A' gravel, stonedust) or asphalt. Recently, some municipalities have been experimenting with concrete and also asphalt mixes that use materials such as recycled asphalt, plastics, rubber and ground glass. Certain types of granular surfaces limit trail access for other wheeled uses such as wheelchairs, strollers and in-

Multi-use/ Boulevard Trail



line skaters, so intended uses should be considered prior to the specification of surface materials. In high volume or tourist areas, it may be desirable to separate slower users from faster ones by providing separate trails.

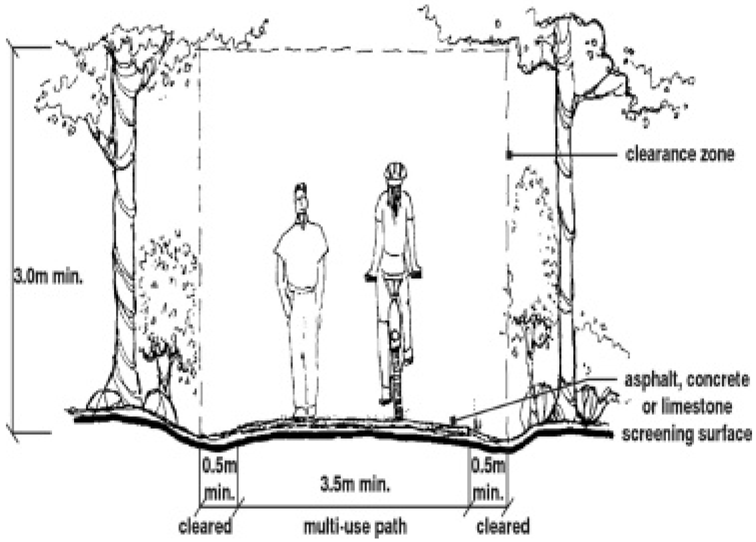
Cyclists often find busy multi-use trails to be ineffective for commuter and utilitarian purposes due to potential conflicts with other user groups. Pedestrians and other trail users can often feel uncomfortable on multi-use trails amongst high volumes of cyclists and inline skaters.

Single-Track Trails

Many experienced off-road cyclists prefer single-track trails. In rural areas they are often associated with large public conservation areas, provincial parks, municipal/regional forests as well as privately owned lands such as cross country and downhill ski resorts. In urban areas, single-track trails are often found in public valleys, forest blocks and public parks.

Single-track trails may or may not be connected by off-road routes. Single-track trails tend to be narrower (0.6 m to 1.0 m), have a natural earth surface, and have the widest variety in topographic and surface conditions. Typically, corner radii are smaller and grades are steeper than bi-directional multi-use trails to provide the greatest variety for off-road cyclists. Extensive single-track trail systems can be organized into a

Off-Road Multi-Use Trail Typical Cross Section



spine, loop, stacked loop or maze arrangement. Obstacles such as logs, rocks and boulders can be left on the trail bed to increase the level of difficulty and to challenge riders. In reality, single-track trails tend to be multi-use, since they are often used by bikers and cross-country skiers.

Intersection Treatments

Bikeway approaches to intersections should be carefully designed to encourage the safe and predictable movement of cyclists, motorists and pedestrians. Since intersections are the most likely areas for conflict between various users of the roadway, care should be taken to design and mark the intersection approach such that all users understand and anticipate the potential movements of other road users.

Off-Road Single Track Trail

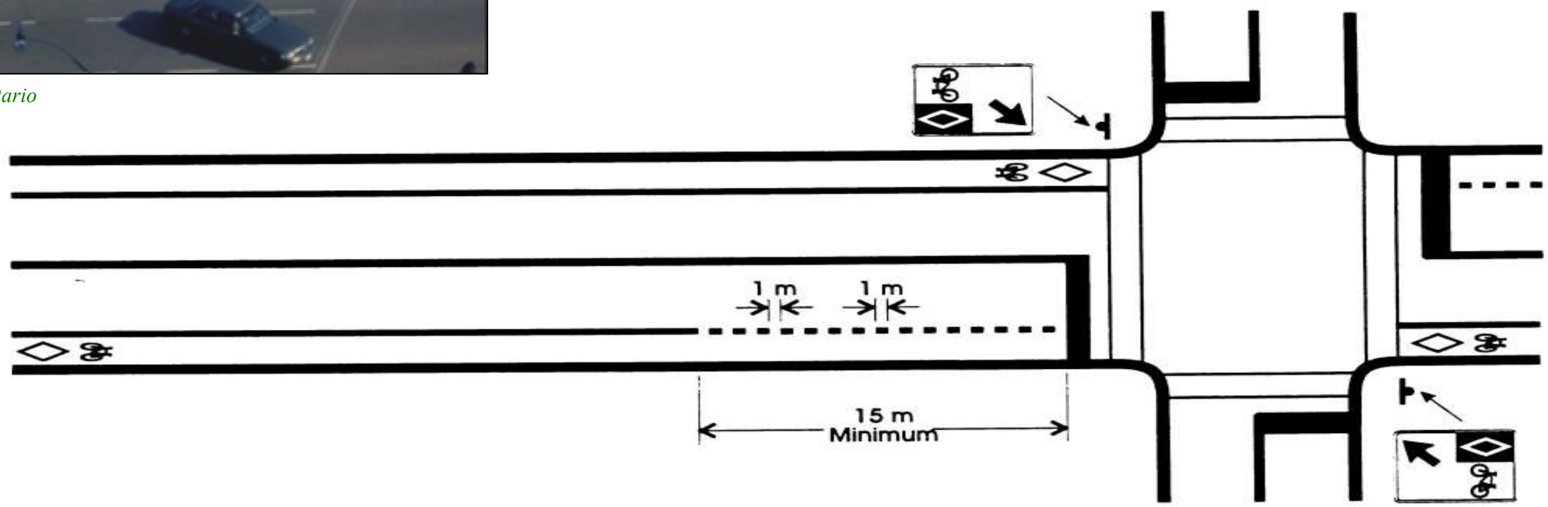
Photo: Guelph, Ontario

Photo: *St. George Street – Toronto, Ontario*

One of the most common conflicts at intersections occurs between right turning motor vehicles and cyclists proceeding straight through, since it is necessary for these two road users to cross paths. Pavement markings and signing should be designed to encourage such crossings in advance of the intersection, rather than in the immediate vicinity of the intersection. Left turning cyclists must also undertake a similar crossing with vehicular traffic whether they elect to undertake a "vehicular style" left turn by using the motor vehicle left turn lane, or they choose to complete a "pedestrian style" turn by proceeding straight through the intersection, then turning left to cross again on the intersecting road.

Bicycle lane at the intersection of St. George St. and Harbord St. in Toronto (above).

Note pavement markings compared to the TAC standard in the picture (right)



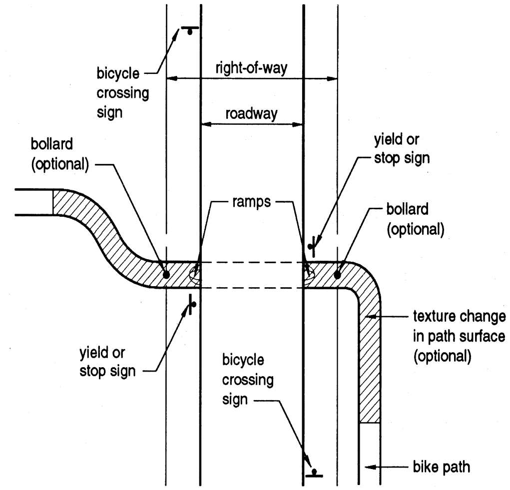
Source: TAC, 1998. *Bikeway Traffic Control Guidelines*

For the above noted reasons, it is usually desirable to discontinue bike lane markings, or to change from a solid to a broken line on the approach to the intersection.

The bike lane marking should be discontinued at the start of the taper when right turn lanes or channelizations are provided, or otherwise a broken line should be used a minimum of 30m from a signalized and 15m from an unsignalized intersection. This allows cyclists to merge with other traffic and prevent right turning motorists from having to cross through a bike lane to make their turn, thereby cutting off cyclists at the intersection. By discontinuing the solid bike lane marking, both the cyclists and motorists are made aware of the fact that they are sharing a common lane and should react accordingly.

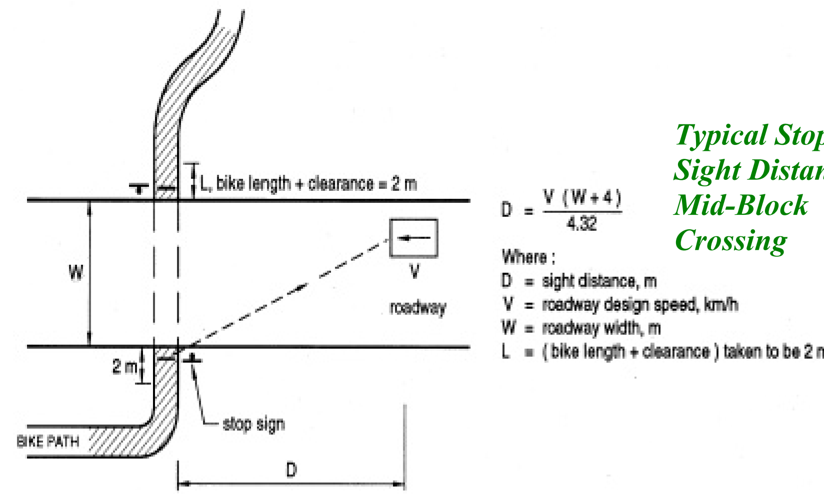
Mid-Block Crossing

Many municipalities are now including hydro and abandoned/active rail corridors in their cycling networks. Abandoned rail corridors in urban areas are especially suited for multi-use trail systems, with many offering grade separated crossings of major arterial roads. Hydro corridors provide excellent opportunities for linear trail links, but they also result in road crossing challenges, often because they occur at mid-block locations. Where a bike path crosses a street, mid-block crossings traditionally tend to be avoided. This is largely



Typical Mid-Block Crossing

Source: TAC, 1999. Geometric Design Guide for Canadian Roads



Typical Stopping Sight Distance at Mid-Block Crossing

Source: TAC, 1999. Geometric Design Guide for Canadian Roads because a motorist may not expect conflicts with cyclists crossing mid-block, and it may be difficult to satisfy the warrants for either a traffic signal or crossover.

Mid-block crossings should be designed to provide advance warning to both motorists and cyclists of the impending crossing. The bikeway should be designed to encourage the cyclist to reduce speed and to stop if necessary. Grade changes on the bikeway in advance of the crossing combined with adequate sight distances, signing, textural surface contrast and bollards should be considered. Mid-block crossings of arterial or collector roads may warrant consideration of a separate traffic signal or a pedestrian crossover (PXO).

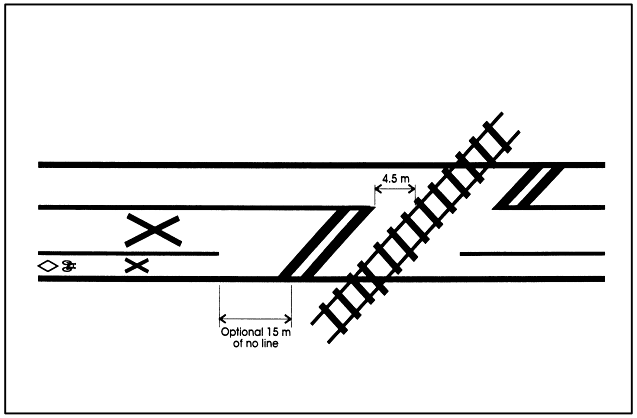
Railway Crossings

Any intersections with track crossings can be extremely dangerous for cyclists, and therefore extra caution should be applied to assure their safe operation. It is strongly recommended that appropriate traffic control devices be installed at the intersections of railway tracks and bikeways.

These include:

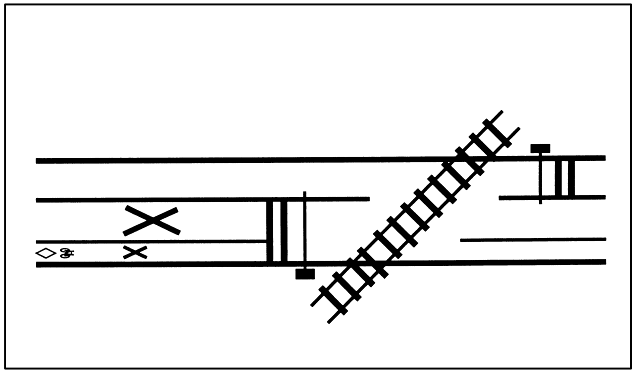
- pavement markings;
- signage; and
- lift gates.

The aforementioned traffic control devices should be designed and installed in accordance with the Bikeway Traffic Control Guidance (TAC, 1998) and the Manual of Uniform Traffic Control Devices for Canada (TAC, 1998).



Source: TAC, 1998. Bikeway Traffic Control Guidelines

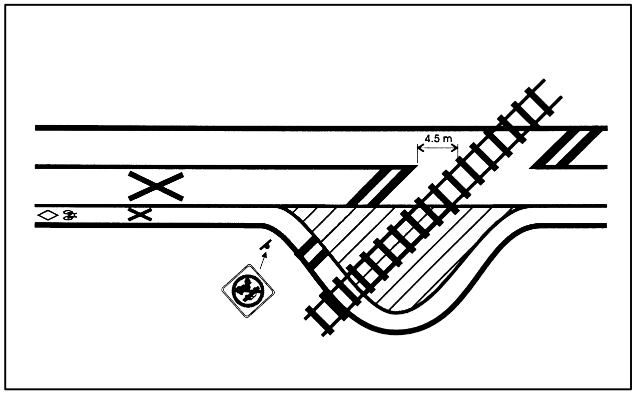
Bicycle Lane at Skewed Railroad Crossing with Restricted Right-of-Way Width.



Source: TAC, 1998. Bikeway Traffic Control Guidelines

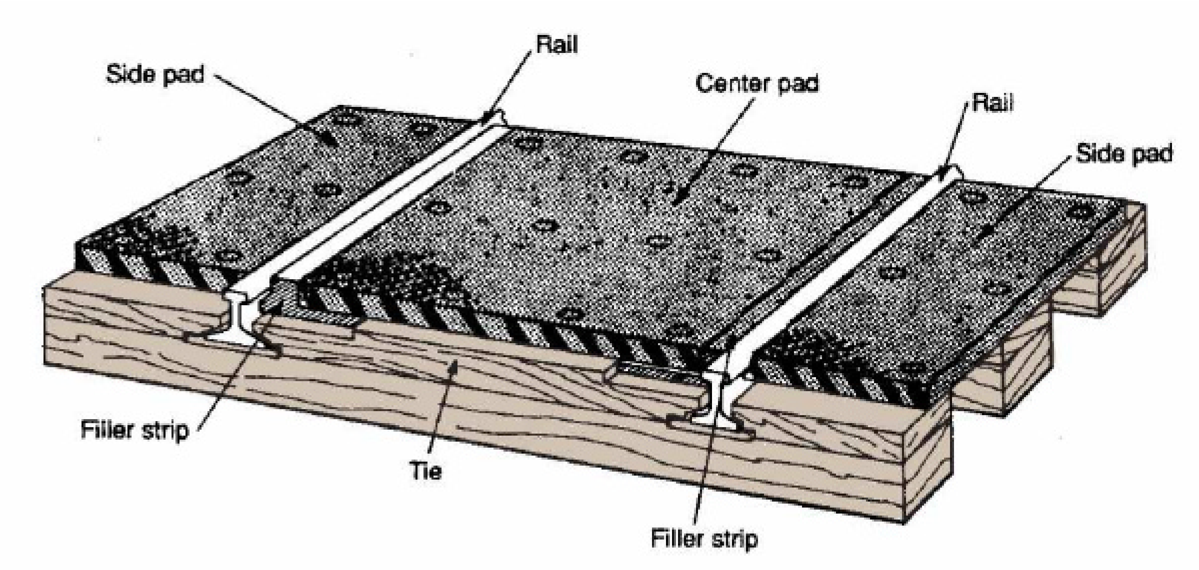
Bicycle Lane at Skewed Railroad Crossing with Restricted Right-of-Way Width and Gate Control.

Furthermore, it is recommended that bikeways be designed to cross railways at as close to right angles as possible. In many situations this may require widening of the trail or bikeway in advance of the crossing, thereby allowing cyclists to reduce their speed and position themselves for crossing at right angles. Rubber track guards are also recommended to assure better friction between bike tires and the pavement, and also to narrow the rail gaps.



Source: TAC, 1998. Bikeway Traffic Control Guidelines

Bicycle Lane at Skewed Railroad Crossing with Unrestricted Right-of-Way Width



Source: MTO, 1991. *Guidelines for the Design of Bikeways* – Ontario

Bicycle Friendly Road Crossing

Cyclists Crossing at Traffic Signals

Bicycles should be considered in the timing of traffic signals and in the selection, sensitivity and placement of vehicle detection devices wherever there is bicycle traffic. It is very important that loop detectors at signalized intersections be sensitive to bicycles, otherwise cyclists are likely to disobey the unchanged signal. Another alternative is to utilize a pedestrian style push-button to actuate traffic signals for cyclists. These should be located on the curb side, separate from the pedestrian push-button.

Coloured and/or Textured Pavement

Intersections, crossings and interchange ramps are considered to be the most difficult elements in a bicycle network. It has been recognized that the application of coloured and/or textured pavement to illustrate pedestrian and bicycle crossing points at intersections may significantly improve the safety of cyclists by informing both cyclists and motorists of a bicycle crossing and the space it comprises. Coloured pavement treatments are widely used in European cities. In North America, a number of cities are now experimenting with coloured pavement and concrete treatments at crossings – Portland, Oregon being one notable example. Textured pavement or concrete is also used in certain jurisdictions.

It is recommended that municipalities consider the addition of coloured and/or textured pavement treatments at interchange ramps and advance warning signs to inform both cyclists and motorists of the bicycle crossing.

Illumination

Effective lighting is an important influence on safe travel on bikeways, particularly after sunset. Modern lighting equipment on bicycles is generally inadequate to illuminate potholes and other hazards to the cyclist while travelling at reasonable speeds. Specific bikeway illumination is recommended for routes expected to have significant nighttime use.

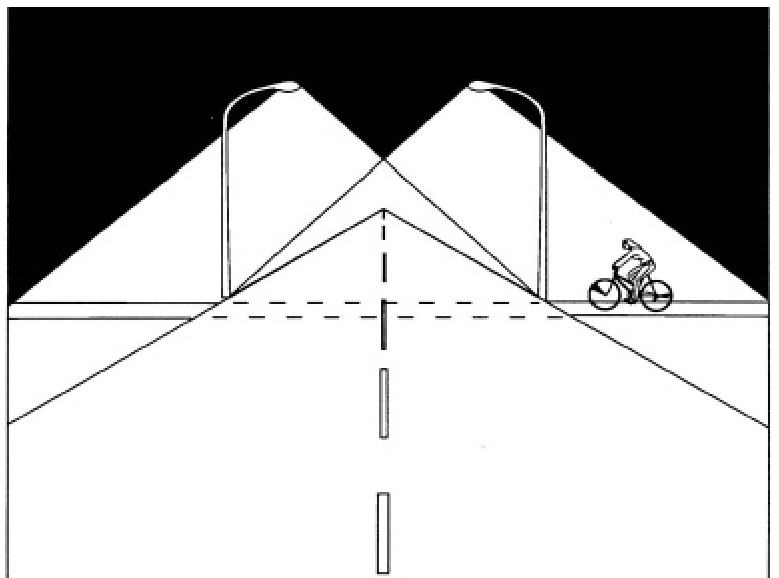
It is recommended that the area bordering bikeways for a width of two to five metres on each side be lighted to levels of at least 1/3 of that for the bikeway. The level of horizontal illumination needs to be sufficient to easily follow the bikeway, avoid potholes and other obstacles and to read pavement markings. Adequate vertical illumination should make vertical surfaces such as fences, walls, curbs, trees and shrubs clearly visible. The lighting system as a whole should:

- enable cyclists to see other cyclists;
- enable cyclists to read signs;
- allow motorists to see cyclists where the path intersects a road or is in close proximity to a road; and

- provide adequate illumination along the entire length and width of the bikeway.

Lighting of hazards or areas that are potentially hazardous to cyclists is recommended. This could include:

- intersections with other trails or roads;
- sharp horizontal and vertical curves;
- steep grades;
- ramps to structures;
- portals of tunnels and subways;
- places where clearance to obstructions is minimal;
- areas where pedestrian volumes are high;
- locations with special security problems/issues; and
- special facilities such as stair and multi-unit bicycle parking facilities.



In the approach to an intersection, cyclists must be lit at least as brightly as the adjacent streets. A cyclist suddenly appearing out of the dark may not be seen by motorists until he begins to cross the intersection, and a collision may result.

Source: MTO, Ontario Bikeways Planning and Design Guidelines. 1996.

Lighting for a Bikeway Crossing a Street

Table 5.8 summarizes the recommended illumination levels for various on-road and off-road locations.

The principal components that determine the performance of a lighting system are the lamppost, the luminaire and the light source. There are many types of light sources including incandescent, fluorescent, mercury vapour, halogen, high-pressure sodium and metal halide. Metal halide, mercury vapour, halogen and high-pressure sodium vapour are most often used because they are high-intensity lamps that are activated by electrical discharges. They provide much greater luminous efficiency and have very long lamp lives. Although high-pressure sodium vapour is the most energy efficient and bulb life is the longest, the colour spectrum is artificial. As a result, human perception and behaviour in the nighttime environment can be enhanced with the use of low wattage metal halide lighting for off-road multi-use trails. The quality of low wattage metal halide light allows trail users to discern both the trailway surface and the surroundings. High pressure sodium vapour lighting is the common standard for roadways, and therefore applies to on-road bicycle facilities.

Note that not all off-road trails need to be lit. Unlit trails can be easier to use at night since cyclists' eyesight can adjust to the darkness. Lighting off-road trails can be very costly to implement and maintain, and depending on the location of the trail, there may be enough ambient light from nearby roads or parking lots to light the trail. Finally, vegetation adjacent to the trail may need darkness to permit time to "rest".

Placement of the lighting poles must be carefully considered. The minimum clear-zone should be applied to the placement of lighting poles. Signs should be installed in accordance with roadway signage standards and be placed so that they are well lit.

It is also important to ensure that tree branches and other obstacles do not obstruct the passage of light. Therefore, periodic inspection and pruning of tree growth is necessary.

Support Facilities

The provision of bicycle parking plus related support and end-of-trip facilities is a key and sometimes overlooked element of bikeway system design. Developing and maintaining a comprehensive network of on and off-road bikeway facilities does not automatically mean cyclists will use the network. The network has to be promoted, cyclists need to feel comfortable and safe in using it, and they must have access to adequate parking and end-of-trip facilities. For commuters, this means secure bicycle parking facilities, showers and change rooms.

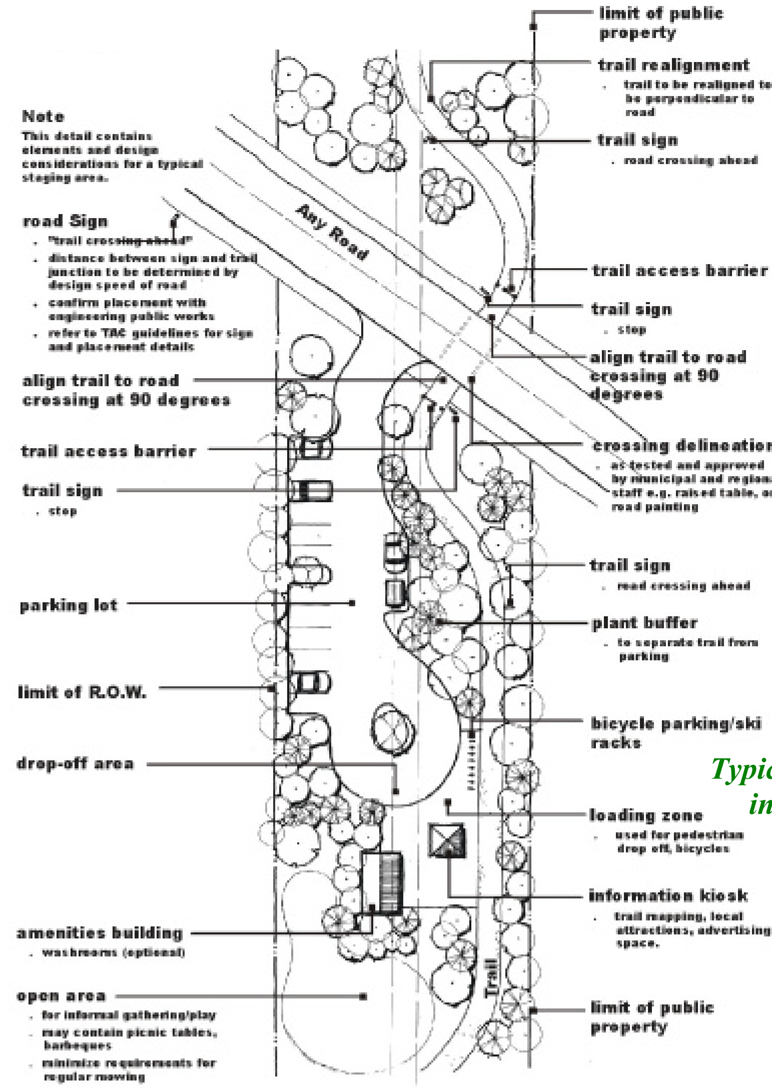
Table 5.8
Bikeway illumination Levels

LOCATIONS	MINIMUM	AVERAGE	UNIFORMITY RATIO
Multi-Use Trail			
Horizontal	1	5	5/1
Vertical	1	5	5/1
Intersection on Unlit and Lit Street			
Horizontal	1	3	3/1
Vertical	2	5	2.5/1
Designated Signed Route or Bike Lane			
Horizontal	2	5	2.5/1
Vertical	2	5	2.5/1
Tunnel (>10 metres)			
Horizontal	10	43	4.3/1
Vertical	12	54	4.5/1
Tunnel (<10 metres)			
Horizontal	6	20	3.3/1
Vertical	7	24	3.5/1

Source: MTO, 1999. Ontario Bikeways Planning and Design Guidelines

Rest Areas

Rest areas should be provided along off-road bikeway systems where highly visible and space permits. Areas where cyclists tend to stop such as interpretative stations, lookouts, restaurants, museums and other attractions or services are logical locations for rest areas. Ideally, there should be a rest area every five kilometres on a recreational bikeway. Typical furnishings to be considered include benches or tables, washrooms, drinking fountains, trash cans, information signing complete with mapping, plus bicycle parking facilities. Additional services may include an air pump, shelter and telephones. Parking for automobiles should be provided at key locations throughout the network, providing opportunities for both recreational cyclists using off-road cycling trails as well as commuters who may be encouraged to include cycling as part of their commute where "car-pool" lots are conveniently located. The number of spaces required should be determined on a site-specific basis, and should account for factors such as supply and demand of automobile parking elsewhere throughout the network.



Typical Elements in a Rest Area Design

Source: ESG International design, 2001.

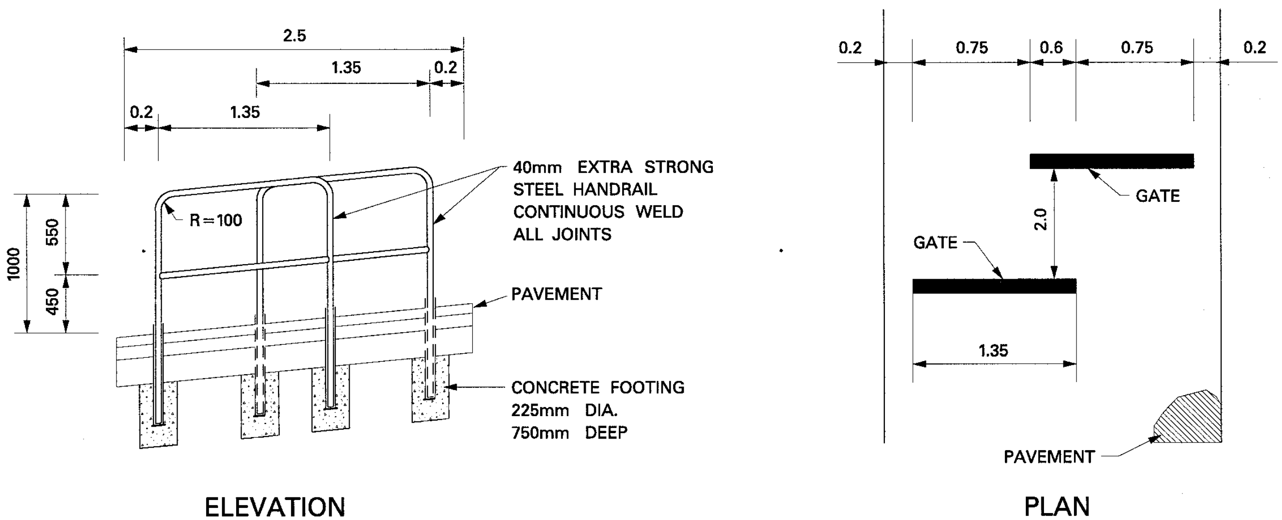
Bollards and Offset Gates

To prevent access by unauthorized users such as motor vehicles, barriers should be installed at the trail entrances. Barriers must be clearly marked and visible, otherwise they can become a hazard to cyclists. Trailside signage alerting cyclists of the upcoming roadway, intersection or other hazards should be appropriately located to provide adequate time to slow down and/or stop as required.

Although not a preferred solution, offset gates can be used as a bicycle traffic calming measure, particularly at busy intersections. Offset gates should be designed to provide uninterrupted through access for bicycle trailers.

Bollards are typically used to control access to bikeways. A single, central bollard should be used to prevent collisions between cyclists and prevent motorized vehicle access. The use of two bollards is typically not recommended because it can cause congestion and collisions as

NTS TYPICAL OFFSET GATE DESIGN



Source: MMM, 2001. Design adapted from Community Cycling Manual – A Planning and Design Guide, Canadian Institute of Planners, 1990.

Stairs with a side ramp.

Source: TAC, 1991. Guidelines for the Design of Bikeways

cyclists converge into the narrow central opening. Bollards should be at least 1.2 metres high and coated with a reflective material to be visible at night.

Both bollards and offset gates should be removable by trail management staff to allow access for maintenance vehicles.

Stairways with Side Ramps

Staircases are a nuisance to cyclists, and in extreme cases can become a barrier to cycling. New staircases should be designed with a channel for bicycles, and existing staircases should be examined for opportunities for retrofitting. A concave or channel-shaped ramp on the side of the staircase will allow cyclists to roll their bicycle while walking up or down the stairs.

On-Road Traffic Control

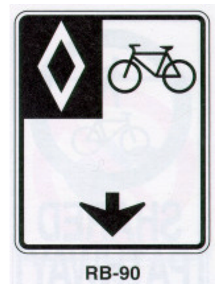
Signs, pavement markings and other traffic control devices for on-road bikeways should be designed and installed to comply with the Manual of Uniform Traffic Control Devices published by the Ministry of Transportation, as well as the TAC Bikeway Traffic Control Guidelines.

It is also recommended that traffic control signs for off-road trails be designed with the same characteristics as on-road signs. This helps to establish consistency throughout the system. It can be assumed that adult cyclists who are also motor vehicle operators will be familiar with this signing system. Following these standards will also benefit child cyclists who will be familiar with on-road signing by the time they become licensed motor vehicle operators.

Signage

The objective of using traffic signs is to inform users of traffic regulations, warn of road characteristics and road hazards, and provide information necessary for route selection. Signs must be designed with these objectives in mind and installed properly to maximize their effectiveness. Only TAC approved bikeway signs are recommended for on-road bikeway facilities.

The Transportation Association of Canada (TAC) *Bikeway Traffic Control Guidelines for Canada* (BTCGC), 1998 is the current national guideline for the signing of bikeways. The three different categories of signs as outlined in the BTCGC are regulatory, warning and information.



Source: TAC, 1998. Bikeway Traffic Control Guidelines for Canada.

Examples of typical regulatory signs.

Regulatory: The regulatory signs convey traffic laws or regulations which would not otherwise be apparent. For example, bicycle lane signs should be located prior to the beginning of a marked bike lane to advise motorists and cyclists of the upcoming roadway designation.

Photo: Windsor, Ontario

Warning: These signs warn motorists or cyclists of potentially hazardous conditions on or adjacent to the road or path. The use of warning signs should be limited to areas where the conditions might not be apparent to avoid overuse of a sign.

Examples of typical warning signs.

Source: TAC, 1998. Bikeway Traffic Control Guidelines for Canada.

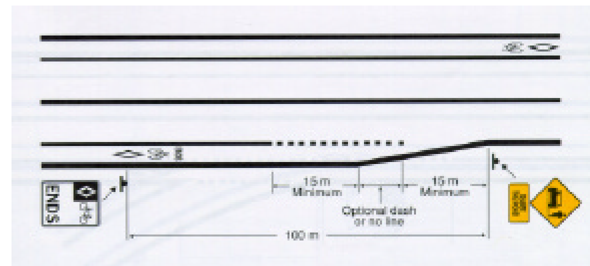
Examples of typical guide and information signs.

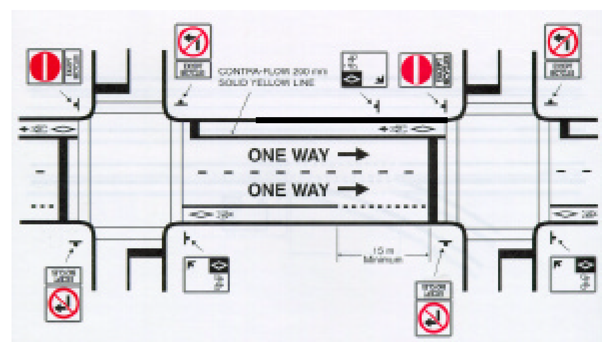
Source: TAC, 1998. Bikeway Traffic Control Guidelines for Canada.

Guide and Information: These signs provide cyclists with information relating to route identification and direction to ensure that the route is accurately followed.

The Windsor Trail Signage Guidelines were developed in 1994 to provide a framework for signage on the off-road trail network. These guidelines have been reviewed and adopted by the City for use on their on-road bicycle network as well. Where there exists a conflict between the Windsor Trail Signage and the BTCGC, however, the national guideline would take precedence.

Examples of appropriate signs and pavement markings that can be used for mid-block discontinued bike lanes (top) and contra-flow lanes (bottom).





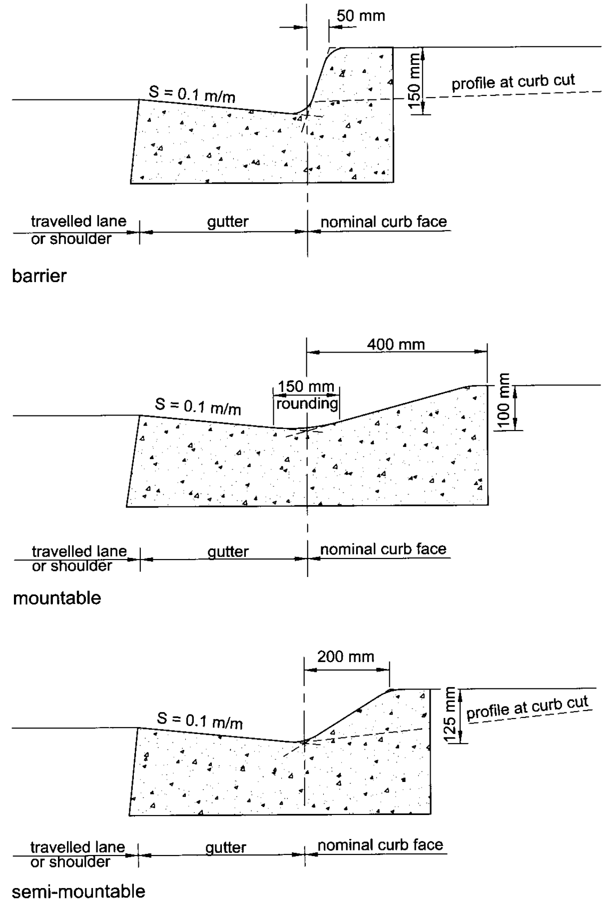
Source: TAC, 1998. Bikeway Traffic Control Guidelines for Canada

Curbs

While typically not a major consideration in the design of bicycle facilities, the type and location of curbs should be considered among other factors such as lane width, on-street parking, vehicle speeds and volume. Generally, there are three types of curbs: barrier, semi-mountable and mountable.

Barrier curbs are the preferred types of curb separation for sidewalks, which are usually located in boulevard areas outside the travelled roadway. On lower speed urban roads, the barrier curb provides an added measure of safety for pedestrians by tending to keep errant vehicles, including bicycles, from leaving the road. Barrier curbs have a near-vertical face and are typically 150 mm high. They are constructed both with and without an integral gutter. Barrier curbs are the most commonly used type of curbing, and are found on most local, collector and arterial urban roads.

Semi-mountable curbs are more rounded in shape than barrier curbs, with somewhat less vertical difference (125 mm) between the gutter and top of curb. They are typically not found in cycling environments. From a cycling perspective, however, their characteristics are more like those of mountable curbs.



Source: TAC, 1999. Geometric Design Guide for Canadian Roads.

Examples of barrier (top) and mountable (middle) and semi-moutable curbs (bottom).

Mountable curbs (sometimes referred to as gutters) have a relatively flat "vee" shaped cross section which is designed to contain drainage without presenting a significant obstruction or hazard to vehicles. They are often found in rural or semi-urban conditions, separating the traveled lanes from an adjacent paved boulevard or shoulder.

Since they can be easily crossed, and their height is such that it does not interfere with pedaling, cyclists will not perceive mountable curbs as a substantial hazard. Catch basin grates are often contained entirely within the width of the mountable curb, and therefore do not take away from the usable width of the roadway. The lateral clearance requirement for mountable curbs is therefore likely to be less than for barrier type curbs. Therefore, where roadway width is constrained, a narrow bicycle lane could possibly be created adjacent to a mountable curb, whereas a similar width roadway with barrier curbs may not be a candidate for bicycle lanes. The fact that a cyclist can easily cross mountable curbs also provides greater opportunity for the cyclist to take evasive action in an emergency situation.

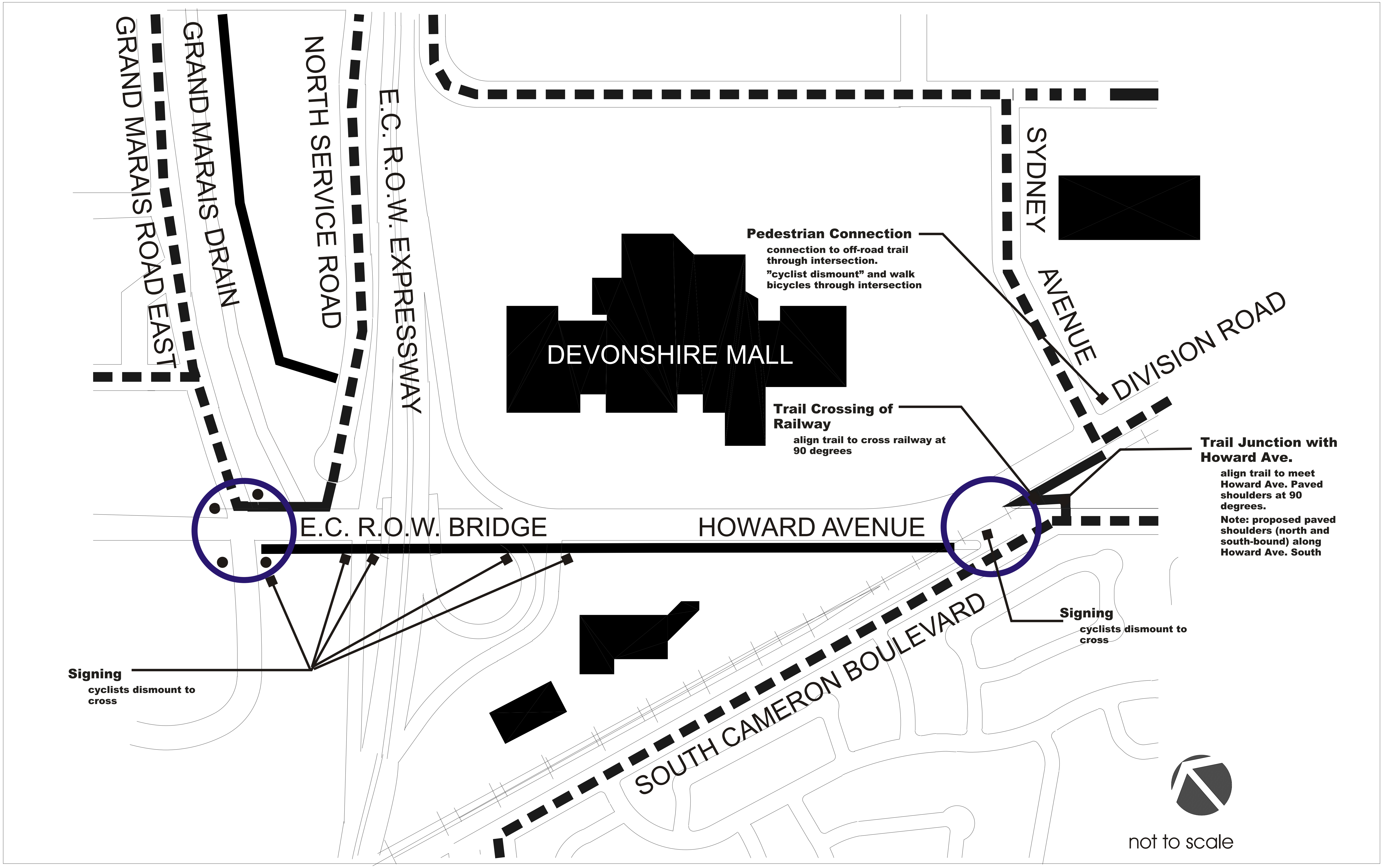
Barrier curbs are the recommended design.

5.2 Site Specific Applications

Implementing the proposed network recommended in this plan will require the municipality to overcome various barriers as discussed in Chapter 4. To assist in this process, six potential design solutions are illustrated on the following pages.

These solutions demonstrate how the following challenging areas may be overcome:

1. Howard Avenue Multi-Use Trail (Devonshire Mall Area).
2. Memorial Drive Multi-Use Trail Connection at Walker Road.
3. Huron Church Road/E.C. Row Expressway Underpass.
4. Intersection of Cabana Road and Dougall Avenue.
5. Howard Avenue/Ypres Boulevard Connection.
6. Walker Road/E.C. Row Expressway Underpass.



Marshall Macklin Monaghan
CONSULTING ENGINEERS • SURVEYORS • PLANNERS
ESG International
Paradigm
Stantec

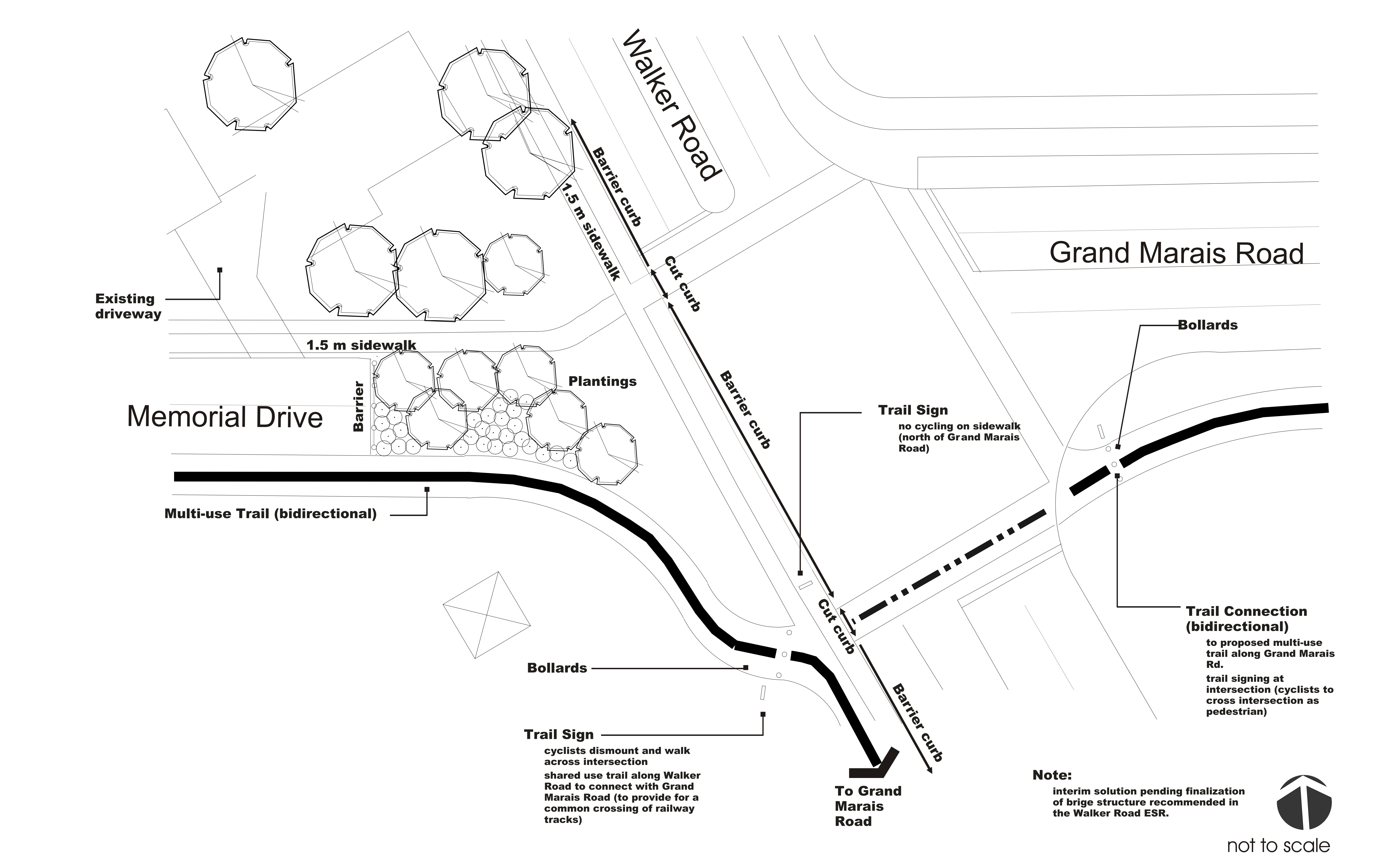
LEGEND

- proposed bike lane
- proposed off-road multi-use trail
- proposed signed route

City of Windsor Bicycle Use Master Plan Study

Conceptual Site Specific Details

Figure 5.1 Howard Avenue Multi-Use Trail (Devonshire Mall Area)



Marshall Macklin Monaghan
CONSULTING ENGINEERS • SURVEYORS • PLANNERS

ESG INTERNATIONAL
Paradigm Transportation Solutions Limited
Stantec

LEGEND

proposed off-road multi-use trail

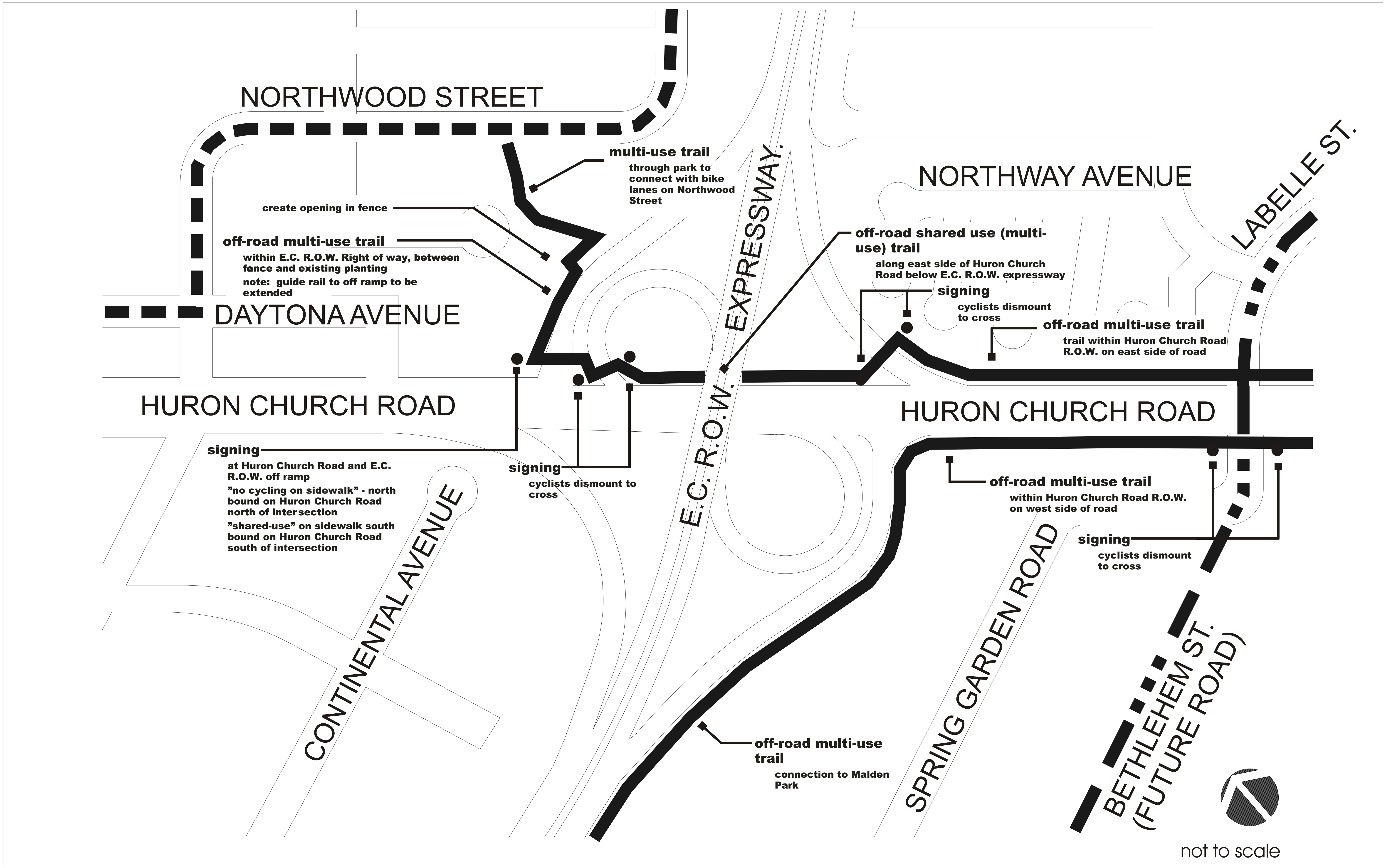
pedestrian crossing through intersection

City of Windsor Bicycle Use Master Plan Study

Conceptual Site Specific Details

Figure 5.2 Memorial Drive Multi-Use Trail Connection at Walker Road

THE CITY OF WINDSOR



Marshall Macklin Monaghan
CONSULTING ENGINEERS • SURVEYORS • PLANNERS
Paradigm
Stantec

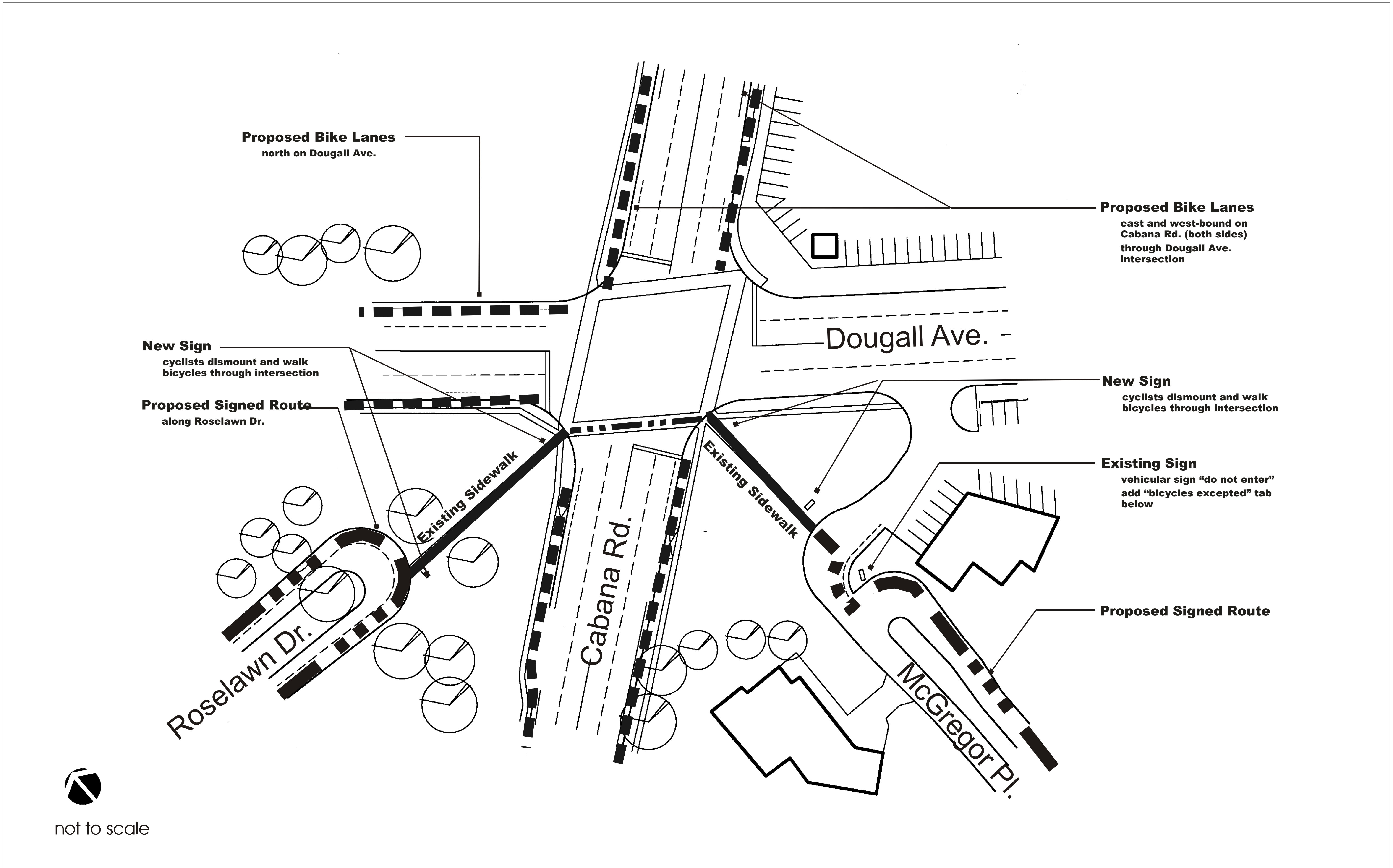
LEGEND

proposed bike lane
proposed off-road multi-use trail
proposed signed route

City of Windsor Bicycle Use Master Plan Study

Conceptual Site Specific Details

Figure 5.3 Huron Church Road/E.C.Row Expressway Underpass



Marshall Macklin Monaghan
CONSULTING ENGINEERS • SURVEYORS • PLANNERS
ESG International
Paradigm Transportation Solutions Limited
Stantec

LEGEND

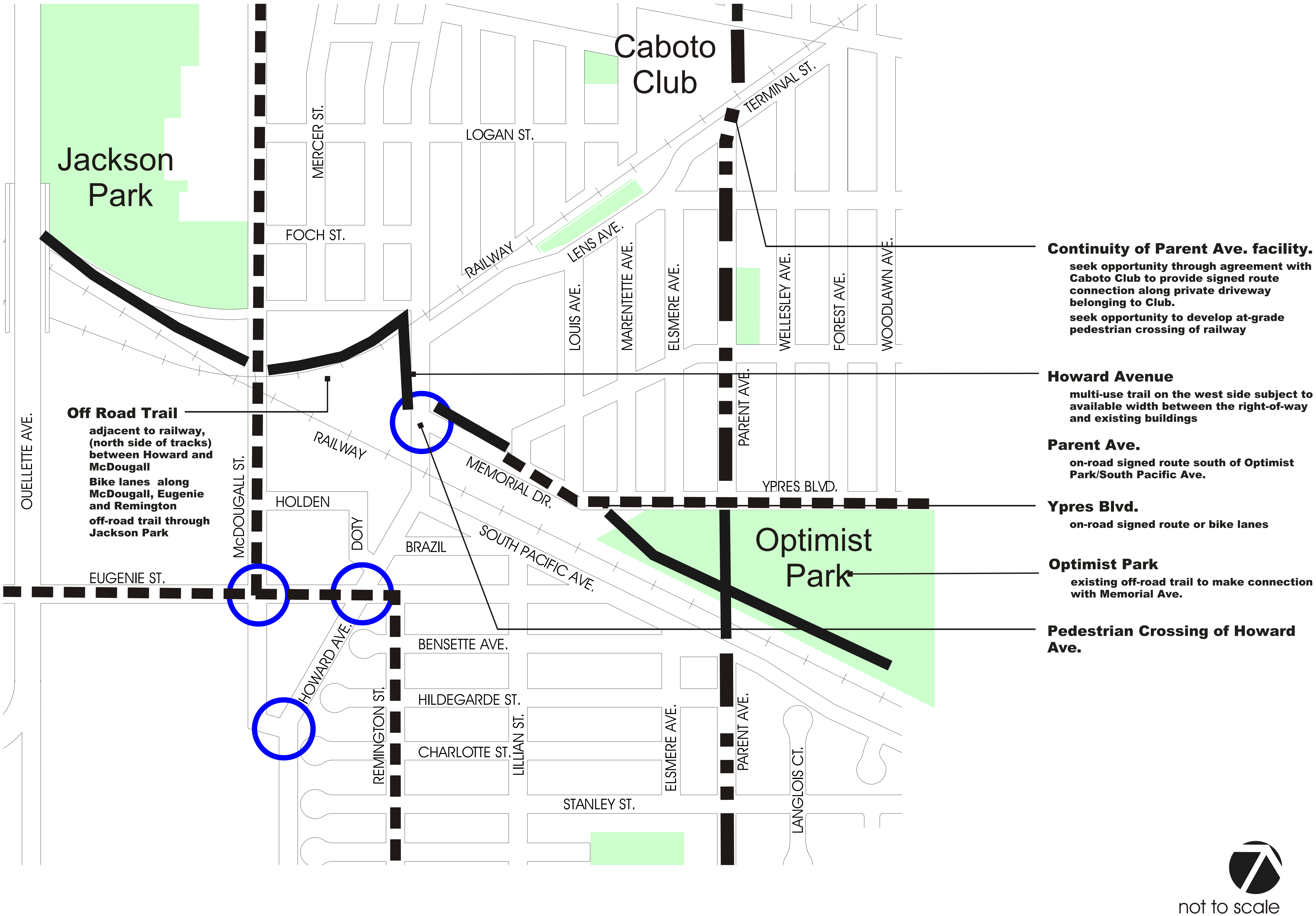
- proposed bike lane
- proposed off-road multi-use trail
- proposed signed route
- pedestrian crossing through intersection

City of Windsor Bicycle Use Master Plan Study

Conceptual Site Specific Details

Figure 5.4 Intersection of Cabana Road and Dougall Avenue

THE CITY OF WINDSOR



LEGEND

- proposed bike lane
- proposed off-road multi-use trail
- proposed signed route
- existing signalized intersection

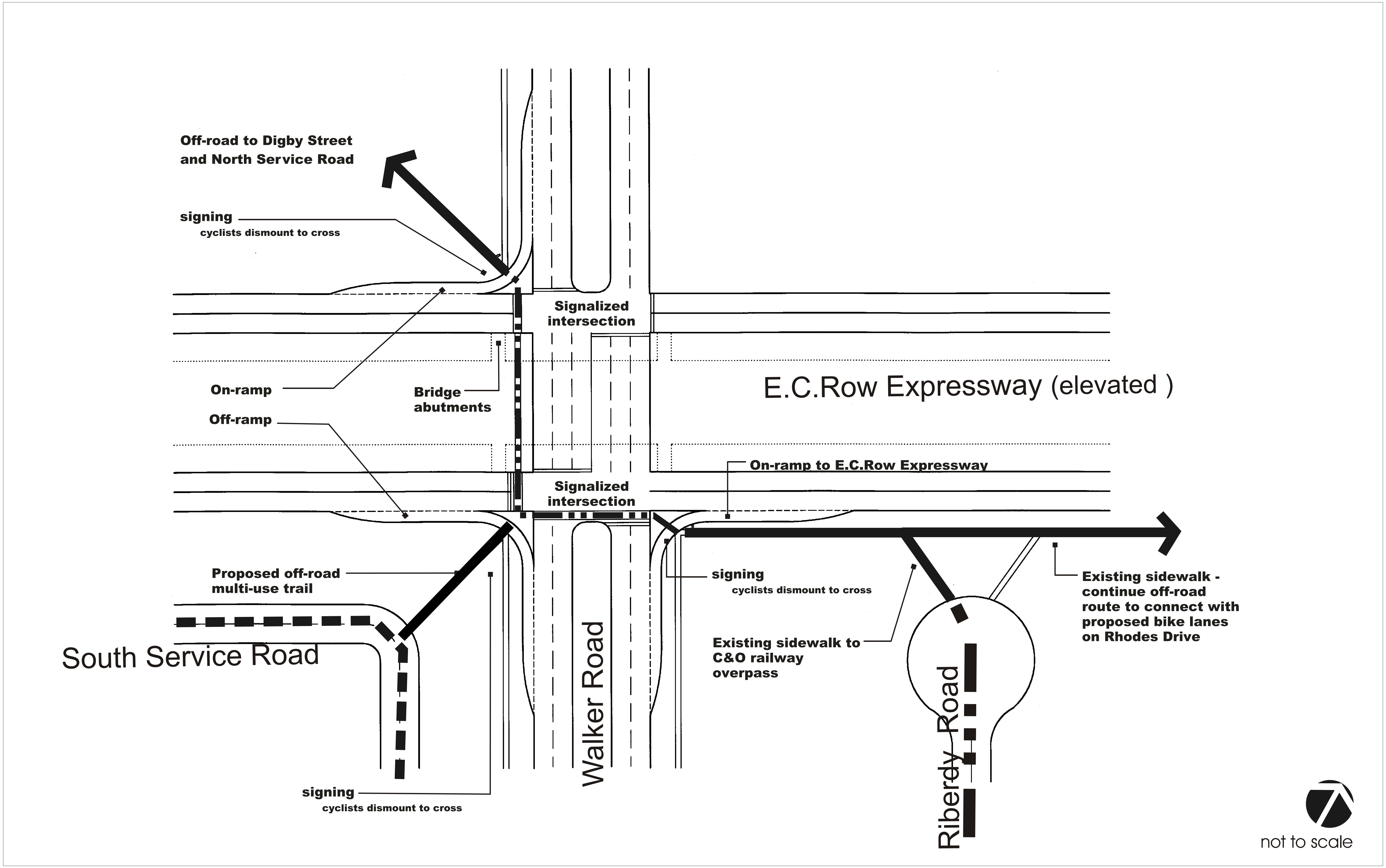
Marshall Macklin Monaghan
CONSULTING ENGINEERS • SURVEYORS • PLANNERS
Paradigm
Stantec

City of Windsor Bicycle Use Master Plan Study

Conceptual Site Specific Details

Figure 5.5 Howard Avenue/Ypres Boulevard Connection

THE CITY OF WINDSOR



LEGEND

proposed bike lane
proposed off-road multi-use trail
proposed signed route
pedestrian crossing through intersection

City of Windsor Bicycle Use Master Plan Study

Conceptual Site Specific Details

Figure 5.6 Walker Road/E.C. Row Expressway Underpass

Marshall Macklin Monaghan
CONSULTING ENGINEERS • SURVEYORS • PLANNERS
ESG International
Paradigm
Stantec