Costing of Bicycle Infrastructure and Programs in Canada

the centre for active transportation
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EXECUTIVE SUMMARY

This report consists of a series of short case studies that describe the components and costs of selected bicycle infrastructure measures and selected cycling programs from 16 Canadian cities.

A total of 29 bicycle infrastructure measures from 15 cities (see Table 1 below) are grouped into five categories: on-street facilities, intersection treatments, traffic calming measures, off-street facilities, and accessory and support features. Case study data includes a description of the infrastructure measure, project location, design specifications and costs. A total of 11 cycling programs from six cities (see Table 2 below) were grouped into the following categories: training programs, repair and maintenance, events, and supports and programs.

Each of the 29 bicycle infrastructure types was costed out specific to one municipality only, and as a result should be considered a general, not specific, cost estimate. The same applies to the 11 types of cycling programs as costs vary from region to region and are further dependent on a wide variety of local and jurisdictional factors and circumstances.

In this light, this report can be used as a rough guide to costs based on bicycle infrastructure and cycling interventions that have been built and implemented, rather than a detailed technical or costing guide.

Table 1. Summary of Costs for 29 Bicycle Infrastructure Measures

Category	Measure	City	Total Cost	Unit	Cost/Unit	Major Cost Components
On-Street Facilities	At grade, bollard protected cycle track	Toronto	$380,274	Metre	$238	Bollards, pavement markings, signage and installation.
	At grade, adjustable concrete barrier protected cycle track	Winnipeg	$15,000	Metre	$115	Pre-fabricated concrete barriers, bollards, pavement markings and signage. Total cost does not include installation.
	At grade, concrete curb/ median protected cycle track	Victoria	$3,447,552	Metre	$2,873	Construction administration, design, signalization, ducting, concrete median, some sidewalk reconstruction, signalization, raised mid-block pedestrian crossings and floating bus pads.

Category	Measure	City	Total Cost	Unit	Cost/Unit	Major Cost Components
	At grade, concrete curb/ median protected cycle track with planting	Vancouver	$905,784	Metre	$1,132	Concrete median, modular planters, pavement markings, conflict paint at intersections, signage and some bicycle parking.
	At grade, modular planter protected cycle track	Hamilton	$461,993	Metre	$154	Planters, pavement markings, signalization and signage, some bollards and rubber curbs, and street resurfacing.
	Paved shoulder	Guelph	$302,460	Metre	$101 per side	Milling and tapering the existing pavement edge to join the addition of full-depth asphalt paving. Pavement markings include two 10mm white edge lines spaced 500mm apart with hatch lines every 22 meters. Between the hatch lines, sections of rumble strips 18.3 m long with 3.6 m gaps were etched into the asphalt.
	Dedicated painted lane	Victoria	$58,811	Metre	$49	Pavement markings, green conflict zone paint, and signage.
Intersection & crossing treatments	Painted through bicycle lane at intersection	Saskatoon	$180	Metre	$4 (for paint only)	Green water-based paint and white pavement markings.
	Painted bike box	Quebec City	$24,944	Metre	N/A	Green thermoplastic paint with a skid-resistant surface treatment and white pavement markings.
	Two-stage turning queue	Montreal	$2,035	Bollard	$185	Bollards.
	Bicycle inductive loop detector	Edmonton	$106,063	Intersection	$106,063	Bike detection loops and fixture upgrades.
	Bicycle signal head	Edmonton	N/A	Signal Head	$1900	Signal heads and yellow backboards. No signalization adjustments were made.

Category	Measure	City	Total Cost	Unit	Cost/ Unit	Major Cost Components
Traffic calming & reduction treatments	Bike-through median	Quebec City	$158,972	Intersection	$158,972	Pavement markings, water main and sewer work, excavation and pavement foundation, sidewalk reconstruction, bollards, street light adjustments and plantings.
	Concrete bulb out	Halifax	$62,491	Curb Extension	$62,491	Replacement of water drainage catch basin frames, new pedestrian crosswalk pushbutton and signalization.
	Concrete bulb out with planting	Montreal	$394,702	Curb Extension	$98,675	Sidewalk reconstruction, tactile paving plates, bollards, utilities work, planters, and traffic management during construction.
	Speed bump	Toronto	$6,644	Speed Hump	$3,322	Asphalt speed hump and pavement markings.
	Neighborhood traffic circle	Calgary	$103,819	Traffic Circle	$103,819	Traffic island, sidewalk and curb work, and four painted crosswalks.
Off-street facilities	Separated shared-use path	Edmonton	$960,386	Metre	$1,223	Concrete path, landscaping, conflict paint, signs, and signalization at three intersections.
	Multi-use bridge – pre-fabricated	Ottawa	$1.52 million	Metre	$76,885	Pre-fabricated bridge and asphalt pathway abutments on either end of the bridge.
	Multi-use bridge – built-in-place	Ottawa	$9.4 million	Metre	$23,578	Built-in-place bridge and pathways on either end of the bridge.

Category	Measure	City	Total Cost	Unit	Cost/ Unit	Major Cost Components
Accessory and support features	Signage	Nanaimo	N/A	Sign	$350	Does not include installation costs.
	Bicycle parking – single hoop	Montreal	$76,662	Parking place	$128	Does not include installation costs.
	Bicycle parking – multiple hoop	Montreal	$62,640	Parking place	$116	Does not include installation costs.
	Bicycle shelter	Charlottetown	$2,949	Shelter	$2,949	Shelter, bike rack and living roof components.
	Modular bicycle locker	Toronto	$22,952	Storage/ parking place	$1,913	Does not include installation costs.
	Secure indoor bicycle parking room	Toronto	$670,951	Parking place	$5,886	Bicycle racks, washroom and change room, and tools and bike pumps. The total cost also includes design costs.
	Bicycle bus rack	Charlottetown	$12,727	Bicycle rack	$1,157	Does not include installation costs.
	Bicycle fix-it station	Charlottetown	$2,992	Fix-it station	$2,992	Stand, tools and wooden platform.
	Bicycle stairway channel	Quebec City	$4,996	Metre	$192	Galvanized steel pipes soldered to a steel base, designed specifically for the staircase in question.

Table 2. Summary of Costs for 11 Cycling Programs

Category	Program or initiative	City	Total Cost	Capital Costs	Operating Costs (hours/FTE)	Major Cost Components
Training Programs	Cycling Skills Training for Youth	Vancouver	Unavailable	Line items available in report	27 instructor hours, 6.5 coordinator hours	A fleet of 18 bicycles with a range of adaptive bikes for kids with disabilities, instructional and evaluation materials, and staff time.
	Cycling Skills Training for Adults	Halifax		N/a	1 FTE	Staff time
Repair and Maintenance	DIY Bike Repair	Peterborough		$ 7,000	2 FTEs (year round), 1 FTE (6 months)	Bike repair tools and stands, and staff time.
	Bike Maintenance Workshops	Peterborough		$ 7,000	18 instructor hours, 4 coordinator hours.	Bike repair tools and stands, and staff time.
Events	Group Rides	Montreal		$ 2,000,000	32-34 FTE	Materials and equipment, rent, insurance and other administrative needs, staff time
	Open Streets	Toronto	$ 150,000			Policing and barricades make up more than one third of the total budget.
Supports and Programs	Active and Safe Routes to School	Toronto	$ 900,000	Cost of 100 bicycles, safety equipment and accessories	2 FTEs, 10-12 part time Cycling Educators annually and external evaluators	Bicycles, safety equipment, accessories and staff time.
	Bike to Work Programs	Toronto	Unavailable	Line items available in report	Built into overall maintenance costs	Cost of materials such as bike lock bars, benches, lockers, vertical racks, and overall maintenance costs.

Category	Program or initiative	City	Total Cost	Capital Costs	Operating Costs (hours/FTE)	Major Cost Components
	Cycling Mentorship Programs	Toronto		$40, 000 per year	1.5 FTE for 6 months	
	Community Bike Hubs	Toronto		$13435 - $19775	1.25 FTE	Bicycles, materials and equipment, and staff time.
	Bicycle Share	Hamilton		$ 1.6 million	14 FTEs	Bicycles, kiosks, and staff time

1 INTRODUCTION

Cycling is an increasingly popular mode of transportation for commuting or other utilitarian trips in North America (Pucher, Buehler, & Seinen, 2011). Scholars and bicycle planners alike agree that there are good reasons for promoting cycling as a mode of transportation, including health, sustainability and access. It is in this context that many Canadian cities are installing bicycle infrastructure including bicycle lanes, bicycle parking, and bicycle signalization, and implementing cycling program interventions that encourage cycling as a mode of transportation,

While this bicycle infrastructure is meant to respond to the needs of current cyclists, research indicates that the presence of high quality bicycle facilities also tends to encourage new cyclists (Dill & Carr, 2003), highlighting the importance of infrastructure for cycling uptake. Research also suggests that cycling programs (like Group Rides, Bike to Work days etc.) not only encourage new cyclists but also help to sustain the cycling behaviour change (Savan, Cohlmeyer, & Lesham, 2017).

This report seeks to fill a gap in existing information on the costing of cycling infrastructure projects and cycling program interventions across Canada. Reference documents that provide design guidelines for different types of bicycle infrastructure (such as the American National Association of City Transportation Officials' Urban Bikeway Design Guide (NACTO, 2014)) don't specify project costs. A small number of costing studies exist (Bushell, Poole, Zegeer, & Rodriguez, 2013), but generally lack detail regarding project components and focus on examples from the United States, where construction costs are likely to vary significantly from those in Canada. Overall project costs for bicycle infrastructure projects can sometimes be found in Canadian news articles or municipal documents (MMM Group Ltd, 2010), but Canadian-specific costing information covering a range of project types presented in a consistent manner had not previously been assembled, as is our intention with this document.

While this document isn't meant to be used as a detailed technical or costing guide, it may be useful for planners or citizen groups who wish to identify options that may be applicable to their communities. The authors are not claiming that the cycling infrastructure and programming initiatives included in the report are best practices, nor are they recommending any particular initiative for any given context. Anyone wishing to implement any of the designs or programs in this guide should seek more detailed guidance from expert sources.

2 COSTS OF BICYCLE INFRASTRUCTURE MEASURES

INTRODUCTION

This section is comprised of a series of short case studies drawn from 15 Canadian cities showcasing the costs associated with selected bicycle infrastructure measures. Data on location, size, design specifications and costs were collected on a specific built project in a single Canadian city for each infrastructure measure. Given that each infrastructure measure was costed in a single municipality, the information presented is meant to give a ballpark impression of the costs related to each of the different types of bicycle facilities and is not a scientific examination of costs.

The costs presented may or may not be representative of cities across the country as local construction and materials costs vary widely. Construction costs may be higher in a city where the availability of labour and construction firms are limited, as is the case in Nanaimo and Victoria, BC. Even within a city, a given project can vary in cost depending on pre-existing conditions. For example, if retrofits such as signalization, curb line or drainage modifications are needed, costs can rise significantly.

METHODOLOGY

Research Process

The research process began with the identification and compilation of a list of bicycle infrastructure measures typically found in Canadian cities. Sources consulted included the American National Association of City Transportation Officials' Urban Bikeway Design Guide (2014), the Portland State University Cost Analysis of Bicycle Facilities (2013) as well as the Ontario Ministry of Transportation's Cycling Facilities guide (Ministry of Transportation of Ontario, 2013). The list was then revised with input from several bicycle planning practitioners and academics in Montreal, Toronto, and Vancouver. A total of 29 measures were grouped into the following five categories: on-street facilities, intersection treatments, traffic calming measures, off-street facilities, and accessory and support features.

In order to gather costing data on the selected bicycle infrastructure measures, municipal bicycle planners in 19 Canadian cities were contacted by phone to determine which of the infrastructure measures had been built in each city and whether costing data would be available for specific projects. 15 of these cities offered costing data on specific projects. Based on this information, projects for costing were chosen so as to maximize the distribution of projects across the country. Each type of infrastructure was costed in a single city.

Each type of infrastructure is backed by any available academic evidence about how successful they are. Additional tips on how the infrastructure works best was also researched. Both of these were conducted through desk research.

Cost Information

This section focuses on hard project costs, namely materials, construction, and installation. Where available, a breakdown of the costs for the different material components of a bicycle infrastructure measure (e.g., concrete curb, signage, signalization) were included in addition to overall project costs.

To estimate project costs, municipal officials drew upon official project estimates and requests for proposals (RFPS), and municipal transportation budgets. In the few cases where city officials could not provide data on the cost of a specific project, they provided general materials and construction costs (for instance, for the installation of bicycle stencil pavement markings) so that the researcher could estimate the cost of a typical project. In several cases, project costs provided by city officials included costs for ancillary features that accompanied the cycling infrastructure project but were not for cycling purposes (such as pedestrian infrastructure associated with a bicycle lane). These have been noted in the project case studies as appropriate. Some types of infrastructure measures were excluded from the study due to the difficulty of isolating costs specific to bicycle infrastructure (Weigand, McNeil, & Dill, 2013).

Project costs do not include planning and design costs or city staff hours unless otherwise indicated. If project costs came from prior years, the Bank of Canada's inflation calculator was used to convert costs to 2017 dollars. Adjusted costs were rounded to the nearest dollar. In cases where infrastructure measures costs are broken down into their various components, numbers may not add due to rounding.

Maintenance costs are not included in the cost estimate provided in this report, though readers are cautioned to consider maintenance costs when estimating the life cycle cost of bicycle infrastructure projects. For example, plastic bollards eventually need replacing, planters must be tended to, and painted and thermoplastic road markings may need refreshing every one to three years. Over the long term, maintenance costs have the potential to dwarf the initial capital cost of a project.

Additional capital costs may be occasioned by investing in cycling infrastructure. For example, cities with snowy winters may need to purchase narrower snow plows in order to plow protected bicycle lanes. These knock-on costs are not included in this section.

ON-STREET FACILITIES

At grade, bollard protected cycle track: Bloor Street Pilot, Toronto, ON

The Bloor Street Bike Lane Pilot Project was installed in Toronto in 2016. The 1.6 km-long cycle track, which is unidirectional on both sides of Bloor Street, is protected by over 400 bollards and on-street vehicular parking. In the fall of 2017, Council decided to make the pilot project permanent.

Figure 1: Bollard protected cycle track on Bloor Street, Toronto, ON. Credit: City of Toronto

Size: 1.6 km

Total cost: $380,274

Cost breakdown:

$127 per bollard x 413 bollards	$52,348
$162 per bicycle & diamond symbol x 83	$13466
$81 per directional arrows x 75	$6,084
$101 per bicycle & chevron symbol x 323	$32,752
$3-7 per m of marked lines on pavement x 2477 m	$7530 – $17642 ($12,586 average)
Traffic control during construction, paid duty officers, tow services	$40,559
Removals of existing paint prior to installment of new pavement markings	$40,559
Installation, paint, signage, evaluation and contingencies	$181,919
TOTAL	$380,274

Cost/metre: $238

Design specifications:

- 1.5 - 1.6 m wide, bollard and parking-protected, one-way cycle track on each side of the roadway.
- Bollards are spaced at an average of 6.6 m apart from one another.
- Existing roadway markings were removed prior to the installment of bollards, bicycle lane pavement markings and green paint at intersections indicating the bicycle path.

Studies have shown that:

- A study comparing many cities in the US showed that there was an increase in cycle ridership ranging from +21% to +171% on streets once they were retrofitted with bicycle lanes protected with flexiposts/bollards (Monsere, Dill, McNeil, & Clifton, 2014).
- The same study showed that the overall frequency of bicycling increased because of the new protected lanes. The increase was higher among women (Pucher & Buehler, 2016).
- Nearly 9 out of 10 (89%) intercepted cyclists agreed that the protected facilities were "safer" than other facilities in their city. A higher percentage of women (93%) agreed with this statement than men (87%) (Pucher & Buehler, 2016).
- Protection with objects such as flexiposts were associated with a higher comfort level than tracks with painted lines only (Pucher & Buehler, 2016).
- Bike lanes that are protected (by raised curbs, bollards or concrete barriers) on roads without parking were found to be 89% safer for cyclists than regular roads (Monsere, Dill, McNeil, & Clifton, 2014).

Tips for best results:

- Studies show that the greater the separation between traffic and the cyclist, the greater the safety and comfort level of the cyclist. Therefore, the design of the buffer space should ensure as much physical separation from traffic as possible (Monsere, Dill, McNeil, & Clifton, 2014).
- It is recommended that the protected cycle tracks provided be wider than the bare minimum as width had an effect on the safety and comfort level of cyclists (Monsere, Dill, McNeil, & Clifton, 2014).

At grade, adjustable concrete barrier protected cycle track: Sherbrook St, Winnipeg, ON

In 2017 the City of Winnipeg installed pre-cast concrete barriers along two streets on two existing painted bicycle lanes, Sherbrook Street and Bannantyne Avenue. The barriers are termed adjustable as they can be easily moved and removed. The barriers were installed on a trial basis to determine their technical feasibility.

Size: Each barrier measures 244 cm long X 30 cm wide x 15 cm high; barriers at the ends of the cycle tracks measure 120 cm long x 45 cm wide x 46 cm high.

Total cost: $15,000

Cost/metre: $115

Figure 2: Adjustable concrete barrier protected cycle track on Sherbrook St, Winnipeg, ON. Credit: City of Winnipeg

Design specifications:

- Adjustable curbs have been installed on approximately 30 m of Bannantyne Avenue between King Street and Albert Street and 100 m of Sherbrook Street south of Cumberland Avenue.
- The barriers were pinned into the road with rebar.

Additional measures not included in total cost:

- Bollards and bicycle lane signage were installed on top of the barriers.

Studies have shown that:

- Lanes demarcated with physical barriers (e.g., flexiposts, planters, curbs, or parked cars) engendered higher comfort levels among cyclists than cycling lanes that were only demarcated with painted buffer zones (Monsere, Dill, McNeil, & Clifton, 2014).
- Bike lanes that are protected (by raised curbs, bollards or concrete barriers) on roads without parking were found to be 89% safer for cyclists than regular roads (Pucher & Buehler, 2016).

Tips for best results:

- The buffer designs should ensure as much physical separation from traffic as possible as studies show that greater the separation between traffic and the cyclist, greater are the safety and comfort levels of the cyclist (Pucher & Buehler, 2016).
- In addition, the width of the bicycle track also has an influence on the safety and comfort level of cyclists. Therefore, it is recommended that the protected cycle tracks provided be wider than the bare minimum (Pucher & Buehler, 2016).

At grade, concrete curb/ median protected cycle track: Pandora Ave., Victoria, BC

In 2016 the City of Victoria, BC built a 3 m wide, 1.2 km bi-directional cycle track protected by 1 m of hatched paint and bollards (60%) and a 1 m concrete median (40%). Intersections were outfitted with green conflict paint indicating cyclist right of way (also known as crossrides) and existing signalization was retrofitted to prioritise cyclist movements.

Size: 1.2 km

Total cost: $3,447,552

Cost/metre: $2,873

Figure 3: Concrete median protected cycle track on Pandora Ave in Victoria, BC. Credit: Dylan Passmore

Design specifications:

- 3 m wide, bidirectional protected bicycle lane.
- Protected on 60% of the lane by a 1 m hatched painted buffer and a total of 31 plastic bollards (60%) and the remaining 40% by a 1 m wide concrete median.
- Green conflict paint and cyclist signalization at all 7 intersections.
- Landscaping in median in select places.
- New bicycle racks installed in concrete median in select places.
- Select sidewalk reconstruction (15% of corridor).
- New mid-block pedestrian crossings.
- Floating bus pads and with raised pedestrian crossings on cycle track.

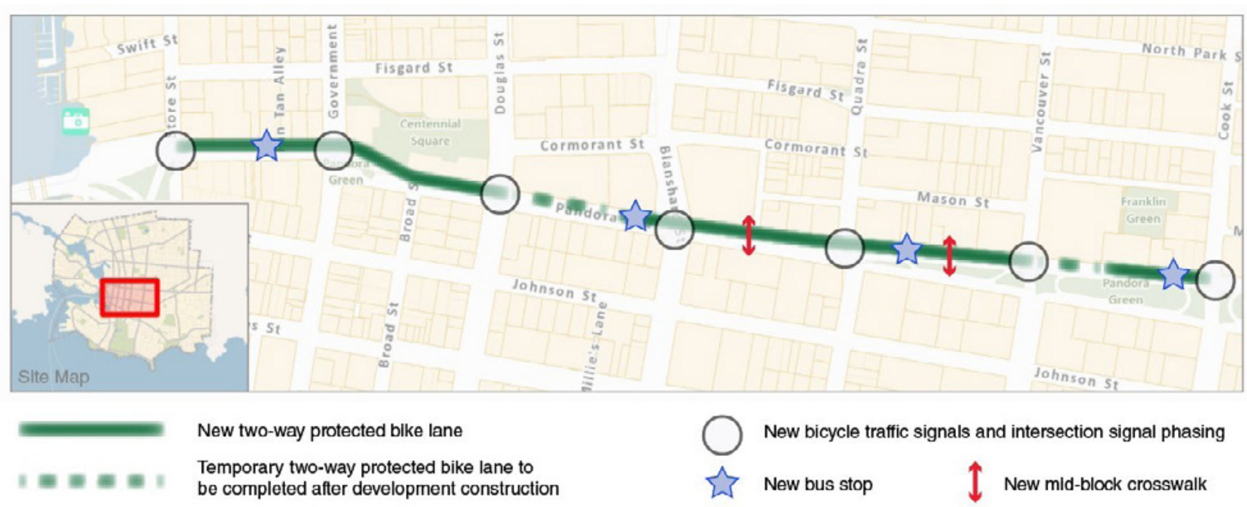

Figure 4: Pandora Avenue Protected Bicycle Lane Facility Map. Credit: City of Victoria

Figure 5: Floating Bus Stop on Pandora Avenue. Credit: City of Victoria

Floating bus pads

Floating bus pads are bus stops that are moved from the sidewalk to a median between a bicycle lane and a vehicle lane when a bicycle lane prevents buses from reaching the sidewalk. This example from the Pandora Avenue cycle track features a floating pad accessed via a painted, raised pedestrian crossing.

Figure 6: Raised pedestrian crossings on Pandora Avenue. Credit: City of Victoria

Raised pedestrian crossings

Raised pedestrian crossings are speed tables that indicate to cyclists in a bicycle lane to watch for pedestrian crossings. They are usually placed at high-volume pedestrian crossings found at intersections or floating bus stops, and will feature paint as a visual cue indicating their presence.

Studies have shown that:

- In a study done in the US, more than 50% of cyclists said they felt 'very comfortable' when buffer spaces between cycle lane and traffic were designed with concrete curbs (Monsere, Dill, McNeil, & Clifton, 2014).
- Bicycle lanes that are protected (by raised curbs, bollards or concrete barriers) on roads without parking were found to be 89% safer for cyclists than regular roads (Pucher & Buehler, 2016).

Tips for best results:

- The buffer designs should ensure as much physical separation from traffic as possible as studies show that greater the separation, greater are the safety and comfort levels of the cyclist (Monsere, Dill, McNeil, & Clifton, 2014).
- The width of the bicycle track also has an influence on the safety and comfort level of cyclists. Therefore, it is recommended that the protected cycle tracks provided be wider than the bare minimum (Monsere, Dill, McNeil, & Clifton, 2014).

At grade, concrete median protected cycle track with planting: Dunsmuir St, Vancouver, BC

In 2010 the City of Vancouver installed an at-grade, bi-directional concrete median protected cycle track on 0.8 kilometres of Dunsmuir Street, a one-way street in downtown Vancouver. The concrete median includes plantings along most of its length.

Size: 0.8 km

Total cost: $ 905, 784

Cost/metre: $ 1,132

Design specifications:

- Bi-directional cycle track is approximately 3 m wide.
- Rows of modular planters are nestled into concrete medians, which separate the planters and cyclists from vehicular traffic.
- Installation included concrete medians, signage, lane markings and green paint at intersections to indicate cycle track path as well as at potential conflict zones such as alleyways.
- At select locations along the cycle track, bicycle parking exists in lieu of planters (see Figure 8).

Figure 7: Concrete median protected cycle track with planting on Dunsmuir Street, Vancouver, BC. Credit: Dylan Passmore

Figure 8: Bicycle parking on Dunsmuir Street, Vancouver, BC. Credit: Dylan Passmore

Studies have shown that:

- In a study done in the US, almost 75% of cyclists said they felt 'very comfortable' when buffer spaces were designed with planters (Monsere, Dill, McNeil, & Clifton, 2014).
- Bicycle lanes that are protected (by raised curbs, bollards or concrete barriers) on roads without parking were found to be 89% safer for cyclists than regular roads (Pucher & Buehler, 2016).

Tips for best results:

- The design of the buffer spaces should ensure as much physical separation from traffic as possible as studies show that greater the separation, greater are the safety and comfort levels of the cyclist (Monsere, Dill, McNeil, & Clifton, 2014).
- The width of the bicycle track also has an influence on the safety and comfort level of cyclists. Therefore, it is recommended that the protected cycle tracks provided be wider than the bare minimum (Monsere, Dill, McNeil, & Clifton, 2014).

At grade, modular planter protected cycle track: Cannon Street Pilot, Hamilton, ON

The 3 km, bi-directional protected cycle track was built in 2014 along Cannon Street in Hamilton. Approximately 32 planters provide protection along half of the cycle track. Where roadway space was more limited, 430 adjustable rubber curbs/ bumpers (pictured in Figure 10) and 300 bollards were used instead. Paint is used to delineate the cycle track along its entire length. Planters are removed each fall and re-installed in the spring to allow winter maintenance and to prevent planting soil from getting sprayed by winter salt. The cycle track was a pilot project and was made permanent in December of 2018.

Figure 9: Protected cycle tracks with modular planters on Cannon Street Pilot, Hamilton, ON. Credit: Norma Moores, IBI Group

Size: 3 km

Total cost: $ 461, 993

Cost breakdown:

Planters	$15,573
Planter installation	$15,573
Pavement markings, signalization and signage	$327,029
Street resurfacing	$103,819
TOTAL	$461,993

Cost/metre: $154,000

Design specifications:

- Approximately 3.4 m wide (2.6-3 m for two lanes with a buffer of 0.3-0.9 m).
- Street resurfacing carried out along the length of the project.
- Planters typically installed in groups of 4 at 8 locations along half of the cycle track. Each planter contains a water reservoir in the bottom and measures 1.4 m long x 0.65 m wide x 0.5 m high.
- Planters were installed on a 0.85 m strip of existing asphalt defined by a solid painted line along each side.
- 430 rubber curbs were installed at 0.75 m intervals along the length of the cycle track not protected by planters.
- Approximately 300 knockdown plastic bollards were installed at the ends of the "runs" of rubber curbing and in segments where the buffer could be wider.

Figure 10: Rubber curb separation along Cannon Street cycle tracks, Hamilton, ON. Credit: City of Hamilton

- The cycle track is delineated by paint markings and includes signage.
- Approximately fifteen traffic signals were added for cyclists riding in the opposite direction of traffic on the one-way street. Vehicle signal green time was modified at two intersections.

Studies have shown that:

- In a study done in the US, almost 75% of the cyclists said they felt 'very comfortable' when buffer spaces where designed with planters (Monsere, Dill, McNeil, & Clifton, 2014).

Tips for best results:

- The design of the buffer spaces should ensure as much physical separation from traffic as possible as studies show that the greater the separation, the greater are the safety and comfort levels of the cyclist (Monsere, Dill, McNeil, & Clifton, 2014).
- The width of the bicycle track also has an influence on the safety and comfort level of cyclists. Therefore, it is recommended that the protected cycle tracks provided be wider than the bare minimum (Monsere, Dill, McNeil, & Clifton, 2014).

Paved shoulder: Victoria Road, Guelph, ON

In 2018, the City of Guelph retrofitted 1.5 km of an existing two-lane rural arterial road by adding paved shoulders, a 0.5 m buffer zone, and rumble. The paved shoulder now serves as a bicycle lane connection from the residential area and popular east-west multi-use trail, to the University of Guelph campus and existing on-road bike lanes further south.

Size: 1.5 km

Total cost: $ 302,460

Cost/metre: $ 101 per side

Figure 11: Victoria Road with buffered rumble strips, Guelph, ON. Credit: City of Guelph

Design specifications:

- The construction involved milling and tapering the existing pavement edge to join the addition of full-depth asphalt paving, using the existing granular shoulder as base.
- Pavement markings include two 10mm white edge lines spaced 500mm apart with hatch lines every 22 metres. Between the hatch lines, sections of rumble strips 18.3 m long with 3.6 m gaps were etched into the asphalt, following the recommendations of the OTM Book 18 (December 2013).

Studies have shown that:

- A study in Florida that evaluated shared-use facilities for bicycles and motor vehicles found that:
    - in the presence of paved shoulders, cyclists are more likely to ride further from the edge than in a wide curb lane. This increases the distance to the right of the

    - bicyclist which can be used as "escape" space.
    - being further away from the edge makes cyclists more visible to motorists.
    - cycling away from the edge improves the cyclist's sight distance (Harkey & Stewart, 1997).
- An article that contained a review of existing policies and designs and a survey of transportation departments in Canada and the U.S. found that paved shoulders are beneficial for a number of reasons:
    - Compared with common-use travel lanes, shoulder bikeways reduce accidents.
    - The bicycle safety benefits of paved shoulders enhance the overall economic feasibility of paving shoulders.
    - The bikeway benefits, as well as rumble strip benefits, are a function of vehicular and bicycle traffic and the economic value of preventing an accident.
    - Rumble strips are cost-effective for reducing run-off road accidents and also serve as a buffer between a travel lane and a bicycle route. (Khan & Bacchus, 1995)
- In a survey done while developing the Lake Huron North Channel Cycling Route, 72% of the respondents said they would be "very comfortable" to cycle and share the road with motor vehicle traffic on minor roads with bicycle lanes or paved shoulders (MMM Group Ltd; The Tourism Company, 2013).

Tips for best results:

- On roads marked as cycling routes or used by cyclists, 1.5 m width provides a clear path between the right edge of the rumble strip and the outside edge of the paved shoulder (TAC-ATC, 2001).
- Providing continuous shoulder rumble strips can alert wandering drivers and reduce the number of run-off-road automobile crashes thereby increasing the safety of bicycle users using the paved shoulder (Garder, 1995).

Dedicated painted bicycle lane: Johnson Street, Victoria, BC

A 1.2 km painted bicycle lane was installed on Johnson Street from Cook Street to Store Street in Victoria, BC in 2016 as a part of the city's expansion of its bicycle network. The installation included removing all longitudinal painted lines along the roadway to accommodate slight changes in the alignment.

Size: 1.2 km

Total cost: $ 58,811

Cost/metre: $ 49

Figure 12: Dedicated painted bicycle lane on Johnson Street, Victoria, BC. Credit: Times Colonist

Design specifications:

- The unidirectional dedicated bicycle lane is approximately 2 m wide and includes bicycle stencils.
- Approximately 75% of the painted lane includes a solid line painted buffer that ranges from 0.7-0.9 m in width.
- Green conflict zone paint and dashed lines used at intersections and other conflict zones such as bus stops.
- “Reserved bicycle lane” and “turning vehicles yield to bicycle” signs installed on new and existing sign posts.
- Longitudinal painted roadway lines removed and repainted to accommodate changes in alignment.
- Some metered parking spaces and commercial loading zones relocated.

Studies have shown that:

- Studies have shown that clearly-marked bike-specific facilities were shown to consistently provide improved safety for cyclists compared to on-road cycling with traffic, or off-road cycling with pedestrians (Reynolds, Harris, Teschke, & Cripton, 2009).
- Marked bicycle lanes and bicycle routes reduced injury or crash rates by about half compared to unmodified roadways (Reynolds, Harris, Teschke, & Cripton, 2009).
- Unprotected bicycle lanes on major roads without parked cars were 53% safer for cyclists than regular roads (Pucher & Buehler, 2016).

Tips for best results:

- Other measures such as reduction of motor vehicular speeds, installation of bike boxes etc. are also required to increase the safety of dedicated painted bike lanes (Chen, et al., 2012).

INTERSECTION & CROSSING TREATMENTS

Painted through bicycle lane/ crossride/ conflict paint: 23rd Street E, Saskatoon, SK

The City of Saskatoon has treated various intersections along its downtown protected bicycle lanes with water-based green conflict paint and white elephant feet (dashed line) paint to indicate space for cyclists as they move through intersections.

Size: 23 m x 1.5 m plus 100 mm of dashed lines on either side of the green paint.

Total cost: Approx. $180 for an intersection with two through bike lanes

Cost/metre: Approx. $3.50 for green paint; $0.20 for white paint

Figure 13: Painted bicycle lane through intersection, 23rd Avenue E and 4th Avenue, Saskatoon, SK. Credit: Google Maps

Design specifications:

- Green paint is bordered by white elephant's feet or dashed lines. Elephant's feet or dashes are each 200 mm long and spaced 200 mm apart from one another.
- Water-based paint must be reapplied approximately every year.

Studies have shown that:

- A study done in Portland, Oregon on the use of coloured markings at bicycle-motor vehicle crossings to reduce conflict showed that the markings contributed to safer bicycling conditions. Both the percentage of cyclists following the recommended path, and the percentage of motorists yielding to cyclists increased. The rate of conflicts decreased from 0.95 per 100 to 0.59 per 100 (Hunter, Harkey, Stewart, & Birk, 2000).
- In Austin, Texas, it was found that there was an increase in the safety of cyclists, and motorists were more likely to yield to cyclists when there was a coloured lane in conflict areas (The City of Austin Bicycle Team, 2010).

Tips for best results:

- A study in Copenhagen of this treatment at 65 signalized intersections pointed out that it might be best when only one bicycle lane at the intersection is marked. Marking two or more cycle crossings is confusing to motorists (Jensen, 2008).
- o The safety benefits of such a treatment will also depend on factors such as intersection size and traffic volume (Jensen, 2008).

Bike box: Dupont Street, Quebec City, QC

A bike box was installed at the Dupont and Prince Edward Street intersection in Quebec City in 2017. The project is comprised of a 30 m green bicycle lane terminating in a 4 x 4.5 m bike box.

Size: 4 x 4.4 m (box only)

Total cost: $ 24,944

Cost breakdown:

30m green thermoplastic bicycle lane	$5,950
White longitudinal bicycle lane and stop lines	$1,495
4m x 1.4m of green thermoplastic skid-resistant surface	$1,175
Green thermoplastic bike box 4 x 4.5 m	$3,475
Three white thermoplastic bicycle chevron markings	$975
Two 4' x 10' green thermoplastic bicycle chevron markings	$1,250
Epoxy for thermoplastic	$125
Removal of existing lines	$750
Installation costs	$6,500
Tax and miscellaneous	$3,249
TOTAL	$24,944

Figure 14: Bike box on Dupont Street, Quebec City, QC. Credit: Ville de Quebec

Design specifications:

- This project includes a 30 m green thermoplastic bike lane terminating in a 4 m x 4.5 m bike box framed by two stop lines.
- The bike lane and bike box include three white thermoplastic bike/ chevron symbols.
- Thermoplastic is chosen because it is likely to last longer (approximately 3 years) than regular paint, especially when subjected to snow and salt.

Studies have shown that:

- A study done in Austin, Texas showed that bike boxes improve the safety of cyclists and motorists. A higher percentage of cyclists approached the intersection in the bicycle lane and stopped within the bike box ahead of stopped motorists, resulting in a significant increase in the percentage of cyclists who left the intersection first (Loskorn, Mills, Brady, Duthie, & Machemehl, 2013).
- In a study done in Michigan on signalised intersection improvements, it was found that bike boxes reduced conflicts and improved mobility for cyclists while reducing crashes for pedestrians (T.Y. Lin International, 2012).

Tips for best results:

- The study done in Texas points out that bike boxes work best when the majority of motorists do not turn right during a red phase (Loskorn, Mills, Brady, Duthie, & Machemehl, 2013).
- The same study observed that bike boxes are utilised best when the volume of bicycle traffic is high (Loskorn, Mills, Brady, Duthie, & Machemehl, 2013).
- The study also noted that cyclists used the box properly and motorists encroached on it less frequently when the bike box is coloured (Loskorn, Mills, Brady, Duthie, & Machemehl, 2013).

Two-stage bicycle turning queue/ waiting area: Berri Street, Montreal, QC

A bollard-protected two-stage turning queue/waiting area was installed at the intersection of Berri and Cherrier Streets, two heavily-used cycling routes in Montreal. The turning queue protects cyclists who want to turn from one bike path to the other while they are waiting for the traffic lights to change in their favour.

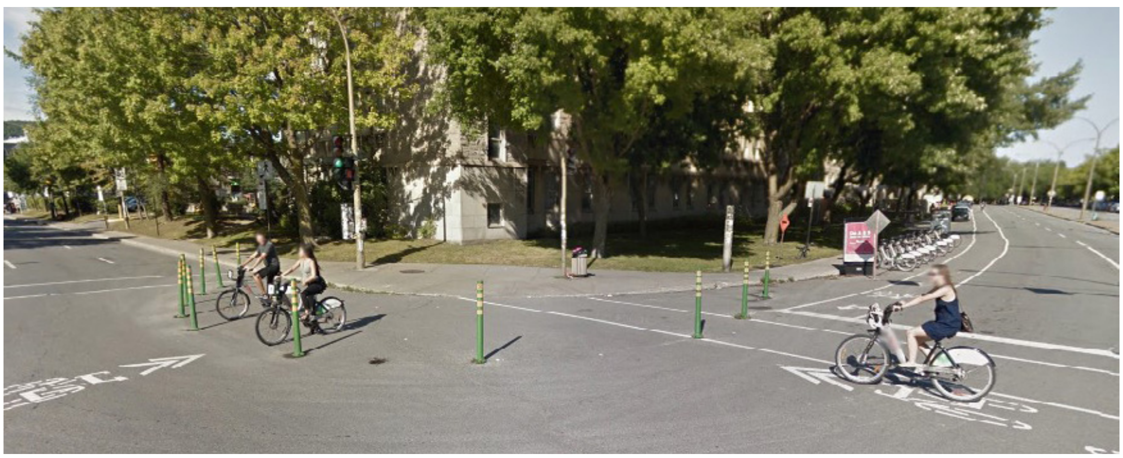

Figure 15: Berri/Cherrier two-stage turning queue/waiting area, Montreal, QC; Credit: Google Maps

Figure 16: Berri/ Cherrier intersection in 2011 before the two-stage turning queue was installed; Credit: Rouler A Velo

Size: Radius from sidewalk reaching approximately 7 m; approximately 16 m in diameter along the sidewalk

Total cost: $ 2,035

Cost/bollard: $125 +$60 for installation

Design specifications:

- 11 bollards are arranged in a dome shape and spaced so that bicycles may enter the protected area with ease.
- Installation costs are $60 per bollard for initial installation, which involves installing small sleeves and screws to secure bollards, and $20 for subsequent replacement bollard installations.

Studies have shown that:

- In a study done in Michigan on signalised intersection improvements, it was found that a two-stage bike left turn reduced potential crashes for cyclists while improving their mobility (T.Y. Lin International, 2012).

Tips for best results:

- A two-stage bicycle turning area is best used in situations where it is undesirable to move to the left-turn lane or where multiple left-turn lanes exist (T.Y. Lin International, undated).

Bicycle inductive loop detector: 136th Street, Edmonton, AB

In 2016, the City of Edmonton outfitted the intersection of 102nd Avenue and 136th Street with two north-south bicycle detection loops in order to facilitate bicycle passage through the intersection as part of the 102nd Avenue shared-use path. The intersection features a pedestrian signal as well as a blue bicycle acknowledgement light with accompanying 'Bike detected' sign.

Size: Loop is approximately the width of the roadway lane x 2-4 m long; pedestrian signal poles are 5 m high

Total cost: $ 106,063

Cost breakdown:

Two North/South bike detection loops	$2,028
Cabinet/comptroller upgrade	$25,350
Fixture upgrades, materials, construction contractor overhead	$78,685
TOTAL	$106,063

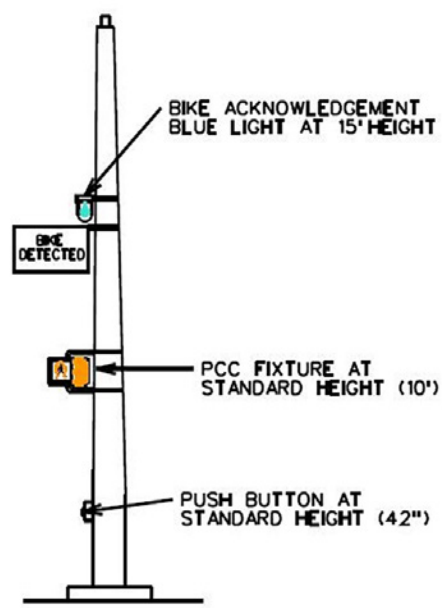

Figure 17: Bicycle detection loop specifications; Credit: City of Edmonton

Design specifications:

- An informational sign in advance of the intersection indicates to cyclists that they are entering bike detection zone. The blue light illuminates once a bicycle is detected, which then triggers the pedestrian/cyclist phase.

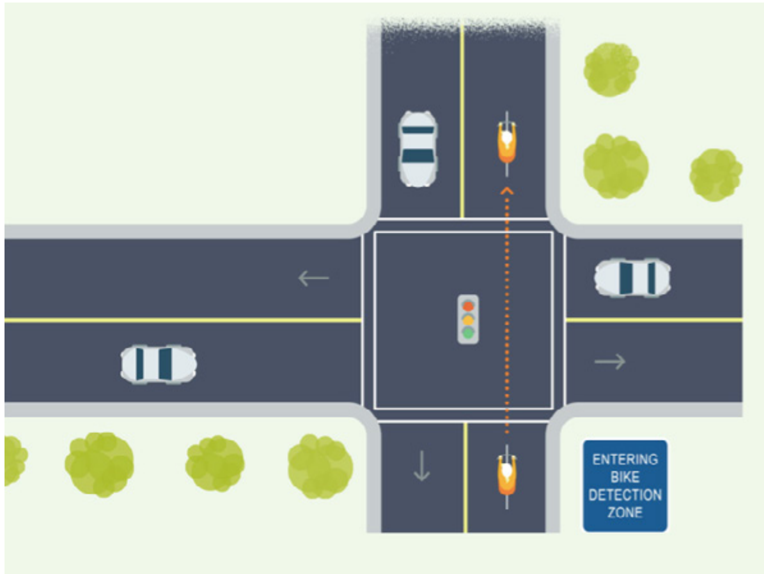

Figure 18: Bicycle detection intersection illustration; Credit: City of Edmonton Downtown Bike Network Education Booklet

Studies have shown that:

- In a study done in Michigan on signalised intersection improvements, it was found that bicycle signal detection reduced potential crashes for cyclists while improving their mobility (T.Y. Lin International, 2012).

Tips for best results:

- A study done in the US noted that signal compliance is highest when there isn't a high volume of bike traffic (Monsere, Dill, McNeil, & Clifton, 2014).
- Conflicts can be further reduced if signal phasing is used to separate the movements of turning motor vehicles and through bicycles (Monsere, Dill, McNeil, & Clifton, 2014).

Bicycle signal head: Downtown Bike Network, Edmonton, AB

In 2017, the City of Edmonton installed bicycle signal heads as a part of their Downtown Bicycle Network. The signals are used mostly without cyclist detection or actuation; instead the signals follow fixed time periods. Most of the signals were mounted on existing poles.

Size: 56 cm x 122 cm including backboard; actual signals are 30 cm in diameter.

Total cost: Approx. $1,900

Figure 19: Bicycle signal head, Edmonton AB; Credit: City of Edmonton

Design specifications:

- Dialight brand bicycle signal heads used.
- Signal heads were mounted onto existing signal poles and run concurrently with the vehicular fixed time sequence rather than using actuation or detection systems, which add to cost significantly.
- Bicycle signals were installed on yellow backboards to help differentiate them from other traffic fixtures, which are on black backboards.

Studies have shown that:

- A survey (video and questionnaire) done in the US on 'bicycle-specific signal comprehension and compliance' at different intersections in Austin, Chicago and San Francisco showed that 77-93% of cyclists complied with the signal (Monsere, Dill, McNeil, & Clifton, 2014).
- In a study done in Michigan on signalised intersection improvements, it was found that bicycle signals reduced potential crashes for cyclists while improving their mobility (T.Y. Lin International, 2012).
- A case study of a bicycle signal head installation in Davis, CA showed that for the two-year period before installation at a busy intersection, there were 16 bicycle and motor vehicle collisions. For the two-year period following the installation, there were no such collisions (Pedestrian and Bicycle Information Center, 2006).

Tips for best results:

- Conflicts can be further reduced if signal phasing is used to separate the movements of turning motor vehicles and through bicycles (Monsere, Dill, McNeil, & Clifton, 2014).
- Typical applications are at complex intersections that may otherwise be difficult for bicyclists to navigate, at intersections with high numbers of bicycle and motor vehicle crashes, and at intersections near schools (primary, secondary, and university) (NACTO, undated).

TRAFFIC CALMING TREATMENTS

Bike-through median: Pere Marquette Street, Quebec City, QC

In 2011, Quebec City installed a bike-through median on Père-Marquette Street at the intersection of Cardinal Bégin Avenue. The bike-through median was part of a large bicycle boulevard initiative for Père-Marquette Street, which connects Quebec City's Parliament Hill and Laval University.

Figure 20: Bike-through median on Père-Marquette Street, Quebec City, QC; Credit: Google Maps

Size: Long medians: Approx. 12 m long x 1 m wide
Short medians: Approx. 3 m long x 1 m wide

Total cost: $ 158, 972

Cost breakdown:

Site organization and signage	$5,424
Pavement markings	$1,085
water main and sewer work	$18,713
Excavation and pavement foundation	$11,255
Granite and concrete curbs	$10,940
Concrete sidewalks	$7,984
Paving – bituminous asphalt	$27,879
Paving – concrete	$4,882
Plantings and topsoil	$2,170
Bollards (x 6)	$3,254
Street lighting – relocation of existing light and addition of one new light	$10,848
Miscellaneous	$1,302
Contingencies (30%)	$37,042
Taxes	$16,196
TOTAL	$ 158,972

Design specifications:

- A total of four planted medians run across Père Marquette Street, two longer ones (approximately 12 m long by 1 m wide) on each end and two shorter ones (approximately 3 m long by 1 m wide) towards the middle of the roadway.
- A roughly 1.7 m space is left between the medians on each side to accommodate pedestrian crossings, and an approximately 3.6 m space allows bicycle through traffic.
- Six bollards indicate the presence of the median and separate the bi-directional bicycle traffic.

Additional measures not included in total cost:

- Twelve bicycle chevron pavement markings indicate the bicycle path through the intersection.

Studies have shown that:

- A study done in Europe showed that streets that restricted movement of motor vehicles using bollards and barriers reduced the volume and speed of motor vehicles while serving as convenient passageways for cyclists (Pucher & Buehler, 2016).

Tips for best results:

- Area-wide strategies for traffic calming treatments have a greater effect on volumes of active travel than isolated interventions. The latter is suitable where there is a need to fix gaps in an existing network of traffic-calming strategies (National Collaborating Centre for Healthy Public Policy, 2012).

Concrete curb extension: Cogswell Street, Halifax, NS

In 2017, Halifax built a concrete curb extension on Cogswell Street where it intersects with the Halifax Common multi-use path. A new crosswalk signal was also installed as part of the same project.

Size: North side curb extension: 18 m long, including tapered sections. Widest section is 8 m long x 2 m wide.

South side curb extension: 16 m long, including the tapered sections. Widest section is 5 m long x 2.4 m wide.

Total cost: $ 62,491

Figure 21: Concrete curb extension on Cogswell Street, Halifax, NS; Credit: City of Halifax

Design specifications:

- 100 mm concrete used for curb extensions.
- Water drainage catch basin frames were replaced and covered with manholes.
- New RA-5 pedestrian crosswalk pushbutton and signalization installed.

Additional measures not included in total cost:

- Roadway resurfacing and pavement markings carried out in addition to the curb extension and crosswalk signal.

Studies have shown that:

- A significant decrease in the 85th percentile speeds (the speed below which 85% of motorists drive) was observed in a literature review that compared the impact of concrete curb extensions/bulb-outs across American, Canadian, Dutch and Australian cities (Huang & Cynecki, 2001).
- One study noted that a greater number of residents reported cycling more, and letting their children play outside and cycle more after traffic calming treatments were implemented (Morrison, Thomson, & Petticrew, 2004).

Tips for best results:

- Traffic calming treatments that promote greening of spaces reclaimed from motorised traffic can help increase trips using active transportation (Victoria Transport Policy Institute, 2017). Traffic calming treatments that succeeded in reducing air and noise pollution caused by traffic could encourage active travel as a study showed that these irritants deterred people from walking or cycling by making active travel less pleasant (National Collaborating Centre for Healthy Public Policy, 2012).
- Pay special attention to the needs of cyclists who may feel less safe in the presence of calming measures that result in road narrowing (e.g., chokers, curb extensions, etc.) or horizontal deflection of vehicles (e.g., chicanes) (Gibbard, et al., 2004).
- While implementing traffic calming treatments, make sure the cycle lanes or tracks allow cyclists to continue moving without forcing them closer to moving vehicles (National Collaborating Centre for Healthy Public Policy, 2012).
- Area-wide strategies for traffic calming treatments have a greater effect on volumes of active travel than isolated interventions. The latter is suitable where there is a need to fix gaps in an existing network of traffic-calming strategies (National Collaborating Centre for Healthy Public Policy, 2012).

Concrete curb extension or chicane with planting: Laurier Avenue, Montreal, QC

Montreal's Plateau-Mont-Royal borough has been steadily installing green curb extensions and chicanes since at least 2010 to calm traffic and green the built environment. Curb extension costs can vary widely depending on the size of the extension, the number of curb extensions per intersection (up to 8, with 2 on each corner), and existing roadway and drainage conditions. Estimates varied from $250,000-800,000 per intersection without the cost of plantings. The following costing example is from Laurier East Street where it intersects with Des Erables Street.

Figure 22: Laurier and Des Erables Curb Extension (under construction), Montreal, QC; Credit: Julia Malmo-Laycock

Size: Between 6.4 and 8 m in length x 2.3 m in width (measured from the edge of existing sidewalk)

Total cost: $ 394,702

Cost breakdown:

Sidewalk and curb work, including bollards and tactile paving plates (see Figures 27 and 28 below)	$ 84,810
Planter beds	$ 9,677
Pavement repair and leveling	$ 90,333
Public utilities work	$ 88,095
Replacement of lead service lines	$23,721
Traffic management during construction	$ 8,244
Miscellaneous	$ 3,106
10% of before tax total for contingency	$ 31,209
TOTAL	$ 394,702

Design specifications:

- Six planted curb extensions of varying lengths.
- Accessible curb ramps on each of four corners featuring tactile pads.
- One to two bollards per curb extension.
- Two to three tactile paving plates (right) ($395 per plate) and one to two reflective steel bollards (left) ($275 per bollard) are two components of curb.
- Curb extensions are also built mid-street in Montreal in addition to at intersections. These mid-street curb extensions are often referred to as chicanes. Costs for planted chicanes are similar to those of planted curb extensions in Montreal.

Studies have shown that:

- A significant decrease in the 85th percentile speeds was observed in a literature survey that compared the impact of concrete curb extensions/bulb-outs across American, Canadian, Dutch and Australian cities (Huang & Cynecki, 2001).
- One study noted that a greater number of residents reported cycling more and letting their children play outside and cycle more, after traffic calming treatments were implemented (Morrison, Thomson, & Petticrew, 2004).
- A study on environmental determinants of walking and cycling showed that the aesthetics of a location is one of the factors that determine the number of pedestrians and cyclists who make use of it (Pikora, Giles-Corti, Bull, Jamrozik, & Donovan, 2003).
- Traffic calming treatments that promote greening of spaces reclaimed from motorised traffic can help increase trips using active transportation (Victoria Transport Policy Institute, 2017).

Tips for best results:

- Traffic calming treatments that succeeded in reducing air and noise pollution caused by traffic could encourage active travel. A study shows that these irritants made active transportation less pleasant and deterred people from walking or cycling (National Collaborating Centre for Healthy Public Policy, 2012).
- While implementing traffic calming treatments, make sure the traffic calming measure restricts motor vehicle access while providing space that allows cyclists to continue to travel without forcing them closer to moving vehicles (National Collaborating Centre for Healthy Public Policy, 2012).
- Area-wide strategies for traffic calming treatments have a greater effect on volumes of active travel than isolated interventions. The latter is suitable where there is a need to fix gaps in an existing network of traffic-calming strategies that already exists (National Collaborating Centre for Healthy Public Policy, 2012).

Figure 23: Example of a planted curb extension, Montreal QC; Credit: Julia Malmo-Laycock

Figure 24: Bollard installed on a Montreal curb extension; Credit: Julia Malmo-Laycock

Figure 25: Tactile paving plates installed on a Montreal curb extension; Credit: Julia Malmo-Laycock

Figure 26: Example of a Chicane, Marie Anne and Laval Streets, Montreal QC; Credit: Google Maps

Speed hump: Withrow Avenue, Toronto, ON

In 2014, the City of Toronto installed two speed humps along the width of the street on Withrow Avenue from Carlaw Avenue to Pape Avenue. Speed humps are currently the principal traffic calming measured used by the City.

Size: 6.4 m wide x 4.0 m long x 75 mm high

Total cost: $6,644

Cost/speed hump: $3,322

Figure 27: Speed hump, Withrow Avenue, Toronto, ON; Credit: Jiya Benni

Design specifications:

- Sinusoidal speed humps are 6.4 m wide, approximately the width of the roadway, and 4.0 m long, and reach a height of 75 mm.
- These specifications are for a one-way street and are used to achieve a desired maximum speed of 30 km per hour.
- Materials include asphalt and two rows of DuraTherm pavement marking arrows placed over pavement (five arrows in total, $260 per arrow).
- Speed humps are generally used with signage, including vehicular speed limit signs.

Studies have shown that:

- A summary of previous research done on the evaluation of speed humps across different American cities showed that there was a significant decrease in the 85th percentile speeds (Huang & Cynecki, 2001).

Tips for best results:

- Area-wide strategies for traffic calming treatments have a greater effect on volumes of active travel than isolated interventions. The latter is suitable where there is a need to fix gaps in an existing network of traffic-calming strategies (National Collaborating Centre for Healthy Public Policy, 2012).

Roundabout traffic island: 8th Avenue NE, Calgary, AB

In 2016, the City of Calgary built a 3.0 m radius concrete roundabout island on 8th Avenue NE where it intersects with 2nd Street as a traffic calming measure. The island is made of concrete and features simple grass landscaping. Sidewalk and ramp work was completed as a part of the project in addition to the construction of the traffic island.

Size: 3.0 m radius

Total cost: $103,819

Figure 28: Roundabout traffic island on 8th Avenue NE, Calgary, AB; Credit: City of Calgary

Cost breakdown:

Construction of traffic island and sidewalk and curb work	$ 96,475
Signage and pavement markings	$7,344
TOTAL	$ 103,819

Design specifications:

- 3.0 m radius concrete roundabout including minor landscaping (grass and sod), four directional arrows on two poles in the island.
- The project included road markings (four painted crosswalks) , some asphalt rehabilitation and curb ramps and concrete sidewalk reconstruction in order to tie existing sidewalks into new curb ramps and safely accommodate pedestrians.

Studies have shown that:

- A study on crash and injury reduction following the installation of roundabouts done in the US concluded that roundabouts were successful in reducing traffic speeds compared to conventional intersections with signal and stop sign control (Retting, Bhagwant, Garder, & Lord, 2001).
- A similar study found out that installation of modern roundabouts in place of conventional intersections was the most effective speed control intervention identified (Retting, Ferguson, & McCartt, 2003).

Tips for best results:

- Roundabouts should be designed with careful consideration of the interactions between cyclists and other traffic modes, as the safety of cyclists is highly dependent on their design (Reynolds, Harris, Teschke, & Cripton, 2009).
- To ensure safety for bicyclists, a separated cycle track should be included in the design of roundabouts (Reynolds, Harris, Teschke, & Cripton, 2009).

OFF-STREET FACILITIES

Concrete shared-use path: 102nd Avenue, Edmonton, AB

In 2016, the City of Edmonton built a shared-use or multi-use path in place of an existing sidewalk on 102nd Avenue from Connaught Drive to 136th Street. Approximately 1200m^2 of existing sidewalk was removed before installing the new path. The 3 m wide concrete path project included landscaping, painted intersections, signage and signalization (one new signalized intersection and retrofit of two existing). The shared-use path is part of a multi-stage crosstown bicycle route project.

Figure 29: Concrete shared-use path on 102nd Avenue, Edomonton, AB; Credit: City of Edmonton

Size: 785 m

Total cost: $ 960,386

Cost breakdown:

Removal of existing concrete	$ 20,077
New concrete	$ 191,035
Gravel base	$ 61,904
Geo-textile base	$ 7,164
Landscaping	$ 81,119
Paint marking at intersections	$ 39,635
Signalization	$ 548,566
Signage	$ 10,887
TOTAL	$ 960,386

Figure 30: Shared-use path signage example; Credit: City of Edmonton

Cost/metre: $ 1,223

Design specifications:

- 3 m wide shared-use path is made of a concrete surface with gravel base and non-woven geo-textile separating soil from the gravel base.
- Landscaping included new sod and trees (approximately 13).
- Conflict paint was used at all 8 intersections.
- Approximately 180 signs of varying sizes were installed along the route, including signs

indicating shared pathway, bike route, hidden driveways, among others.
- The project included one new signalized intersection and a retrofit of two existing signalized intersections.

Additional infrastructure measures not included in total cost:

- Two 25 m^2 concrete nodes, which are concrete slabs (averaging $3,500) featuring, bicycle racks (cost unavailable), benches (averaging $2,000), and litter receptacles (averaging $ 1,250).

Studies have shown that:

- In a study done in Canada, it was found that apart from (protected and unprotected) bicycle lanes, paved shared-use paths saw the most bicycle traffic (Teschke, et al., 2012).
- A study in UK showed that traffic-free routes are vitally important if cycling and walking are to be encouraged. It also demonstrated that it is not generally feasible to provide wholly separate pedestrian and cycle routes; most routes will have to cater for both types of user (Phil Jones Associates, 2011).

Tips for best results:

- Shared-use paths take into account the different kinds of users (pedestrians, cyclists, people in wheelchairs) that will share the path and makes space for them, e.g., wider paths in areas with high volume of pedestrians and cyclists, strategically located passing areas where slow users can move aside to let the fast users pass (Phil Jones Associates, 2011).
- Shared-use paths could be made safer by ensuring the paths are free of obstacles like bollards and ensuring the paths have better sight lines (Harris, et al., 2011).

Pre-fabricated multi-use bridge: Hickory Street, Ottawa, ON

The Hickory Street/Adeline Street multiuse bridge was installed in 2015 to provide a cyclist and pedestrian link between Hickory and Adeline Streets, spanning the Trillium line light-rail tracks. The pre-fabricated, 4 m wide bridge was installed with a crane.

Size: Approx. 20 m

Total cost: $ 1.5 million (including planning and design)

Cost/bridge: $ 1.5 million

Cost/metre: $ 76,885

Figure 31: Hickory Street Bridge, Ottawa, ON; Credit: City of Ottawa

Design specifications:

- 4 m wide to accommodate pedestrians and cyclists traveling in both directions.
- The bridge deck is made of pre-fabricated, fiberglass reinforced plywood and features steel railings and hand rails.
- The installation included abutments and a few metres of asphalt pathway to connect the bridge to existing pathways.

Figure 32: Hickory Street Bridge abutments, Ottawa, ON; Credit: City of Ottawa

Studies have shown that:

- A study in the UK showed that traffic-free routes are important to encourage both cycling and walking. The study also showed that since it is generally not feasible to provide wholly separate pedestrian and cycle routes, most routes will have to accommodate both cyclists and pedestrians (Phil Jones Associates, 2011).
- In another UK study, a multi-use bridge in Cardiff was seen by the residents of the city as a viable alternative to other cycle routes that were hostile, unsafe and less direct (Sahlqvist, et al., 2015).

Tips for best results:

- Multi-use bridges work best when the barrier being crossed is below the natural surface level (e.g., sunken rail tracks, rivers, gorges etc.) (Renfro, 2007).
- Multi-use bridges should be located on logical walking and bicycling routes, and be easy to access from the surrounding network (Renfro, 2007).
- It is important to provide access choices such as access ramps, bicycle stairway channels, provisions for mobility-impaired users, etc (Renfro, 2007).
- Multi-use bridges should be wide enough and well-lit, as shown by the bridge in Cardiff (Sahlqvist, et al., 2015).

Built in place multi-use bridge: Adawe Crossing, Ottawa, ON

The multi-use Adàwe Crossing, built in 2015, was designed to connect Ottawa's downtown core and the Sandy Hill and University of Ottawa neighbourhoods across the Rideau river, addressing a missing link in both pedestrian and cycling networks. As such, it is a key feature of one of Ottawa's Crosstown Bikeway Routes.

Size: 400 m

Total cost: $ 9.4 million (including planning and design)

Cost/bridge: $ 9.4 million

Cost/metre: $ 23,578

Figure 33: Adàwe Crossing Bridge, Ottawa, ON; Credit: City of Ottawa

Design specifications:

- The 120 m long bridge is 4 m wide, wide enough to accommodate pedestrians and cyclists traveling in both directions.
- The bridge rests on two concrete mid-river piers and consists of a concrete deck, stainless steel railings, and lighting.
- The bridge and multi-use path feature a painted line down the middle.
- Public art was commissioned and installed on the bridge to celebrate the historic river crossing site.
- Paved multi-use pathways were installed leading up to the bridge (approximately 280 m total).

Studies have shown that:

- A study in the UK showed that traffic-free routes are important to encourage both cycling and walking. The study also showed that since it is generally not feasible to provide wholly separate pedestrian and cycle routes, most routes will have to accommodate both cyclists and pedestrians (Phil Jones Associates, 2011).
- In another UK study, a multi-use bridge in Cardiff was seen by the residents of the city as a viable alternative to other cycle routes that were hostile, unsafe and less direct (Sahlqvist, et al., 2015).

Tips for best results:

- Multi-use bridges work best when the barrier being crossed is below the natural surface level (e.g., sunken rail tracks, rivers, gorges etc.) (Renfro, 2007).
- Multi-use bridges should be located on logical walking and bicycling routes, and be easy to access from the surrounding network (Renfro, 2007).
- It is important to provide access choices such as access ramps, bike stairway channels, provisions for mobility-impaired users, etc (Renfro, 2007).
- Multi-use bridges should be wide enough and well-lit, as shown by the bridge in Cardiff (Sahlqvist, et al., 2015).

ACCESSORY & SUPPORT FEATURES

Signage: Boundary Avenue, Nanaimo, BC

Signage is an important feature of bicycle infrastructure projects and networks. The City of Nanaimo follows signage guidelines set by the Transportation Association of Canada's Bikeway Traffic Control Guidelines for Canada.

Size: 600 mm X 750 mm

Total cost and cost/ sign: $ 350

Design specifications:

- As per the Transportation Association of Canada's Bikeway Traffic Control Guidelines for Canada, dedicated/ reserved bike path signs are installed at a minimum of one sign between each intersection, with subsequent signs installed at 200 m intervals.

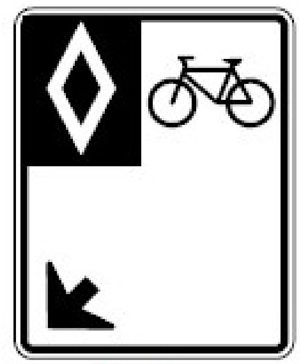

Figure 34: Signage Example - Reserved Bike Lane Regulatory Sign; Credit: TAC Bikeway Traffic Control Guidelines for Canada Second Edition (2012)

Studies have shown that:

- A study carried out to investigate the effect of 'good design of bicycle infrastructure' on cycling in six European cities found that clear signage was an important factor in encouraging more people to cycle (Hull & O'Holleran, 2014).
- A significant component of town-wide cycling initiatives in England that led to increased cycling in these towns was the installation of various signs along 814 km of the cycle network (Goodman A. , Panter, Sharp, & Ogilvie, 2013).

Tips for best results:

- Signage works best when it is clear, shows destinations, and destination distances (Hull & O'Holleran, 2014).

Bicycle parking - single post and hoop, and multiple hoop: Clark Srteet, Montreal, QC

In 2016, Montreal's Plateau Mont-Royal borough purchased 300 stainless steel post and hoop bike racks and 90 stainless steel three-hoop bike racks. In general, the single post and hoop racks are installed on sidewalks, while their multiple hoop counterparts are installed in-street. Both types of racks must be removed during winter for snow clearing purposes, and thus require a yearly maintenance budget.

Size:

- Approx. 65 cm high x 250 cm long three-hoop rack
- Approx. 110 cm high x 30 cm wide single post and hoop

Total cost:

- $ 62,640 for 90 three-hoop racks
- $ 76,662 for 300 single post and hoops

Cost/bike rack:

- $696/ three-hoop rack
- $256/ single post and hoop

Cost/ parking place:

- $116 three-hoop rack
- $128 single post and hoop

Design specifications:

- The single post and hoop bike racks accommodate up to two bikes.
- The three-hoop bike racks accommodate up to six bikes. They are modular in nature, meaning that they can be installed in groups of two or three depending on the need and space.
- The three-hoop bike racks sometimes feature plastic bollards to mark off the parking space, which cost approximately $125 each.

Figure 35: Single post and hoop bicycle rack, Montreal, QC; Credit: Julia Malmo-Laycock

Figure 36: Two three-hoop bicycle racks, Montreal, QC; Credit: Julia Malmo-Laycock

Studies have shown that:

- Better bicycle parking leads to increased levels of cycling. Improved bicycle parking at railway stations and bus stops have resulted in more bike-and-ride trips (Brook Lyndhurst, 2016).
- In Holland, evidence suggests that improved bicycle parking in workplaces and at regional bus stops has led to a modest modal shift from the car to the bicycle (Brook

Lyndhurst, 2016).

- The study in Holland shows that standard cycle parking is more popular among users than bicycle lockers (Brook Lyndhurst, 2016).

Tips for best results:

- Bicycle parking facilities must be easy to use and conveniently located (Smith Lea & Behan, 2010).

Bicycle shelter: Charlottetown Farmer's Market, Charlottetwon, PEI

In 2016 the City of Charlottetown funded the installation of a bicycle parking shelter at the Charlottetown Farmer's market through a community sustainability micro-grant. The shelter consists of a wooden structure with a planted, 'living roof' and a cast-iron bicycle rack.

Size: Approx. 3 m long X 2 m wide X 3 m high

Total cost: $ 350

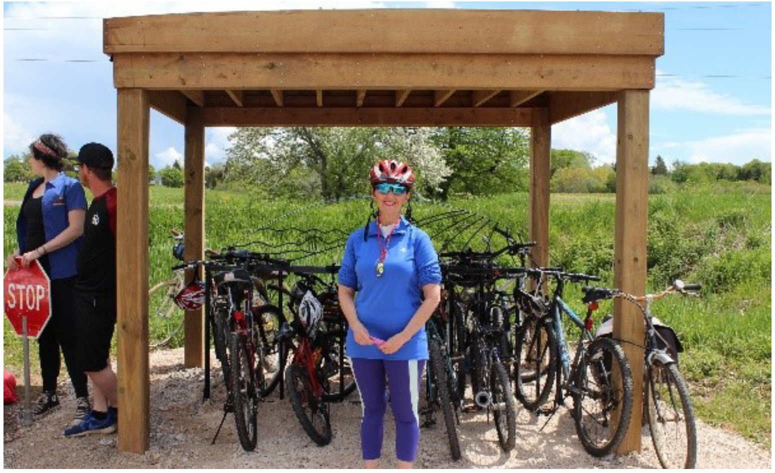

Figure 37: Bicycle parking shelter, Charlottetown, PEI; Credit: City of Charlottetown

Design specifications:

- The wooden shelter's living roof component was achieved using a pond liner, growing media, and plantings.
- The shelter and cast-iron bike rack sit atop a gravel base.

Studies have shown that:

- A study on bicycle parking showed that good parking facilities can reduce the risk of theft and protect bicycles from weather elements, boosting the numbers of cyclists (Guit, 1993).
- Better bicycle parking leads to increased levels of cycling. Improved bicycle parking at railway stations and bus stops have resulted in more bike-and-ride trips (Brook Lyndhurst, 2016).
- In Holland, evidence suggests that improved bicycle parking in workplaces and at regional bus stops has led to a modest modal shift from the car to the bicycle (Brook Lyndhurst, 2016).

Tips for best results:

- Bicycle parking facilities must be easy to use and conveniently located (Smith Lea & Behan, 2010).

Modular bicycle lockers: Bayview Subway Station, Toronto, ON

The City of Toronto has installed modular bicycle lockers at over 21 locations, and continues to expand its bicycle locker program. Six of these double-doored modular lockers capable of storing up to 12 bikes are located at the Bayview Subway Station in Toronto.

Size: Each locker measures 128 cm high x 107 cm wide x 197 cm long

Total cost: $ 22,952 for six lockers

Cost/locker: $ 3,825

Cost/ storage space: $ 1,913

Figure 38: Modular bicycle lockers at Bayview Subway Station, Toronto, ON; Credit: Jiya Benni

Design specifications:

- Each locker is divided into two angular compartments with room for one bike accessed by an individual door.
- Users receive a key that unlocks an individual door.

Studies have shown that:

- Better bicycle parking can support increased cycling (Brook Lyndhurst, 2016). A study on bicycle parking showed that good parking facilities can reduce the risk of theft and protect bikes from weather elements, boosting the numbers of cyclists (Guit, 1993).
- Improved bike parking at railway stations and bus stops have resulted in more bike-and-ride trips (Brook Lyndhurst, 2016).
- In Holland, evidence suggests that improved bicycle parking in workplaces and at regional bus stops relates to a modest modal shift from the car to the bicycle (Brook Lyndhurst, 2016).

Tips for best results:

- Bicycle parking facilities must be easy to use and conveniently located (Smith Lea & Behan, 2010).

Secure indoor bicycle parking room: Union Station South, Toronto, ON

In 2010, a secure indoor bicycle parking station was installed inside Toronto's Union Station. Union Station is a hub for a variety of bus and rail services including GO Transit, Via Rail, Amtrak and Ontario Northland, as well as The Toronto Transit Commission (TTC). The station features a total of 114 bicycle parking places.


Figure 39: Indoor bicycle parking room at Union Station South, Toronto, ON; Credit: Toronto Star

Size: Approximately 100 m^2 + 40 m^2 of floor space

Total cost: $ 670,951

Cost/ parking rack: $ 5,886

Price/metre: $ 4,793

Design specifications:

- The facility features 114 bicycle racks, a washroom and change room and tools and pumps meant for minor repairs.
- Saris brand galvanized steel, two-tiered stacking racks used.
- The indoor facility is monitored by 24-hour video surveillance, and can be accessed 24/7 by paying members with a key fob. Non-members can access the station when staff are onsite.

Studies have shown that:

- Better bicycle parking leads to increased levels of cycling (Brook Lyndhurst, 2016). A study on bicycle parking showed that good parking facilities can reduce the risk of theft and protect bikes from weather elements, boosting the numbers of cyclists (Guit, 1993).
- Improved bike parking at railway stations and bus stops have resulted in more bike-and-ride trips (Brook Lyndhurst, 2016).
- In Holland, evidence suggests that improved bicycle parking in workplaces and at regional bus stops has led to a modest modal shift from the car to the bicycle (Brook Lyndhurst, 2016).

Tips for best results:

- Bicycle parking facilities must be easy to use and conveniently located (Smith Lea & Behan, 2010).

Bicycle bus rack: Charlottetown, PEI

In 2016, the City of Charlottetown outfitted eleven of its buses with stainless-steel bicycle racks.

Size: 76.2 cm x 139.7 cm

Total cost: $12,727 for 11 racks

Cost/rack: $ 1,157

Design specifications:

- Stainless steel racks that accommodate up to two bicycles.

Figure 40: Bicycle bus rack, Charlottetown, PEI; Credit: City of Charlottetown

Studies have shown that:

- A study in Florida on a bikes-on-bus (BOB) program that includes bicycle bus racks showed the program attracted new patrons, encouraged the use of transit and expanded the transit service area (National Center for Transit Research , 2005).

Tips for best results:

- Survey the users to understand their needs and increase rack capacity as per demand (National Center for Transit Research , 2005).
- Install more bicycle parking infrastructure at bus stations so that users can choose to park their bicycles at the bus station if the racks have reached their limits (National Center for Transit Research , 2005).
- The usage of this service was found to be dependent on weather according to one study. More people used the service on warmer and drier days than cold, rainy or snowy days (Flamm, 2013).

Bicycle fix-it station: Joe Ghiz Park, Charlottetown, PEI

In 2016, the City of Charlottetown installed a bicycle fix-it station along the Confederation Trail multi-use path in Joe Ghiz Park. The fix-it station, the first of its kind in Charlottetown, is outfitted with repair tools and a tire pump. The station includes a stand so users can hoist up their bikes to facilitate making repairs.

Size: 21.6 cm x 126 cm x 40.6 cm

Total cost: $ 2,992 ($200 of which was for installation)

Design specifications:

- Stand is made of steel tubing. Tools are hung from stainless steel cables.
- Tools include: Phillips & standard screwdrivers, steel core tire levers, headset/ pedal wrench, 8/10 and 9/11 mm cone wrenches, Torx T-25, and a Hex key set.

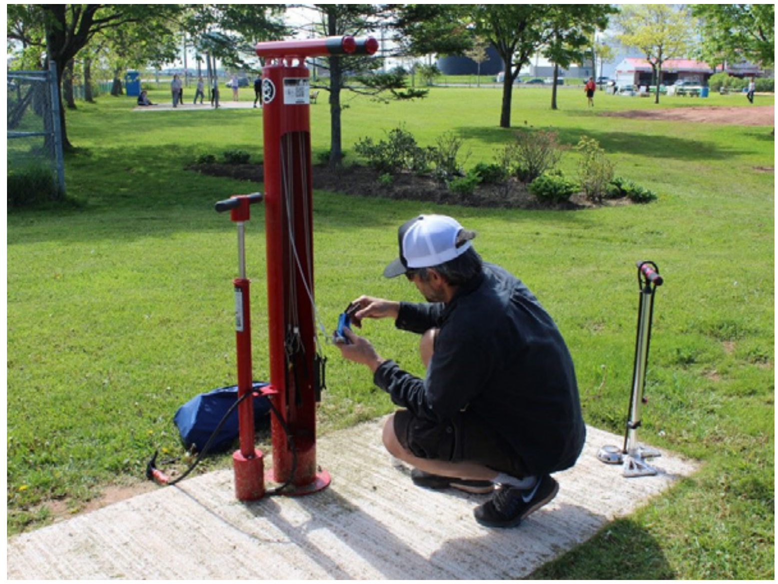

Figure 41: Bicycle fix-it station, Charlottetown, PEI; Credit: City of Charlottetown

Studies have shown that:

- Many reports on making universities bicycle-friendly suggest installing bicycle fix-it stations as a quick and low-cost method of promoting active transportation (Environmental Studies 50, 2014) (Cornish, et al., 2013) (MacDonald, 2016).
- A report on best practices in bicycle transport in Europe mentions self-service repair stations as being a welcome convenience for cyclists whose most frequently cited barrier to cycling is repairing their flat tires (Meggs, Pashkevich, & Rupi, 2012).

Tips for best results:

- Locate bicycle fix-it stations in high traffic areas (Cornish, et al., 2013).

Bicycle stairway channel: La Chapelle staircase, Quebec City, QC

In 2017, Quebec City built a bike stairway channel on the La Chapelle staircase in order to facilitate cyclist use of the staircase. The structure was then installed on the wooden staircase.

Size: 26 m

Total cost: $ 4,996

Cost/metre: $192

Design specifications:

- Two galvanized steel pipes soldered to a galvanized steel base, leaving 10 cm for bicycle wheels. Installed on wooden stairs.
- The stairway channel was designed specifically for this staircase as opposed to a pre-cast alternative.

Figure 42: Stairway Channel, Quebec City, QC; Credit: Ville de Québec

Studies have shown that:

- A study done by the Bay Area Rapid Transit (BART) on stairway channels installed in one of their stations reported that about 40% of cyclists entering the station and 43% exiting the station use it to carry their bicycles while at another station 45% of users reported it to be the most convenient way to transport their bicycles between levels (Eisen | Letunic, 2012).

Tips for best results:

- Stairway channels should be accompanied by wayfinding signage to improve bicycle accessibility (Eisen | Letunic, 2012).
- Signage should ensure cyclists keep to their right while going up or down the stairs (Eisen | Letunic, 2012).

3 COSTS OF CYCLING PROGRAMS

INTRODUCTION

The purpose of this section is to identify a suite of programmatic cycling interventions that have the potential to increase cycling. The goal is to provide stakeholders with an effective tool on how they may increase active transportation in their communities.

The overall potential and effectiveness of the cycling programs included in this section are inherently dependent on a variety of factors (i.e., labour, rent costs, etc.) that vary across regions in Canada. Thus, evaluating each to determine which are the most cost-effective will require additional research and the development of a suitable evaluation framework, and is therefore beyond the scope of this report.

METHODOLOGY

Research Process

The first step was to draft a list of cycling programs and initiatives that have been shown to increase cycling most effectively. A preliminary list was created, incorporating the findings and cycling initiatives recently identified by Savan, Cohlmeyer, and Ledsham (2017). For that paper the authors conducted a literature review and synthesis of international case study research that examines practical/community-based cycling programs that have demonstrated success in encouraging cycling adoption.

The second step was to develop a more comprehensive list of cycling programs using the list developed by Savan et al (2017) as a base. A total of 11 cycling programs were grouped into the following categories: training programs, repair and maintenance, events, and support and programs.

The cycling programs identified in this paper were further complemented by incorporating the following additional data sources:

- Community Bike Centres Report (Heffernan & Ledsham, 2017) - This unpublished research examined the management, governance, and programming activities of community bike hubs in both Canada and the US. The report is based on interviews with staff from eight different community bike hubs during fall 2016. The interviews incorporated a semi-structured/open-ended format with each interview lasting 20-40 minutes in length.
- TCAT's prior knowledge about cycling programs offered in Canada and the U.S., and internet research to fill in gaps

This list includes a few examples of representative case studies across Canada from both large and small cities. When selecting examples, we attempted to include those cycling projects/initiatives that exhibit an established legacy in their community, have shown innovation in both their solutions/partnerships, and/or have been in operation for several years.

The third and final step was to research the costs associated with cycling programs in Canada, the majority of which is developed and delivered by non-profit organizations. 12 organizations were contacted and invited to participate in a phone interview. Of these, nine organizations in six different cities provided costing information for 11 cycling programs. For each program type, a vignette is provided that describes the measure (including a photo), the actual costs and any information about the impact of the project. Where actual costs were not available, an effort has been made to list out the line items.

Similar to the sections on different types of infrastructure, the 11 different cycling programs showcased here are backed by any available academic evidence about how successful they are. Additional tips on how the programs work best was also researched. Both these were done through internet research.

Cost Information

This sections focuses on the capital costs and operating costs. Capital costs include those costs associated with buying material and equipment for the program whereas operating costs include costs associated with staff time represented in FTEs (full-time equivalents). Where organizations were not able to provide capital costs, line items have been provided to help the reader estimate the cost of a typical project.

In some cases, the capital and operating costs are not exclusive to the program. For instance, the operating costs of the PEDAL program, a Bike to Work program, is built into the overall maintenance costs of the building and office it is part of. Another example is the Bike Host program where the program borrows bicycles from their partners or other programs within the organization. In such cases, the reader has to note that these costs will affect the total cost of the program. The total costs don't include the rent of the space either as it is not a capital cost or an operating cost.

TRAINING PROGRAMS

Cycling Skills Training for Youth: Learn2Ride, HUB Cycling, Metro Vancouver, BC

HUB Cycling's Learn2Ride course, delivered in two sessions for grade 4 and 5 students, was started in 2012 to provide an urban cycling course for youth. Multiple evaluation and revision processes over the years resulted in a refined course format in 2019. The Learn2Ride course is provided in public schools in numerous Metro Vancouver municipalities and is funded almost exclusively by municipal engineering departments in support of their active transportation goals.

Figure 43: Learn2Ride, HUB Cycling, Metro Vancouver, BC; Credit: HUB Cycling

Program specifications:

- Program is delivered for grade 4 and grade 5 students over two days.
- Day 1 consists of a 45-minute session where the students are introduced to cycling and helmet safety. Day 2 consists of an 80- to 90-minute session where the students learn cycling skills.
- Students typically bring their own bikes when participating in the course but a fleet of bicycles is available for back-up in case they are needed.
- The office space is rented and not included in the cost break-up below.

Size: 112 youth in total. Each Learn2Ride course is designed to instruct four classes of approximately 28 students each.

Total cost: Capital costs:

- A fleet of 18 bicycles with a range of adaptive bikes for kids with disabilities.
- Instructional materials (eg: street traffic mock-up).
- Evaluation materials (eg: surveys).

Operating costs: The two-day course requires 27 total instructor hours and 6.5 coordinator hours. Line items include:

STAFF TIME
Overall coordination of the course including communications, scheduling and follow-up.
Overall management of the course.
Book-keeping
Evaluating the course and making reports
Instruction of the course
Transportation of instructors, bikes and other materials to and from the schools
Staff-training and orientation
Maintaining the website
Marketing the course
Maintenance of the bicycles
INSURANCE & BENEFITS
Mandatory Employment Related Costs like Employment Insurance, Canada Pension Plan
Staff benefits package.
RENTAL
Office space
Van to transport bicycles
Storage unit for storing bicycles

Studies have shown that:

- A study that assessed a group of 1,974 children, half of whom had completed a cycle training course at age 10, found that trained children performed significantly better than untrained children in the practical and knowledge tests (Savill , Bryan-Brown, & Harland, 1996).
- A study from Belgium that studied short-term effects of practical cycle training in five primary schools found that cycle training had a statistically significant effect (with an effect size of 1.30) on children's cycling skills (Ducheyne, De Bourdeaudhuij, Lenoir, & Cardon, 2013). Effect size is a name given to a family of indices that measure the magnitude of a treatment effect.

Tips for best results:

- Training courses are more effective when they have an on-road element (Savill , Bryan-Brown, & Harland, 1996).
- Training courses that contain more than one stage which are completed at different ages have been found to be effective (Savill , Bryan-Brown, & Harland, 1996).
- If different organizations are delivering the same program, then there should be a system of internal quality assurance to monitor and improve the quality of training being delivered (National Foundation for Educational Research, 2015).

Cycling Skills Training for Adults: Intro to Urban Cycling Course, Halifax Cycling Coalition, Halifax, NS

The Halifax Cycling Coalition offers two versions of this course – one that is open to everyone and one that is open to women, trans, and non-binary individuals who want to learn in a safer space. The workshop empowers people to ride bicycles and practice cycling skills in a place that might not otherwise have been accessible. This course teaches people practical knowledge and skills for riding a bike in the city. The course is sponsored by the local bicycle shop Halifax Cycles and they teach most of the courses.

Figure 44: Intro to Urban Cycling Course, Halifax Cycling Coalition, Halifax, NS; Credit: Halifax Cycling Coalition

Program specifications:

- Space used is rent-free.
- Participants bring their own bikes to learn on.

Size: No more than eight participants generally.

Total cost: Capital costs: n/a
Operating costs: 1 FTE

Studies have shown that:

- In Columbia, a bicycle proficiency education programme that trained 300 people resulted in 75% of participants using their bicycles more often and 35% of car trips being replaced by cycle trips after six weeks (Brook Lyndhurst, 2016).
- 96.8% of the participants in the AustCycle training programme indicated they intended to keep cycling (Brook Lyndhurst, 2016).
- In England, the Cycling Demonstration Towns programme used methods like town-wide media campaigns, cycle repair and cycle training services amongst others. There was an increase in the proportions of residents who reported cycling for at least 30 minutes once per month or 12 or more times per month (Yang, Sahlqvist, McMinn, Griffin, & Ogilvie, 2010).
- In a review of 12 different studies on cycling skills training, it was found that there was an associated increase in bicycling frequency in 10 of them. One of the studies noted that the gender gap in bicycling was reduced post-intervention (Sersli, DeVries, Gislason, Scott, & Winters, 2018).

Tips for best results:

- The potential of cycling skills training in increasing ridership may be related to having both a supportive infrastructural and social environment. These include physical infrastructure, landuse policies that promote and support cycling as well as aspects such as "bicycle culture" or attitudes towards cycling (Sersli, DeVries, Gislason, Scott, & Winters, 2018).
- A longitudinal study of 28 bicycle skills training courses in Vancouver did not find long-

term changes in bicycling or confidence relative to a comparison group. The study concluded that teaching skills and knowledge alone are not enough to increase cycling. Other forms of support (infrastructure, social context) are also needed (Sersli, Scott, & Winters, 2019).

- Cycling training workshops should be targeted. Having such a workshop for parents could help differentiate perceptions from reality around distance and safety and help mitigate barriers for children (Savan, Cohlmeyer, & Lesham, 2017).
- Group training rides with a focus on creating a supportive fun cycling culture can also help reduce fear (Savan, Cohlmeyer, & Lesham, 2017).
- Supervised road rides can also help provide the on-road training experience that traffic-free settings like playgrounds cannot (Sersli, DeVries, Gislason, Scott, & Winters, 2018).

REPAIR & MAINTENANCE

DIY Bike Repair: Open Shop, B!KE: The Peterborough Community Cycling Hub, Peterborough, ON

Open Shop is B!KE's year round drop-in workshop with five repair stations. Each station consists of a bicycle repair stand and a set of tools. Additional tools are accessible on master tool boards. They also have two truing stands.

Figure 45: Open Shop, B!KE, Peterborough, ON; Credit: B!KE: The Peterborough Community Cycling Hub

Program specifications:

- In 2018, the program was delivered for 40 hours a week.
- Use of the space is included in hub's membership fees.

Size: 3007 participants (in 2018)

Total cost: Capital costs: $7,000 for bike repair tools and stands.

Operating costs:

- 2 FTEs (year round).
- 1 FTE (for 6 months).
- The space is rented at $2,000 per month.

Studies have shown that:

- One study found that DIY Bike Repair spaces, sometimes referred to as "Bike Kitchens", provide economic, environmental and social benefits over and above access to bike repair, especially for newcomers (Hult & Bradley, 2017).
- The Bike Kitchen at STPLN, a multipurpose space in Malmo, Sweden, is very well used. People come here to recycle old bikes and repair their own bikes instead of buying a new one or getting it repaired by someone else (Hult & Bradley, 2017).

Tips for best results:

- DIY Bike Repair programs need the financial and political support of local governments to sustain them in the long run (Hult & Bradley, 2017).
- In order to be more than temporary initiatives and to be a stable and influential part of a community, there need to be clear rules and regulations as to how citizens can be involved. (Hult & Bradley, 2017).
- DIY Bike Repair programs work best when they are part of a larger programming space where there is a diversity of uses and functions (Hult & Bradley, 2017).

Bicycle Maintenance Workshops: Home Mechanic Workshop Series, B!KE: The Peterborough Community Cycling Hub, Peterborough, ON

The Home Mechanic Workshop Series is a six-part workshop series conducted by B!KE where participants deepen their understanding of bike mechanics to prepare them for repairing their own bike home at home. The workshop series teaches how to identify the function, potential problems, and basic maintenance needed for each system of the bicycle. Workshops include an introduction to the topic, a short demonstration, and hands-on learning.

Figure 46: Home Mechanic Workshop Series, B!KE, Peterborough, ON; Credit: B!KE: The Peterborough Community Cycling Hub

Program specifications:

- The workshops are conducted with the same resources (space, tools, staff) as the DIY Bike Repair program.
- The series consist of six two-hour workshops.
- The space has five repair stations – each with a set of tools and a repair stand.

Size: Eight participants per session.

Total cost: Capital costs: $7,000 for five sets of bike repair tools and bike repair stands

Operating costs:

- 18 instructor hours
- Four coordinator hours.
- The space is rented at $2,000 per month

Studies have shown that:

- In England, the Cycling Demonstration Towns programme, which included cycle repair and cycle training services amongst others, resulted in an increase in the proportions of residents who reported cycling for at least 30 minutes once per month or 12 or more times per month (Yang, Sahlqvist, McMinn, Griffin, & Ogilvie, 2010).

Tips for best results:

- Studies show that these interventions work best when they are part of a multifaceted package rather than a stand-alone activity. Hence it is important that these measures are part of a larger programme (Savan, Cohlmeyer, & Lesham, 2017).

EVENTS

Group Rides: Go Bike Montreal Festival, Montreal QC

Go Bike Montreal is a week-long festival organized by Velo Quebec, coinciding with Bike to Work week, consisting of three very large and popular group rides: the Metropolitan Challenge, Tour la Nuit, and Tour de l'Ile de Montreal.

Figure 47: Tour de l'ile, Go Bike Montreal Festival, Montreal, QC; Credit: Maxime Juneau

Program specifications:

- As a non-profit, road closures, use of parks and security officers are free of charge for Velo Quebec.
- Volunteers are recruited through agreements with high schools which require students to complete mandatory community work. This helps in volunteer retention.
- Through a special arrangement with BIXI Montreal (the bicycle share system in Montreal) participants in the rides are able to borrow BIXI bikes at a lower rate.
- Bikes and helmets are not provided for the rides.

Size:

- Metropolitan Challenge: 3,500 participants
- Tour la Nuit: 15,000 – 18,000 participants
- Tour de l'Ile: 25,000 participants

Total cost: $2,000,000 (in 2018)

Capital costs:

- Materials and equipment: $460,000

Operating costs:

- Rent, insurance and other administration: $100,000
- Staff: 32-34 FTE

Studies have shown that:

- Community-based physical activity interventions led to an increase in activity levels among those who are least active (Brook Lyndhurst, 2016).
- In an intervention carried out in a suburban region of Toronto, group celebrations and rides reinforced cycling and provided visible role models and social interactions (Savan, Cohlmeyer, & Lesham, 2017).
- Studies have shown that Cycle to Work Day programs have positive impacts on walking and cycling well beyond the day of the event. Cycle to Work in UK attracted a high proportion of participants who did no regular cycling beforehand and was estimated to have generated between £448,000 - 485,000 of physical benefits over 10 years (Brook Lyndhurst, 2016).

- In San Francisco, in 2008, it was found that bicycle counts went up 100% on Cycle to Work Day compared to regular days and remained 25.4% higher several weeks later. In the same year, the Seattle Cycle to Work Day reported 2,474 new cyclists (up from 845 in 2004) while the Portland Cycle to Work Day saw 2,869 new cyclists (up from 433 in 2002) (Brook Lyndhurst, 2016).
- In Sydney, Australia, a community based social marketing programme involving information provision, cycle training, free bike hire, and a Ride to Work Day campaign resulted in increased use of cycle paths with a greater increase in the intervention area (Yang, Sahlqvist, McMinn, Griffin, & Ogilvie, 2010).

Tips for best results:

- Group activities should be strategic. Women-only group rides, especially those that integrate shopping and child pick-up and drop-off en route, help increase female cycling (Savan, Cohlmeyer, & Lesham, 2017).
- Identifying local cycle facilities and specifying the distance to be cycled can improve social networks and peer support for cycling (Savan, Cohlmeyer, & Lesham, 2017).
- Studies show that cycling events work best when they are part of a multifaceted package than a stand-alone intervention. Hence it is important that these measures are part of a larger programme (Savan, Cohlmeyer, & Lesham, 2017).
- In Cycle to Work programs, results improve when the participants already own their cycles (Brook Lyndhurst, 2016).

Open Streets: Open Streets TO, Toronto, ON

Open Streets TO (OSTO) is a free and accessible recreation and social inclusion program that opens streets to people by closing them to cars in Toronto. OSTO was founded as a non-profit organization in 2014.The first program took place in 2014 and since then, it has held 10 program dates. Open Streets programs, also known as Ciclovias, are held in hundreds of cities around the world. The inspiration for Open Streets TO came from the example of world class programs in Guadalajara, Mexico and Bogota, Colombia as well as the advocacy of City Councillor Kristyn Wong-Tam, and internationally recognized open streets experts, 8 80 Cities. Open Streets TO takes place on two of Toronto's most iconic streets, Yonge and Bloor, and has a route length of between 5-10 kilometres, depending on the year.

Figure 48: Open Streets TO, Toronto, ON; Credit: 8 80 Cities

Program specifications:

- Policing and barricades make up more than one third of the total budget.
- Open Streets TO secures the street permit and encourages businesses on the route to activate their storefronts in whatever way they want. Businesses do this on a voluntary basis.

Size:
- Route length: 5 – 10 km.
- Participants: 300,000

Total cost: $150,000

Studies have shown that:

- CicLAvia, a non-profit group in Los Angeles, conducts a car-free open streets program four times a year. A study analyzing the level of physical activity in the April 2014 edition of the program estimated that if it wasn't for the event, 45% of the participants would not have been physically active. It also estimated that there were between 34,000 – 51,000 cyclists and between 2,800 – 3,750 pedestrians (Cohen, et al., 2016).
- In a study to evaluate the Open Streets initiative in San Diego, CicloSDias, it was found that respondents who were Latino, non-white, younger or with a lower income were likely to be inactive if it weren't for the event. The study found that 85% of attendees bicycled and 15% walked and that the event made it possible for almost all respondents to meet the 30 minute a day physical activity guideline (Engelberg, Carlson, Black, Ryan, & Sallis, 2014).

Tips for best results:

- A study on Ciclovias in Bogota suggested that Ciclovias could be more successful in walking-friendly places or compact neighbourhoods (Cervero, Sarmiento, Jacoby, Gomez, & Neiman, 2009).
- The same study suggested having 1,000 metres or more of Ciclovia lanes within one's neighbourhood increased the chances of using Ciclovia at least once a month relative to having no Ciclovia lanes. The configuration, connectivity and density of streets also had some influence on Ciclovia usage (Cervero, Sarmiento, Jacoby, Gomez, & Neiman, 2009).
- The study on the Open Streets initiative in San Diego noted that for the program to have an impact on public health, it would have to be a regular event and attract more people to be physically active (Engelberg, Carlson, Black, Ryan, & Sallis, 2014).
- The San Diego study recommends specifically recruiting diverse and disadvantaged by reaching out to community organizations, ethnic-specific media, senior centres and retirement communities for better participation. Selecting routes through diverse neighbourhoods and commercial areas, and engaging with them will ensure health equity and build support of businesses respectively (Engelberg, Carlson, Black, Ryan, & Sallis, 2014).

SUPPORTS & PROGRAMS

Active and Safe Routes to School: Bike to School Project, Toronto, ON

The Bike to School Project is a collaborative project between CultureLink Settlement and Community Services and Cycle Toronto, in partnership with the Toronto Cycling Think and Do Tank at the University of Toronto and the Toronto District School Board. From 2016-2019, with funding from the Ontario Trillium Foundation, the Bike to School project in Toronto had three streams: 1) Delivering cycling education programs in elementary and high schools, 2) a comprehensive cycling program in secondary schools that provided schools with equipment, special events, and support for bike clubs, and 3) coordination of Bike to School Week, an annual campaign coinciding with Bike Month. First celebrated in 2015 with schools registered in the Greater Toronto and Hamilton Area, in 2018 Bike to School Week expanded to schools across Ontario.

Figure 49: Bike to School Project, Toronto, ON; Credit: Shadab Shahrokh Hai

Program specifications:

- The Cycling Education Programs and Comprehensive Cycling Program"
  - The program was carried out in partnership with Toronto District School Board (TDSB)
  - Schools that received free cycling education programs were selected by TDSB staff. TDSB contributed to the cost of these programs and also funded release time for teachers to attend two day-long workshops.
- Bike to School Week:
  - Campaign tools include a web-based registration and reporting system, marketing materials and some centralized incentives.
  - A working committee of staff from school boards, public health units, municipal transportation departments, and non-governmental organizations promotes the campaign to schools in their respective areas.
  - The campaign was funded by Metrolinx, the regional transportation authority of the Greater Toronto and Hamilton Area. Sponsorship by the Ontario Active School Travel Fund enabled expansion of the program across Ontario in 2018. MEC and the National Cycling Institute Milton sponsored prizes in 2018.

Size:
- Cycling Education Programs: 37,000 students over three years in 70-80 schools per year.
- Comprehensive Cycling Program: 6,000 students in 13 secondary schools, and 90 teachers over three years. Six schools started extracurricular bike clubs which involved over 230 students.
- Bike to School Week: Over 96,000 students are reported to have participated over a three-year time period.

Total cost: $900,000 (2016 – 2019)

Capital costs
- 100 bicycles
- safety equipment and accessories

Operating costs
- 1 FTE for supervision and program development
- 1 FTE staff lead for comprehensive cycling program
- 10-12 part-time Cycling Educators annually and services of external evaluators.

Studies have shown that:
- A Safe Routes to Schools programme in Dublin resulted in an increase of 2.4% of schoolchildren (aged 5-12) cycling to school in 2011 (Brook Lyndhurst, 2016).
- The UK charity's Sustrans' 'Tackling the School Run' saw an increase in the number of students walking and cycling to school (Brook Lyndhurst, 2016).
- Through the Sustainable Travel Towns initiative in UK, towns like Darlington, Peterborough and Worcester saw an increase in active transportation (Brook Lyndhurst, 2016).
- A study that assessed changes in rates of active school travel after the implementation of the State Safe Routes to School program in four cities in the US showed that there was an increase in cycling from 2.5% to 3.0% (Stewart, Moudon, & Claybrooke, 2014).
- In Eugene, Oregon, an analysis of 14 schools revealed that the Safe Routes to School program was associated with an increase in cycling to school (McDonald, Yang, Abbott, & Bullock, 2013).
- One-time events like Walk to School Day can increase the number of students who walk or bicycle to school even weeks after the day of the event (Buckley , Lowry, Brown, & Barton, 2013).
- Walk to School Day events often turn into regularly occurring walking and bicycling programs, which over time can get significantly more students walking and bicycling to school (Buckley , Lowry, Brown, & Barton, 2013) (McDonald, et al., 2014).

Tips for best results:
- A UK study noted that the success of a Bike to School program will depend on the degree of interest and commitment from the school (Brook Lyndhurst, 2016).
- Success is more likely when the aim of the program is clear: i.e., whether to increase active travel to school or to instill active habits for later in life (Brook Lyndhurst, 2016).
- An analysis in Eugene, Oregon showed that when education was combined with Safe Routes to School interventions, there was an increase in walking and cycling of 5-20 percentage points (McDonald, Yang, Abbott, & Bullock, 2013).

Bike to Work Programs: PEDAL program, Toronto, ON

The PEDAL program at Menkes Developments in Toronto was started in 2015 with the aim of removing barriers for building occupants in commuting to work by bicycle. Promoting cycling is a priority for Menkes Developments from not only the perspective of sustainability but also from a mental and physical health perspective for employees. All of their sites have secure storage for bikes while their downtown sites also have onsite shower rooms and change rooms. 1 York Street, one of their sites, also has a bike repair stand and tools where Velofix, a mobile bike shop, comes to repair bikes on site every two weeks.

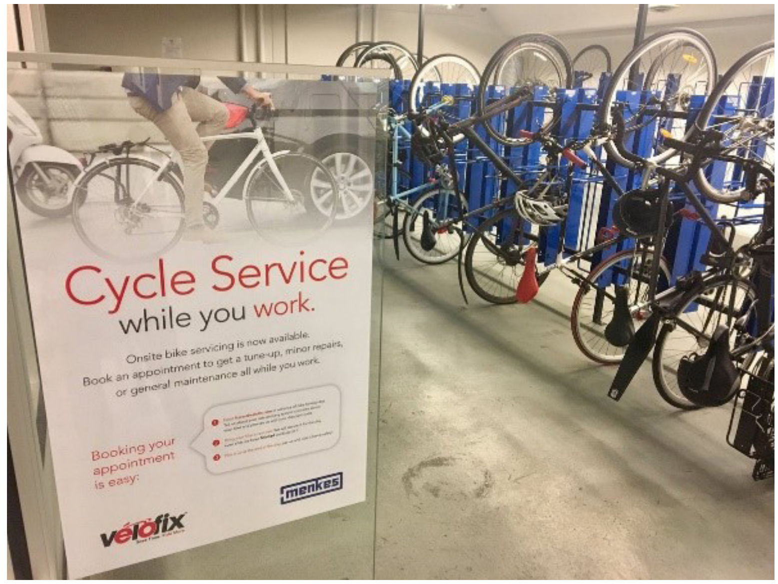

Figure 50: PEDAL program at Menkes Developments, Toronto, ON; Credit: Jon Douglas

Program specifications:

- Office buildings contain secure storage for bicycles, shower rooms, change rooms, bicycle repair stands and tools.
- Menkes partners with Velofix, a mobile bicycle shop, to conduct bicycle repairs on site.
- Menkes commissions Cycle Toronto to conduct awareness programs in the buildings.
- Those who join the PEDAL program are provided with a $50 Uber ride credit for emergencies.

Size: 1 York Street has:

- 300 secure parking spots with card access and 200 semi-secure spots.
- 18 shower rooms (nine for men and nine for women).

Total cost: The total cost for the program was not available but some of the major costs involved are provided below. The costs are from 2015.

Capital costs include cost of parking with items such as:

Bike lock bars	$75-80 per piece + installation fees
Benches	$250 per piece
Lockers	$300 for four lockers
Vertical racks	$150 + installation for one bike

Operating costs is built into the overall maintenance costs and as such was not available.

Studies have shown that:

- In a survey done by Cycle to Work Alliance in the UK to assess the efficacy of various cycle to work programs, 66% of respondents reported that they cycled more since they joined the program and 9% didn't cycle at all previously (Institute for Employment Studies, 2016).

- A study done in Scotland on the impact and benefits of Cycle to Work programs introduced by the UK government noted that 96% of their respondents started cycling weekly as a result of the program while 84% started cycling to work at least twice a week. 53% of the users in the survey sample did not cycle regularly beforehand (Clarke, Shires and Laird, (2014).
- The Scottish study also found that around half of their respondents used their bikes for non-commuting trip purposes such as shopping, personal business, accessing leisure activities and visiting friends and family (Clarke, Shires and Laird, (2014).
- Cycle to Work in the UK attracted a high proportion of participants who did no regular cycling beforehand and was estimated to have generated between £ 448,000 - 485,000 of physical benefits over 10 years (Brook Lyndhurst, 2016). It also had a positive impact on physical fitness, absenteeism and decongestion (Clarke, Shires and Laird, (2014).

Tips for best results:

- When combined with infrastructure improvements, Cycle to Work programs can play an important role in a comprehensive and cost-effective strategy to increase cycling (Institute for Employment Studies, 2016).

Cycling Mentorship Programs: Bike Host, Toronto, ON

CultureLink Settlement and Community Services first offered their "Bike Host" cycling mentorship program to their newcomer clients in 2011. The purpose of the program is to help newcomers to Canada get familiar with their new home in a healthy, sustainable and enjoyable manner. Volunteer cycling mentors are matched with newcomer clients who are also loaned a bicycle for the season if they do not have one themselves. Together, they explore the city.

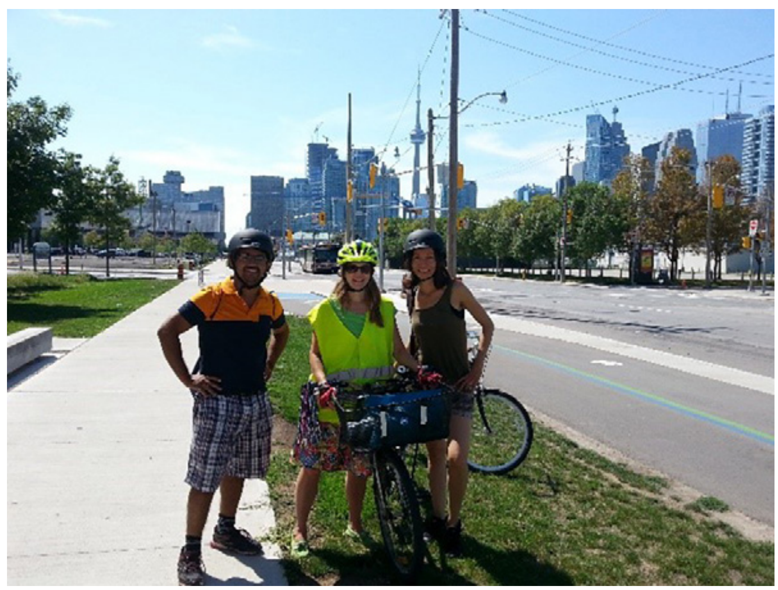

Figure 51: Bike Host Project, Toronto, ON; Credit: Yvonne Verlinden

Program specifications:

- The program is supported by staff from CultureLink's Community Connections program, which is funded by Immigration, Refugees and Citizenship Canada.
- Bicycles are shared with CultureLink's Bike to School Project or other program partners.
- Volunteers are not compensated.
- The ratio of newcomers to mentors has been about 3:1.

Size: 70 – 100 newcomer clients since 2011.

Total cost: Capital costs: $40,000 per year
Operating costs: Approximately 1.5 FTE for 6 months.

Studies have shown that:

- The PedalWise cycling mentorship program implemented in a suburban region west of Toronto saw an increase in cycling among program participants despite the low density urban form and lack of cycling infrastructure. While their motor vehicle trips declined from 54% to 42% by the time the program ended, their cycling trips increased from 5% to 25% (Savan, Cohlmeyer, & Lesham, 2017).

Tips for best results:

- Mentorship programs should be strategically designed and targeted. In the PedalWise mentorship program, participants were required to make a public pledge, set personal goals and sign a card to keep in their wallets as a commitment to cycling. They were encouraged to record their weekly trips to ensure they remained on track with their goals (Savan, Cohlmeyer, & Lesham, 2017).
- Mentors selected should be experienced community cyclists (Savan, Cohlmeyer, & Lesham, 2017).

Community Bike Hubs: Scarborough Cycles, Toronto, ON

Scarborough Cycles is a collaborative project with partners from different sectors like health, research, advocacy and other community-based services. The project used a four-step process to incubate suburban cycling – 1) Find the neighbourhood, 2) Identify local barriers, 3) Remove barriers and start cycling, and 4) Keep Cycling. In 2016, the project launched two community bike hubs in Scarborough, a suburban district of Toronto. The information below is for a single year of programming (2017) at one of the two community bike hubs.

Figure 52: Scarborough Cycles, Toronto, ON, Credit: Access Alliance and Multicultural Services

Program specifications:

- The bike hub offers access to bicycles and tools, as well as cycling programs such as bike repair, bike maintenance workshops, earn-your-bike programs and group rides.
- Space is provided by Alliance Multicultural Health and Community Services, the local host partner.

Size:

- Bike Repair: 643 visits.
- Bike Maintenance Workshops and/or Education: 10 participants.
- Earn Your Bike: 10 participants.
- Group rides: 406 participants across different group rides.

Total cost: Capital Costs:

Storage shed with padlocks	$1,075 - $1,612
16 bicycles	$7,523 - $10,748
Bicycles - yearly maintenance	$215 - $537
Helmets, locks and lights for 16 bicycles	$2,687 - $3,762
Bicycle repair stands and tools	$322 - $537
Consumables	$54 - $161
Used bicycles and parts	By donation
Health and safety equipment	$269 - $376
Collapsible canopy with branding	$1,075 - $1,612
Outdoor signs	$215 - $430

Operating Costs:

- Daily operations: 1 FTE
- Community Animators: 0.25 FTE

Studies have shown that:

- Between 2016 and 2019, the Scarborough Cycles project repaired over 2,000 bicycles, led over 1,000 people on rides, provided training in cycling skills and bike maintenance at 13 workshops, and logged over 2,500 volunteer hours (Ledsham & Verlinden, 2019).
- Studies show that community hubs encourage civic involvement. The 'face to face' environment supports the group's commitment to their action and can encourage behaviour change initiatives (Savan, Cohlmeyer, & Lesham, 2017).

Tips for best results:

- Initiatives such as community hubs can see higher local-level involvement when they are accessible, fun and inclusive (Savan, Cohlmeyer, & Lesham, 2017).

Bicycle Share: SoBi Hamilton, Hamilton, ON

SoBi is a bicycle sharing system in Hamilton, Ontario. It was started by City of Hamilton in collaboration with SoBi Hamilton in 2015 with funding from Metrolinx, the regional transportation agency for the Greater Toronto and Hamilton Area. The bicycles can be reserved using an app or from a hub station. The login info can be entered on the bike itself thereby making it possible to leave your bicycle anywhere after use (for a fee). SoBi Hamilton is unique in the fact that it is a collaborative project between provincial, municipal and non-profit companies.

Figure 53: A SoBi kiosk in Hamilton, ON; Credit: Neal Jennings

Program specifications:

- The City of Hamilton owns the bikes while SoBi takes care of the day to day operations.

Size: 750 bikes
10 kiosks
1200 parking spaces

Total cost: Capital cost: $1.6 million
Operating cost: 14 FTEs

Studies have shown that:

- In London, UK, the bikeshare program has added 68-80 million minutes of active travel per year. 48% of the program members did not cycle in Central London prior to the initiative. 6% of users had switched from car to cycling, while 19% have bought their own bicycles and 9% have increased the amount they cycle on their own bicycles. On average, 60% of bikeshare trips replaced sedentary modes of travel (Brook Lyndhurst, 2016).
- In Montreal, the bikeshare program resulted in 21% of users replacing walking trips and 10% replacing car trips with cycling trips (Brook Lyndhurst, 2016).
- A study showed that between March 2007 and August 2009, cycle trips in Barcelona had increased by 30% (with more than two-thirds of trips for commuting to work or school) due to a bicycle sharing program (Brook Lyndhurst, 2016).

Tips for best results:

- The success of bicycle share programs is dependent on having good bicycle infrastructure (Brook Lyndhurst, 2016). One study found that more people start trips from bikeshare stations located near bike lanes and that ridership increased with the number of nearby lanes (Buck & Buehler, 2011). NACTO's study on bikeshare systems across the US found that implementing a large scale bike share system combined with good bike infrastructure increases cycling and is associated with large decreases in the risk of injury or death while cycling (National Association of City Transportation Officials, 2016).
- A study on performance of bicycle sharing systems worldwide found that station density increased the performance by 16% per station per square kilometre. The recommended density of stations is 10-16 stations (Medard de Chardon, Caruso, & Thomas, 2017).

- A study done for Washington DC's bicycle sharing program, Capital Bikeshare, recommended that addressing four major financial, cultural and structural barriers such as 'lack of convenient and reliable accessibility to bikeshare stations', 'fear of safety', 'difficult-to-afford memberships' and 'a perceived lack of diversity in the ages and ethnitices of users' can result in increasing the ridership even in high crime and high poverty areas. The study recommends intra-agency and inter-agency partnerships as well as partnerships with local institutions to achieve this (Cohen A. , 2016).
- A study on performance of bicycle sharing systems worldwide found out that cities with mandatory helmet legislation had very low performance in terms of trips per day per bicycle (Medard de Chardon, Caruso, & Thomas, 2017). A report by NACTO suggests eliminating mandatory adult helmet laws to increase ridership (National Association of City Transportation Officials, 2016).
- Hybrid funding from different sources (e.g., the local government, the local transportation authority and the locally situated state university as shown by the NGO-led bicycle share system in Ann Arbor, Michigan) is the recommended approach for NGO-led bicycle share systems (A2B Bikeshare, 2014).

CONCLUSION

This research has sought to fill a gap in existing information on the costing of bicycle infrastructure projects and cycling program interventions in Canada. Rough costing estimates were compiled on 29 bicycle infrastructure measures and 11 cycling programs. The infrastructure measures were grouped into the following five categories: on-street facilities, intersection treatments, traffic calming measures, off-street facilities, and accessory and support features while the cycling programs were grouped into four categories: training programs, repair and maintenance, events, and supports and programs.

More detailed costing estimates for some of the infrastructure types can be calculated with the help of engineering guides. For example, average unit prices for concrete, paving, curbs, pavement markings, plantings, traffic signal signalization and pre-fabricated bridges may be obtained from the RS Means Building Construction Costs reference handbook, which is updated annually (Plotner, 2017). These average unit prices can then be modified using the handbook's city cost indexes, which cover 72 Canadian cities.

The overall potential and effectiveness of the cycling programs included in this report are inherently dependent on a variety of factors (i.e., labour, rent costs, etc.) that vary across regions in Canada. Thus, evaluating each to determine which are the most cost-effective will require additional research and the development of a suitable evaluation framework, and is therefore beyond the scope of this report.

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