

An aerial photograph of a city, likely Seattle, showing a central dark lake (Lake Union) surrounded by dense urban development. The city grid is visible, with various buildings, streets, and green spaces. A large white circular structure, possibly a stadium or arena, is visible near the lake. The text is overlaid on a semi-transparent dark blue rectangle in the center of the image.

Cycling-Friendly Transit Stations: Convenient and Comfortable for All Ages and Abilities

The background image shows a city street scene. In the foreground, a paved sidewalk runs alongside a modern building with large glass windows. A covered walkway with a metal roof structure extends from the building. In the background, a large, white, geodesic dome structure is visible, likely a sports arena. A traffic light and a street sign are also present on the left side of the image.

Craig Busch, Tadayori Nakao, Kelsey Yamasaki & Zak Zenasni

Contents

- Executive Summary..... 4
- Introduction..... 6
 - Context..... 6
 - Purpose..... 7
 - Scope..... 7
 - Methodology..... 8
- Background..... 9
 - Policy Alignment..... 9
 - Relevant Research..... 10
- Design Matrix..... 11
- Recommendations..... 12
 - Site Objectives 12
 - Open Space 12
- Arbutus Street..... 13
 - Site Analysis..... 15
 - Site Layout..... 16
 - Cycling Facilities..... 17
 - Transit Hub..... 17
- Cambie Street..... 19
 - Site Analysis..... 21
 - Site Layout..... 22
 - Cycling Facilities..... 23
 - Transit Hub..... 23
- Commercial Drive..... 24
 - Site Analysis..... 26
 - Site Layout..... 27
 - Cycling Facilities..... 28
 - Transit Hub..... 28
- References..... 29
- Appendices..... 31





Executive Summary

Conducted in partnership with TransLink and with the cooperation of the City of Vancouver, the TransLink Station Areas project team developed this project to explore and propose conceptual designs of bike-transit interactions at key locations on the Major Bikeway Network. In particular, the objectives of this project are to determine what types of infrastructure are needed to promote seamless multi-modal transportation, as well as to accommodate bike utility, safety, and legibility. The project team decided to select three sites along the 10th Avenue Corridor as the study areas because of their key conflict points with transit infrastructure. These sites include Arbutus Street (intersection of two major bikeway routes, one B-Line, and one future SkyTrain line), Cambie Street (intersection of one major bikeway route, one B-Line, and one SkyTrain line), and Commercial Drive (intersection of 3 major bikeway routes, one B-Line, and two SkyTrain lines). The purposes of this project align with TransLink and the City of Vancouver's goal of creating a healthy, prosperous future for Vancouver, in part by increasing the number of trips made by foot, bicycle, and transit. This project is also timely given the recent approval of Phase 2 upgrades of the 10-Year Investment Plan, and in particular the Millennium Line Broadway Extension. This extension involves six new stations (two of which are the focus of our study sites) that will be fully integrated with walking and cycling facilities to provide seamless interactions and to promote intermodality.

The project team collected both qualitative data (survey data from local cycling organizations, case study analyses, and a best practices review) and quantitative data

(crash statistics, bike locker and bike parkade statistics, ridership counts, crash statistics and cyclist profiles). The project team also visited each of the three sites throughout the project timeframe in order to observe what bike-transit interactions look like, to understand how cyclists navigate the network, and to identify key conflict points that cause concerns for safety and seamless multi-modal transportation. After conducting the data analyses, the project team created a design matrix for three key contexts: traveling to the transit station, arriving at the transit station, and boarding transit. The project team then used the design matrix to help inform the recommendations and produce the renderings.

Through a comprehensive site analysis, the project team identified problematic areas at each of the three study sites. The project team's recommendations have been developed to provide guidance on how to achieve the two primary project objectives of seamless multi-modal transportation (intermodality), and minimizing conflict points for cyclists (cyclist safety). The recommended interventions for Arbutus Street, Cambie Street, and Commercial Drive include the following:

Arbutus Street

- Fix the pavement quality along 10th Avenue – this is crucial for ensuring cyclists are able to maintain their control and have a comfortable riding experience.
- Provide leading pedestrian intervals to give pedestrians an advanced walk signal.
- Time pedestrian walk signals to appropriately accommodate walking speeds, and provide an extended push-button.
- Provide adequate lighting on the roadways approaching the intersection, as well as along the pedestrian crosswalk area.
- Install raised pedestrian crossings to increase visibility and reduce vehicle speeds.

- Install special crosswalks with pedestrian-activated overhead flashing lights and downward lighting to help increase motorists' awareness of the crosswalk
- Relocate the Mobi bike-share station to beside the SkyTrain station, in order to help with bike-transit connectivity.

Cambie Street

- Enhance pedestrian safety by utilizing traffic calming treatments and establish reserved bus lanes to improve the safety of bus passengers.
- Provide a bike parkade to ensure that cyclists have access to secure bike parking, and provide a roof over the path to the exit of the SkyTrain station to enhance utility for parkade users.
- Implement an exclusive bike path from Cambie Street to the parking lot exit in order to enhance cyclists' safety and accessibility to the new bike parkade.
- Provide safety treatments such as coloured lanes and appropriate traffic signs to prevent collisions between cyclists and pedestrians.

Commercial Drive

- Provide additional bike parking facilities along Commercial Drive and at the Commercial-Broadway Skytrain Station.
- Ensure new parking facilities are secure, plentiful, and offered in desirable locations that experience high foot traffic.
- Move the existing Mobi bike-share station to in front of the Commercial-Broadway Skytrain Station and expand the capacity to allow for additional bicycles.
- Redesign the bicycle crossing at Broadway and Victoria Drive to allow eastbound cyclists to follow along the northern sidewalk of Broadway until Victoria Drive, where they can then safely cross the road en-route to either 10th Avenue or the Central Valley Greenway.

- Redesign the crossing at 10th Avenue and Victoria Drive to include a cyclist activated signal, as well as green bike route pavement markings crossing Victoria Drive.
- Speak with developers Westbank and Crombie REIT to safeguard 10th Avenue from additional traffic volumes by incorporating traffic calming measures in this section.

Each of the three study sites is unique in its current conditions and existing needs. While Arbutus Street, Cambie Street, and Commercial Drive are all key conflict points with transit infrastructure and experience high vehicle and cyclist volumes, planning for adequate cyclist facilities that meet future demands is especially important at Arbutus Street and Cambie Street with expected changes to the sites resulting from the Millenium Line Broadway Extension . With Vancouver's population expected to increase by 130,000 residents over the next 30 years and with ambitious 2040 targets for an increase in sustainable transportation, it is essential that an adequate supply of bicycle amenities and facilities is planned for to meet the cycling needs of today and into the future.

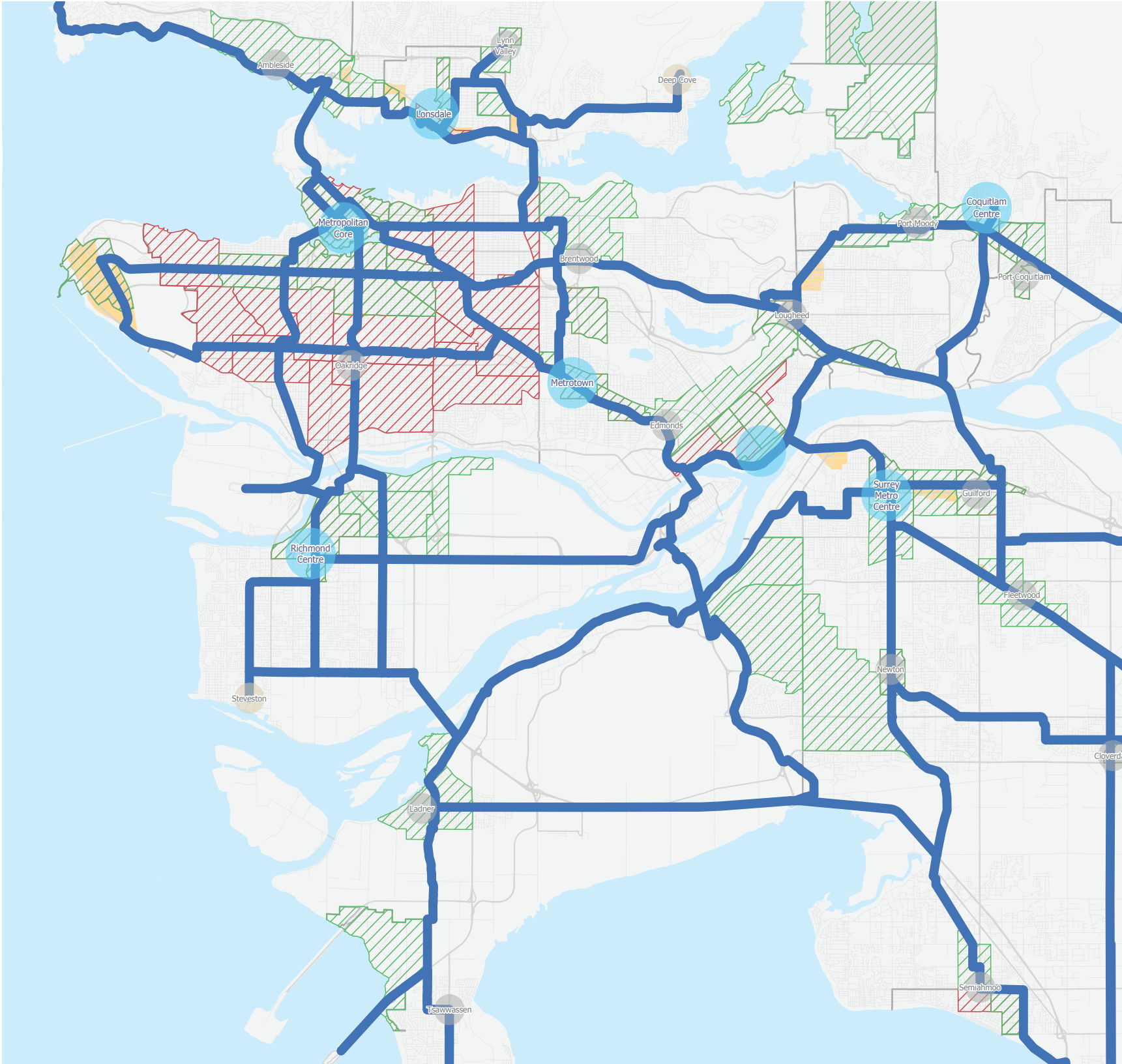


Introduction

Context

TransLink engaged with the School of Community and Regional Planning (SCARP) in Summer 2018 to propose a studio project focusing on bicycle interactions surrounding major transit stations. As a part of its mandate, TransLink maintains various regional bike routes, provides bike parking at transit hubs across the region, and regularly cost shares bike infrastructure upgrades with municipalities in the Vancouver region. TransLink's goal is to create a consistent user experience across the region on its Major Bikeway Network (MBN). Recognizing the need to develop basic concepts or examples of how the MBN could interact with transit infrastructure, TransLink proposed a project in partnership with SCARP to investigate bike-transit interactions on the MBN by developing preliminary concepts at key transportation nodes with a high degree of intermodality and conflict.

Figure 1. Map of the Major Bikeway Network (TransLink, 2018a).



Purpose

In June of 2018, Phase Two of TransLink's 10-Year Vision Plan was approved by the Mayor's Council and the TransLink Board of Directors. Approval of the Phase Two Plan provides funding for a variety of transportation improvement projects in the region, one of which is the Millenium Line Broadway Extension (MLBE) project. The MLBE will extend the existing Millenium Line SkyTrain system from VCC-Clark Station to a new terminus station at Arbutus Street, with six underground stations that will provide riders with access to main locations along the 10th Avenue Corridor (the Corridor). Approval of funding for this project has important implications for passenger travel along the Corridor, and is part of the rationale for the selection of the three study sites. The MLBE is projected to accommodate daily ridership levels of 143,000 to 163,000 passengers by 2030, and is expected to encourage more transit ridership by providing an efficient, convenient transportation system. With passenger traffic increasing and six new stations being built (including one at Cambie and one at Arbutus), it is crucial to plan for infrastructure that will support safe, seamless bike-transit integration. The Corridor is currently the busiest bus route in North America, indicating a need to provide safe routes for all passengers and to facilitate intermodality through adequate facility design.



Scope

The project team, in consultation with project partners, decided to select 10th Avenue as the key study area. Along the 10th Avenue Corridor, there are three key conflict points that the project team identified, including: Arbutus Street, Cambie Street, and Commercial Drive. The qualitative and quantitative data collection has been guided by the following three questions:

1. What are the existing design/planning precedents for bike-transit interactions at major transportation nodes in urban environments in other jurisdictions?
2. What infrastructure is needed to promote and accommodate bike utility, safety, and legibility at larger transportation nodes?
3. What infrastructure is needed to promote and accommodate legible and seamless multi-modal transportation in Vancouver and the Vancouver region?

Methodology

This project provides the final recommended alternatives for each site. The alternatives are informed through qualitative data analysis (survey data from local cycling organizations, case studies, and a best practices review) and quantitative data analysis (bike locker and bike parkade statistics, ridership counts, crash statistics and cyclist profiles). These alternatives are an extension of the project team's preliminary alternatives (see Appendix I, J & K), which were proposed in an interim report. The project team went through an iterative design process to evolve the renderings based on client feedback and new design ideas. This process of iteration helped the project team produce site-specific alternatives that incorporate designs that are necessary in promoting intermodality and cyclist safety and utility, including interventions that support a safe, functional bicycle transportation network and specific end-of-trip facilities

Following a review of the data collected, the project team created a decision framework and design matrix to inform the proposed alternatives. A timeline of the project and its achievements is displayed in Figure 2.

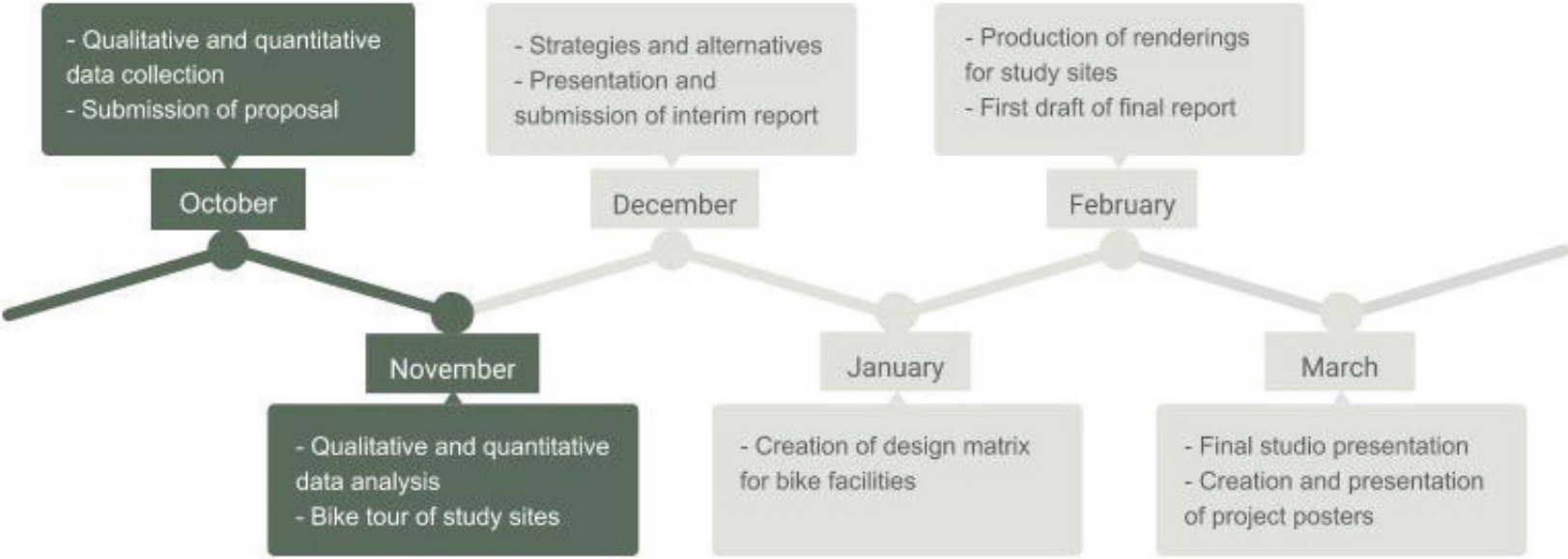


Figure 2. The project's timeline with associated achievements.



Figure 3. 10th Avenue facing east from the Arbutus Greenway.

Background

Policy Alignment

Existing Policies

In 2012 Vancouver City Council adopted *Transportation 2040*, a long-term strategic plan for an efficient transportation system that supports the health and wellbeing of residents and protects the natural environment. As part of this plan and building on Greenest City targets, the City established the goal of at least two-thirds of all trips by 2040 to be made by foot, bike, or transit. Increasing the number of trips made by sustainable modes, however, requires adequate transit and bicycle integration in a variety of contexts. Since a commuter's trip does not begin and end solely at the station, creating safe, seamless bike-transit interactions requires planning in three key contexts: traveling to the transit station, arriving at the transit station, and boarding transit.

TransLink's Guiding Principles

Through documents such as *Transport 2040* and the *10-Year Investment Plan*, TransLink is dedicated to providing a sustainable transportation system that meets the needs of Metro Vancouver residents and businesses both currently and into the future. Adopting a 2040 vision for a reliable transit network that offers safe, convenient, and equitable access, TransLink is guided by six strategic goals that serve as a framework for future action. Included in these goals is an aggressive reduction in greenhouse gas emissions, an increase in the number of trips made by foot, bicycle, and transit, and ensuring that mobility within the region is safe, efficient, and accessible for everyone.

TransLink also maintains a set of design guidelines for passenger facilities, which are at the core of every stage of the planning process. These principles correspond to

TransLink's wider corporate and community visions by ensuring that designs are consistent, cost-efficient, and lead to systematized outcomes. These design guidelines – usability, accountability, placemaking, operations, and environment – described in more detail in Figure 4, are applied to specific projects and paired with an evaluation framework to assess areas for improvement. These guidelines helped to inform our matrix, and are crucial for evaluating safe, convenient, and seamless integration at transit facilities.

TransLink's Cycling Guidelines

TransLink's cycling guidelines are informed by their regional cycling strategy *Cycling for Everyone*. This strategy provides a vision for the state of cycling in Metro Vancouver, as well as guidance on how cycling can help to achieve *Transport 2040* goals of safety, sustainability, and seamless integration. TransLink's vision to construct low-stress bikeways that make cycling safe for everyone is based on their mandate to treat bicycles as their own distinct vehicle class. Cyclist

comfort levels are influenced largely by perceptions of safety from motor vehicle traffic, and thus treatments such as traffic calmed streets, bike lanes and paths, and separated cycle tracks on arterial roads are crucial for increasing cycling rates. When designing facilities for a high degree of cyclist safety, it is important to note that the greater the speed and volume of motor vehicle traffic, the greater the amount of separation and protection required for cyclists.

The bikeway design guidelines referenced for this project include the National Association of City Transportation Officials' (NACTO) *Urban Bikeway Design Guide*, the City of Vancouver's (COV) *All Ages and Abilities Cycling Routes* guidelines, and TransLink's general facility classifications. NACTO's guidelines for the construction of cycling facilities will be discussed in more detail in the design matrix. These guidelines have helped inform our designs and recommendations, and are crucial for building bikeways and facilities that assist TransLink and the CoV in achieving their 2040 targets for an increase in sustainable transport.

Usability	Accountability	Placemaking	Operations	Environment
<ul style="list-style-type: none">-Is bicycle parking located adjacent to desire lines and close to entrances?-Is proper wayfinding integrated with facility design?-Is the space designed to minimize conflict zones and enable safe pedestrian movement?-Are parking facilities located in areas of high visibility?	<ul style="list-style-type: none">-Is the facility designed to accommodate future growth?-Does the design provide convenient access to existing and future external destinations and surrounding public-Does the design contain natural elements that reflect the identity of the community?	<ul style="list-style-type: none">-Are public spaces located along key bicycle, pedestrian, and transit routes?-Are amenities fully integrated with transit facilities and surrounding buildings?-Have public art opportunities been considered and local community groups engaged?	<ul style="list-style-type: none">-Is appropriate space provided to transit vehicles and passengers considering future changes in growth and technology?-Is bicycle access safe, convenient, and located in a well-lit area?-Is bicycle parking located close to entrances and exits for convenience and natural surveillance?	<ul style="list-style-type: none">-Can building materials be reused or recycled?-Does the design optimize daylight to minimize the need for electric light sources?-Has sight vegetation been maximized without compromising natural surveillance or visibility?-Have opportunities been considered for electric bicycle/vehicle charging stations?

Figure 4. TransLink design guidelines for passenger facilities. Note: This figure is based on a selection of key design guidelines associated with each design theme.

Relevant Research

Research conducted on cycling safety and bike-transit integration is vast and provides a strong foundation of existing knowledge. In order to identify best practices and to inform our research and recommendations, we have reviewed both academic and grey literature, and have organized the findings into categories that correspond with the project objectives. These two categories are intermodality (seamless bike-transit integration) and minimizing conflicts for cyclists (cycling safety).

Intermodality

Existing research demonstrates the importance of bicycle infrastructure in intermodal transport as it serves as a means of diversifying and strengthening the existing transit network. Coordinating cycling with public transport is mutually beneficial for both networks, and identifying ways to make cycling safe and convenient can help TransLink achieve its goal of facilitating seamless bike-transit trips on a regional scale. One way to combine cycling and transit trips is to provide adequate bike-and-ride facilities at transit stations. The attractiveness of bike-and-ride facilities is in its potential to solve one of the key problems of public transport: the accessibility of stations and stops (Martens, 2004). Bicycles can be used by transit networks as a feeding mode for access trips from the beginning of a trip, for egress trips at the end of a trip, or for both (Martens, 2004). The use of bicycles supports transit by extending the catchment area of transit stops far beyond the typical walking range, and does so at a much lower cost to that of neighbourhood buses or park-and-ride facilities (Pucher & Buehler, 2009). The relationship is reciprocal, as not only does an increase in bicycle trips help support the use of public transport, but transit helps cyclists by allowing them to make longer and more difficult trips than would be capable by the average cyclist (Pucher & Buehler, 2009).

It should be noted that bike-and-ride facilities can be problematic if the demand exceeds the supply. The literature reveals that capacity problems are common in European cities with well-used public transportation networks and high levels of cycling, leading several municipalities to not allow bicycles on transit (Pucher & Buehler, 2009). Many train stations across Europe also experience a shortage of available parking facilities and an overcrowding of existing bicycle space (Bruntlett & Bruntlett, 2018). In order to address this issue, municipalities are increasing the amount of parking being provided at major transit terminals while also making it higher quality with more sheltered and secured spaces (Pucher & Buehler, 2009). While the demand for bicycle-transit integration across the Metro Vancouver region is not at the same level as many European cities, offering an adequate amount and the right mix of bicycle parking is also a crucial focus at transit facilities in the region. Transit vehicles are limited by space constraints on the number of bicycles that can be brought on board, and so providing secure, covered parking at transit stations is necessary for promoting bike-transit trips and making cyclists' journey more comfortable.

Minimizing Conflict for Cyclists

Another objective of this project is to provide recommendations for interventions that help address bike-transit conflicts at major transportation nodes. Ensuring that cyclists have safe routes to transit will help make their trip safer and more comfortable, and will help TransLink achieve *Transport 2040* targets for more sustainable transport.

Having low-stress, well-connected cycling routes is essential for road safety and for promoting cycling as a practical option for people of all ages and abilities. Just as motor vehicles, transit vehicles, and pedestrians are often accommodated through the use of signage, pavement markings, and signalization, cyclists also require specific accommodations that promote safety and convenience

(Road Safety BC, 2015; City of Cambridge, 2014). A review of the literature suggests that minimizing conflicts at major nodes and intersections requires a focus on four key design principles: clearly communicating right-of-way priority, providing adequate site distance, minimizing exposure to conflicts, and reducing speeds at conflict points (MassDOT, 2018). Implementing these design principles at major nodes, however, may be complicated by a variety of variables that differ for each location. These variables are crucial for considering conflict points for cyclists, and include factors such as: user volumes, design speeds, bus stop locations, existing terrains, land use, on-street parking, and available right-of-ways (MassDOT, 2018).



Figure 5. 10th Avenue at Commercial-Broadway SkyTrain Station.

Design Matrix

The design matrix was used to inform the final alternatives proposed for each of the sites. The matrix is categorized by the three key dimensions of interaction: traveling to the transit station, arriving at the transit station, and boarding transit. For these categories, various interventions were researched and detailed according to four descriptors: qualitative indicators, specifications, benefits, and drawbacks.

Qualitative indicators are subjective assessments of each intervention, based upon each team member’s perception of that intervention. The project team decided to divide the qualitative indicators into five key evaluators, including:

- S - Safety
- A - Accessibility
- C - Covienance
- D -Directness
- C - Cost

Each of the appendices has a different definition for each of the evaluators. This definition was then applied to inform a value for each of the interventions, given a ranking of low, medium, high or not applicable. Each team member assessed the different matrices individually using the definitions provided, with the final value displayed as an average of the four assessments.

- - Low
- ◐ - Medium
- - High
- ⊘ - Not applicable

Specifications detail the different physical characteristics in a specific intervention, such as size, material, or installation considerations.

Benefits describe the beneficial elements of an intervention.

Table 1. A summary of the proposed interventions organized by category.

Traveling to the Transit Station	Roads <ul style="list-style-type: none">Shared lane markingsSpeed humpsConventional bike laneBuffered bike laneContra-flow bike laneLeft-side bike laneOne-way protected cycle trackRaised cycle trackTwo-way cycle track	Intersections <ul style="list-style-type: none">Bike boxIntersection crossing markingTwo stage turn queue boxMedian refuge islandThrough bike laneCombined bike lane/turn laneSpeed management (curb extension, edge island, neighborhood traffic circle, raised intersection)Volume management (channelized right-turn/right-on island, diverter, diagonal diverter)	Wayfinding <ul style="list-style-type: none">Bike signal headsSignal detection and actuationActive warning beaconColoured bike facilitiesConfirmation signsTurn signsDecision signs
Arriving at the Transit Station	Parking <ul style="list-style-type: none">Bike lockersBike racksVertical and double-decker bike racksStaple racks/inverted ‘U’Coat hangerHoop and postUnderground parking facilityBike cages		
Boarding Transit	Facilities <ul style="list-style-type: none">Bicycle shopsBathroomsTune-up stationsBike-stair access rampElevatorsAccessible entry gates		

Drawbacks explain a feature that renders the intervention as less acceptable or contains some disadvantage.

Each of the interventions also includes a small illustration in the form of a vignette.

The five matrices can be found in the appendices.

Recommendations

In consultation with project partners, the project team selected the 10th Avenue Corridor as the study site for an analysis of bike-transit interactions, intermodality, and safety because of its significance as a key branch of the MBN. It is one of the busiest east-west bikeways in the city, with over 500,000 cyclists travelling on it every year (CoV, n.d.). It is also slated for upgrades as part of the Transportation 2040 plan to make cycling safe, convenient, and comfortable for all ages and all levels of cyclists. More specifically, the project team selected Arbutus Street, Cambie Street, and Commercial Drive because they are key conflict points with transit infrastructure, requiring special consideration of MBN routes, bus service lines, and SkyTrain lines.

The background of each of these specific sites and their significance to cycling and transit is discussed in the following sections. Figure 6 illustrates the location of these sites along 10th Avenue.

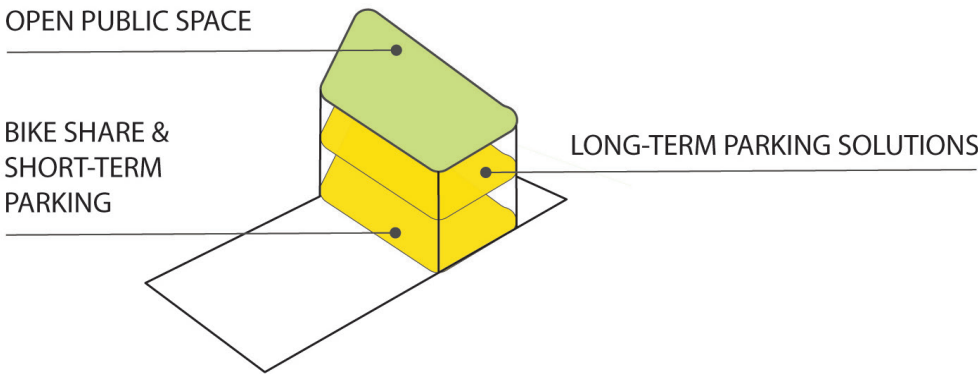
Site Objectives

The following designs are based on a high-volume, high-demand transportation projection. By 2040, Vancouver’s population is expected to grow by 130,000 residents, and as a result significant changes in mode share are expected. The number of trips made by cycling have been steadily increasing over the past decade (from 4% in 2011 to a projected 7% by 2020), and are projected to reach 12% by 2040. To accomodate this projected growth, the project team’s designs are focused on providing various cycling interventions that promote safe cycling to the station, as well as adequate and conveniently-located secure bike parking and amenities at the station.

Open Space

Providing open public spaces that encourage pedestrians and cyclists to use the street is an important aspect of supporting transit-oriented communities, and more specifically a key consideration when planning the design of transit stations. In line with TransLink’s *Transit-Oriented Communities Design Guidelines*, open public spaces can take many different forms, from small placemaking spaces to larger plazas that provide convenient access to public transit. Integrating lively, welcoming public spaces with transit facilities is an important part of encouraging intermodality, and the design of the space can increase overall feelings of safety and security.

CYCLING FACILITY CONCEPT (3 floors)



CYCLING FACILITY CONCEPT (4 floors)

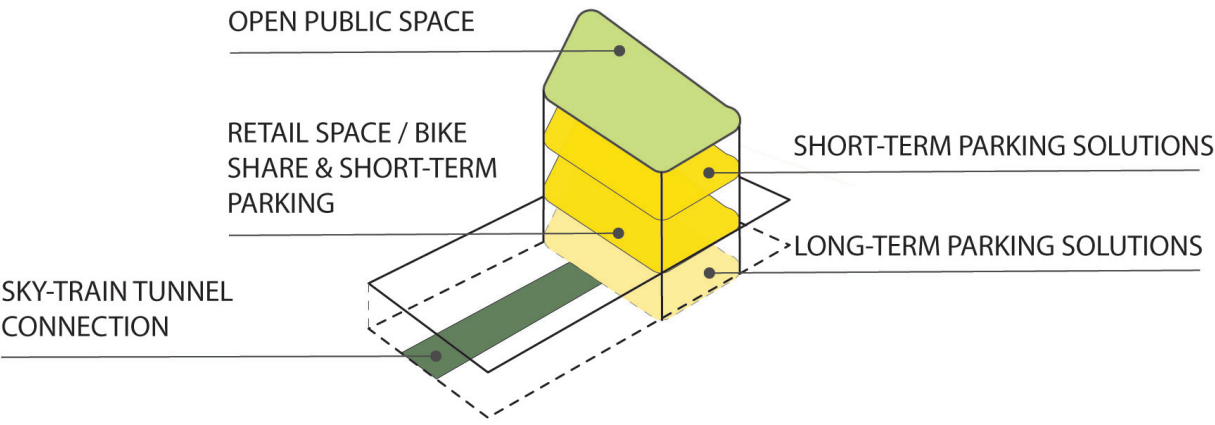


Figure 6. Concept designs for two types of cycling facility.

An aerial photograph of a suburban neighborhood, likely in the Pacific Northwest, showing a grid of streets, houses, and trees. A large, semi-transparent dark grey rectangle is centered over the image. The word "Arbutus" is written vertically in a white, serif font across the center of this rectangle. The text is oriented vertically, reading from top to bottom. The background image shows a mix of residential buildings, some with flat roofs and others with gabled roofs, interspersed with green trees. A baseball field is visible in the lower-left corner of the image.

**A
r
b
u
t
u
s**

Active Greenway

Arbutus Street is a busy arterial along the 10th Avenue Corridor that has high motor-vehicle as well as pedestrian and cyclist volumes. Important considerations for Arbutus Street include an increase in pedestrian and cyclist traffic from the recently developed Arbutus Greenway, as well as predicted traffic increases with the future Arbutus SkyTrain station. The Arbutus Greenway – a nine-kilometer route with separated areas for walking and cycling that spans from Milton Street to 6th Avenue and Fir Street – has contributed to important changes along Arbutus in regard to infrastructure as well as pedestrian and cyclist traffic.

Arbutus and Broadway are frequent transit corridors, with the number 9 and 14 servicing westbound, the number 16 servicing northbound, and the 99 B-Line servicing eastbound. The 99 B-Line bus has significant implications for pedestrian traffic and safety along Arbutus Street as it is both the busiest and most overcrowded route in Metro Vancouver (BC Ministry of Transportation and Infrastructure, 2018). Moreover, pedestrian and cyclist traffic is expected to grow significantly with the MLBE project, as the last station has people unloading on Arbutus Street. The extension’s capacity to move roughly 7,100 people per hour – an increase of 255% more than the B-Line service capacity – means that traffic will rise greatly along the Corridor (TransLink, 2018b).

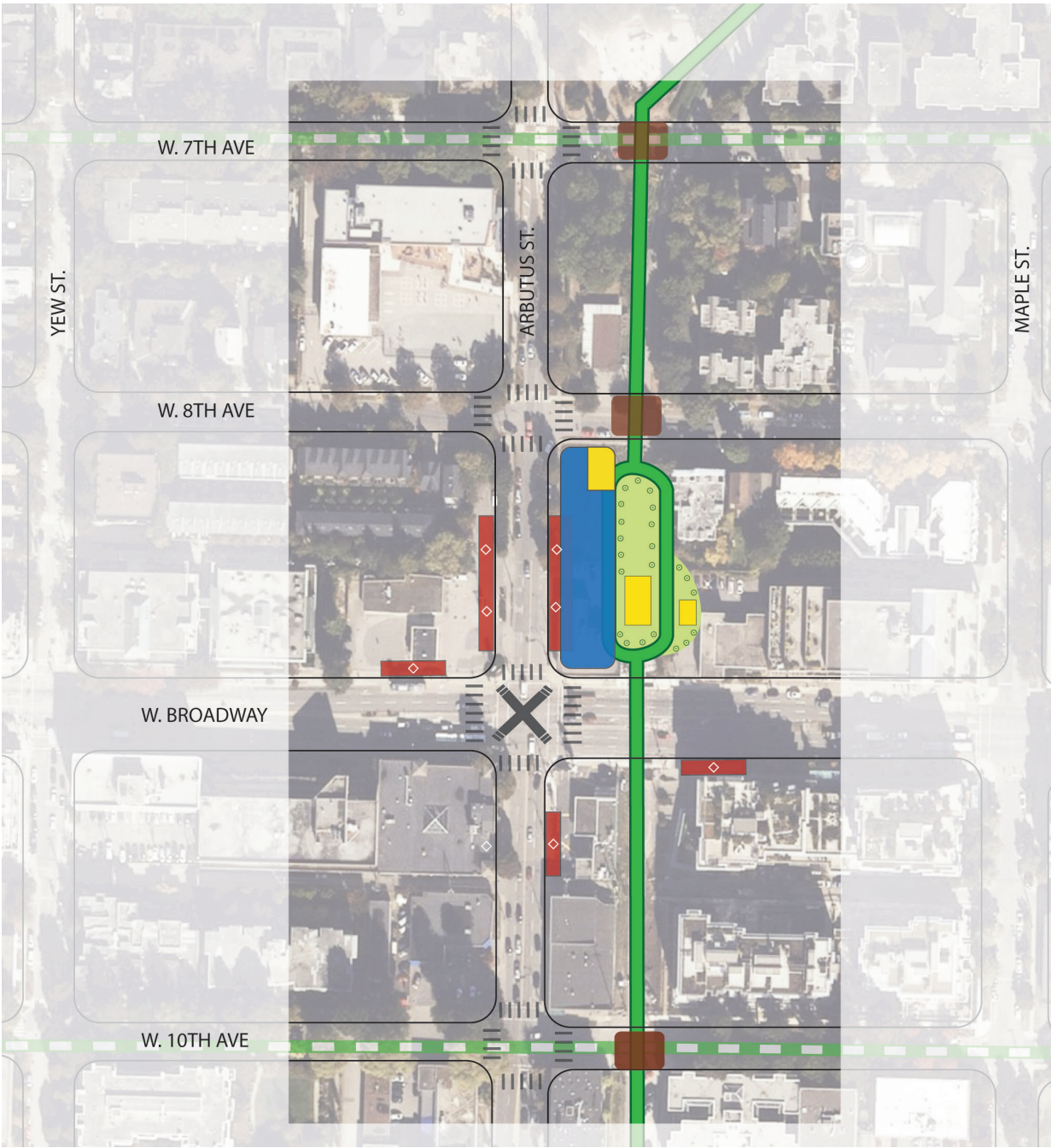
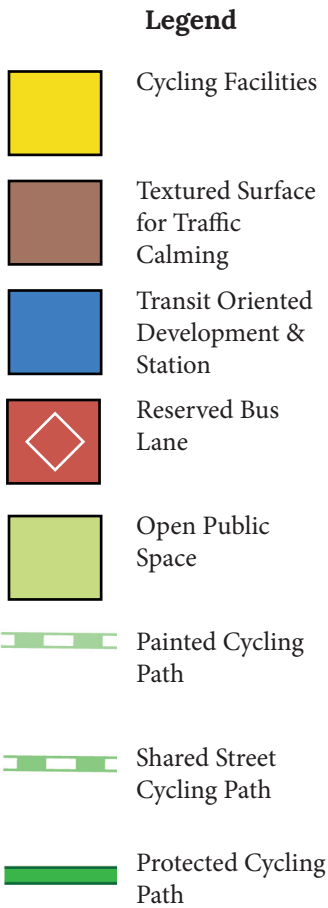


Figure 7. Context map of Arbutus Street and Broadway.

Site Analysis

Vehicle traffic volumes along Arbutus Street are moderate in comparison to volumes along Commercial Drive and Cambie Street. Vehicle volumes are greater, however, for east-west traffic (on Broadway) than north-south traffic (on Arbutus), with north-south figures being 50-70% that of east-west figures (see Appendix F). Also important for consideration, the 10th Avenue Corridor has high bicycle volumes (50-90/hour during peak commute times) and the peak volume times begin earlier in the afternoon than at both Commercial Drive and Cambie Street (3:15PM - 4:15PM).

With the expected increase in pedestrian and cyclist traffic resulting from the new Arbutus station, there are some important considerations for design interventions that promote safety and convenience. Some of the current issues around the site are:

1. Poor pavement quality along 10th Avenue approaching Arbutus Street presents a risk to cyclist safety, as the presence of small potholes and fissures may cause cyclists to lose balance or control, or even worse swerve into the line of traffic.



Figure 8. Uneven road surface on 10th Avenue at the Arbutus Greenway.

2. A lack of safe crossing interventions (e.g. special crosswalks and advanced warnings) are of concern as the SkyTrain station will be directly across from a daycare, as well as next to an elementary school - posing a greater risk for vehicle-pedestrian conflict, especially for children and parents during drop-off and pick-up times.



Figure 9. Pedestrian crossing off of the Arbutus Greenway.

3. Inconvenient location of bike-share stations will have bike-share users who are wanting to access the SkyTrain station crossing a busy intersection, making the transition from bike to SkyTrain both less convenient and less safe.



Figure 10. The current bike-share station sits south of Broadway along the Arbutus Greenway.

Site Layout

Based on the site analysis, the project team’s recommended design interventions for the Arbutus Street site include the following:

- Fix the pavement quality along 10th Avenue – this is crucial for ensuring cyclists are able to maintain their control and have a comfortable riding experience.
- Provide leading pedestrian intervals to give pedestrians an advanced walk signal.
- Time pedestrian walk signals to appropriately accommodate walking speeds and provide an extended push-button.
- Provide adequate lighting on the roadways approaching the intersection as well as along the pedestrian crosswalk area.
- Install raised pedestrian crossings to increase visibility and reduce vehicle speeds.
- Install special crosswalks with pedestrian-activated overhead flashing lights and downward lighting to help increase motorists’ awareness of the crosswalk.
- Relocate the Mobi bike-share station to beside the SkyTrain station in order to help with bike-transit connectivity.

Legend

Seperated Cycling Lane

Cycling Facilities

Transit Oriented Development & Station

Reserved Bus Lane

Open Public Space

A site layout map of the intersection of Arbutus St and W. Broadway. The map is oriented with Arbutus St running vertically on the left and W. Broadway running horizontally at the bottom. To the right of the intersection, there are several building footprints. The map uses color-coding to indicate different design zones: a large blue rectangular area on the left side of the intersection represents 'Transit Oriented Development & Station'; a green area along the top and right sides of the intersection represents 'Open Public Space'; a yellow rectangular area in the center of the intersection represents 'Cycling Facilities'; a red rectangular area on the left side of the intersection, adjacent to Arbutus St, represents a 'Reserved Bus Lane'; and a green dashed line along the top and right sides of the intersection represents a 'Seperated Cycling Lane'. The map also shows a crosswalk at the intersection and a small red square with a white diamond symbol on Arbutus St.

Figure 11. Site layout with design objectives for Arbutus Street and Broadway.

16

Cycling Facilities

Providing the right type and adequate number of bike parking facilities is an important aspect of planning for the new Arbutus SkyTrain station. It is projected that the Arbutus Station will be one of the busiest stations, with large volumes of traffic transferring to and from the 99 B-Line. The provision of long-term bike facilities will be useful for commuters who will be gone for most of the day and require a more secure parking option. However, providing adequate short-term parking will also be important for people wanting to get off of their bike to experience features of the planned Arbutus Greenway character zones.

Transit Hub

Important considerations for the new station at Arbutus Street include helping to move people quickly through the congested Corridor, as well as connecting SkyTrain users going to UBC with the 99 B-Line service (BC Government, 2018). Based on current ridership levels, it is expected that the station will be a major transit hub. Given the projected high volumes of traffic, integrating the station with existing and future walking and cycling networks will be crucial for promoting seamless interactions.

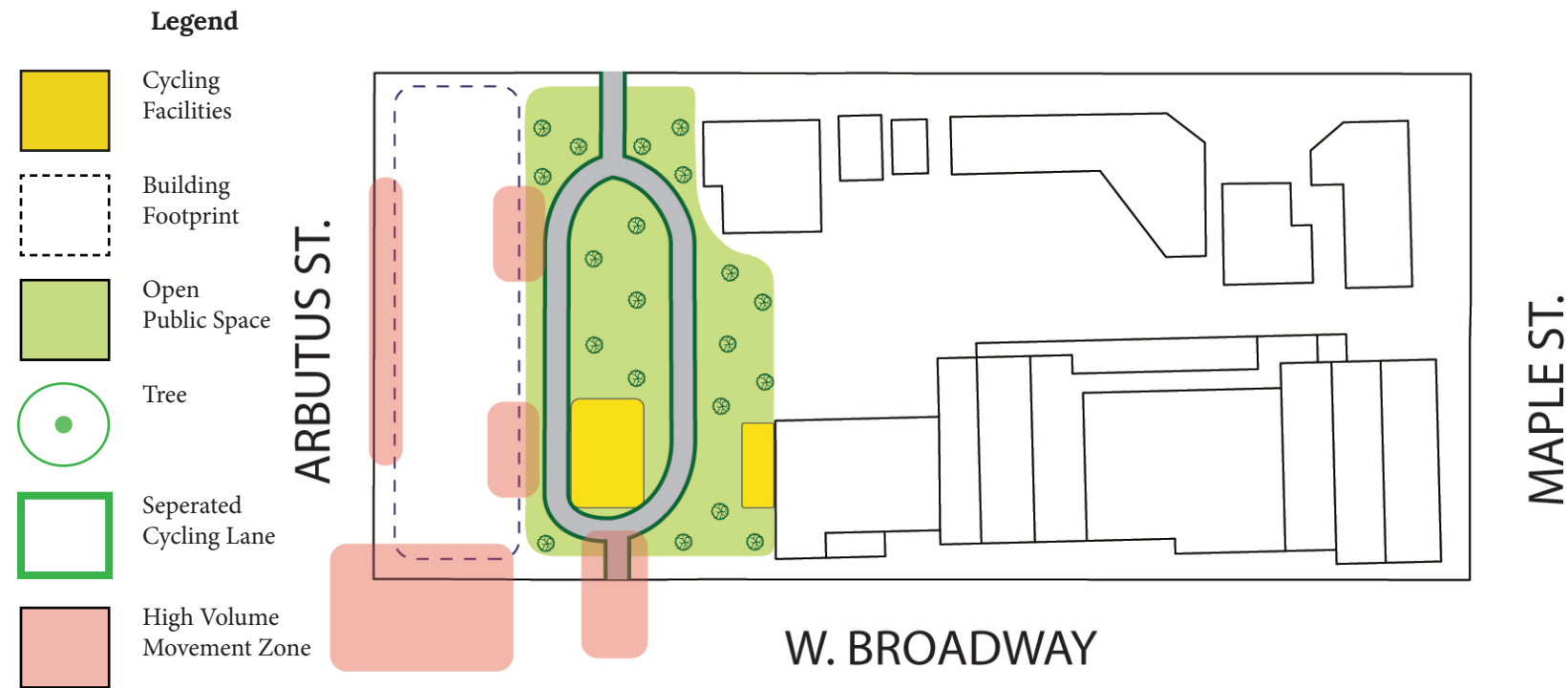


Figure 12. Site analysis for conflict zones at Arbutus Street and Broadway.

Seamless Interaction with Transit

Underground ramps exclusively for cyclists between bike parking facilities and the platform in the station will separate cyclists from pedestrians and minimize conflicts between the two. The ramps should be designed to assure visibility and predictability for cyclists to prevent crashes with other cyclists, and the slope should be moderate with an enough width so that cyclists go down to the platform safely and go up easily from the platform. Markings should be installed on the platform to indicate the transit door where cyclists are expected to board the transit to reduce collisions with pedestrians.

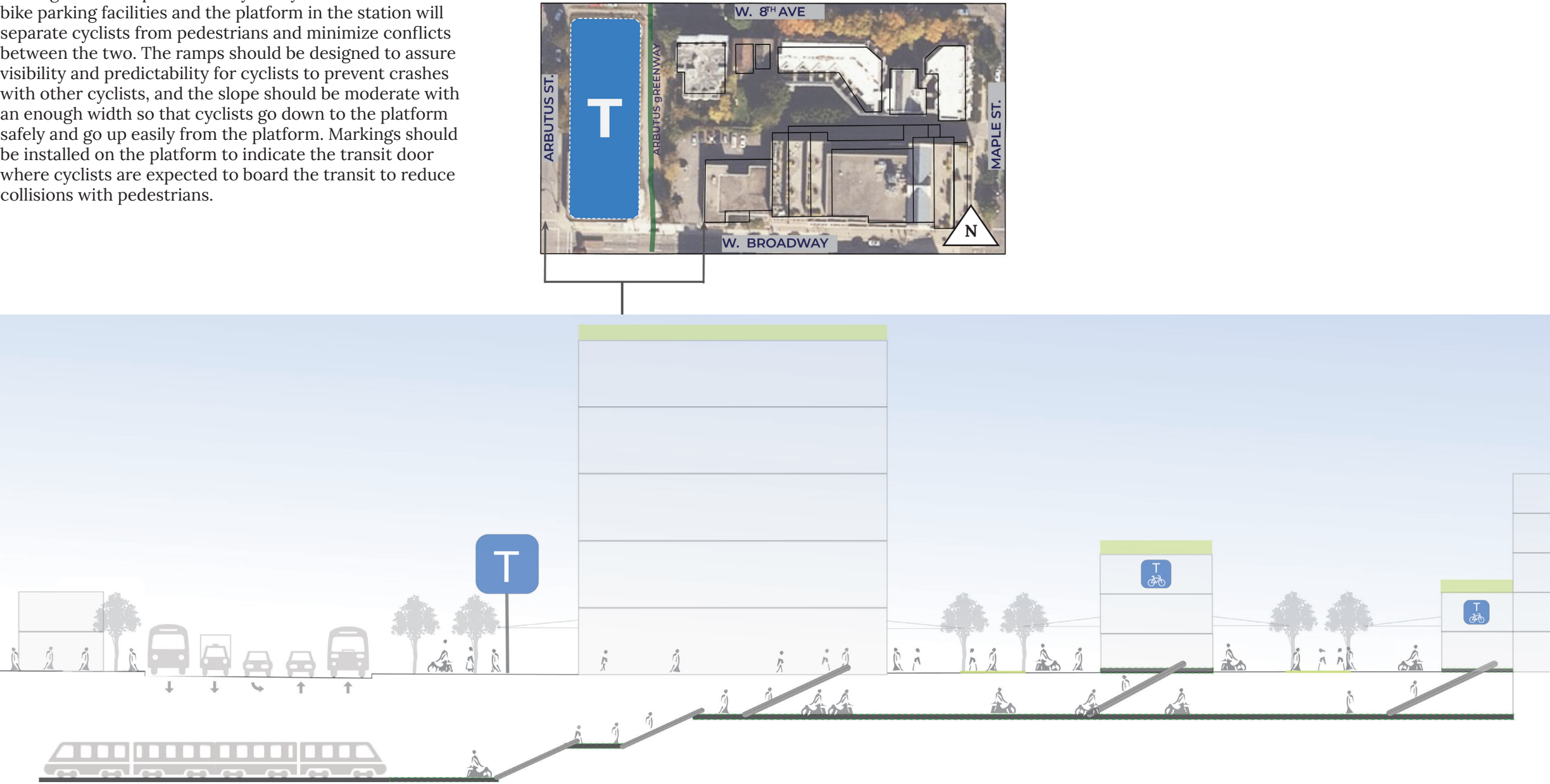


Figure 13. Cross section of Arbutus Greenway with accompanying SkyTrain station.

An aerial photograph of a city street grid, likely in Vancouver, British Columbia, showing Cambie Street running vertically. The image is divided into three horizontal sections. The top and bottom sections show the actual aerial view with buildings, trees, and streets. The middle section is a semi-transparent grey band that spans the width of the image. Centered within this grey band is the word "Cambie" in a large, white, serif font, with each letter on a new line.

C a m b i e

New City-Hall

The site around the intersection of Cambie Street and Broadway is an economic hub, with high residential and employment density making it a regional destination. The area on 10th Avenue between Oak and Cambie is the Health Precinct, which serves an essential access point to medical institutions such as Vancouver General Hospital. The Canada Line SkyTrain goes underground along Cambie Street, and the exit of the Broadway-City Hall Station is located at the southeast corner. The site will have a new station as part of the future Millennium Line extension, located at the northwest corner and with underground connection to the Canada Line. There is a redevelopment project occurring at southwest of the intersection and are several potential redevelopment sites nearby. Both Cambie and Broadway are arterial streets with high vehicle volumes, as well as high pedestrian volumes from the SkyTrain and three bus lines (number 9, 15, and 99 routes).

Of particular note, there are three key bikeways around the site. Yukon Street, one-block east of Cambie Street, goes north-south with bike lanes. This area has a moderate uphill slope towards the south, and has relatively low cycling volumes travelling in this direction. On 7th Avenue, two blocks north of Broadway, there is a shared local street bikeway that also has low cycling volumes. It is easier to access Olympic Village Station along 7th Avenue, which is located just two blocks north. Notably, 10th Avenue - one block south of Broadway - has some of the largest cycling volumes. Vehicles are restricted to one-way westbound travel from Cambie Street, and eastbound from Cambie Street towards the City Hall parking lot there are protected cycling tracks.

Legend

Cycling Facilities

Textured Surface for Traffic Calming

Transit Oriented Development & Station

Reserved Bus Lane

Open Public Space

Painted Cycling Path

Shared Street Cycling Path

Protected Cycling Path

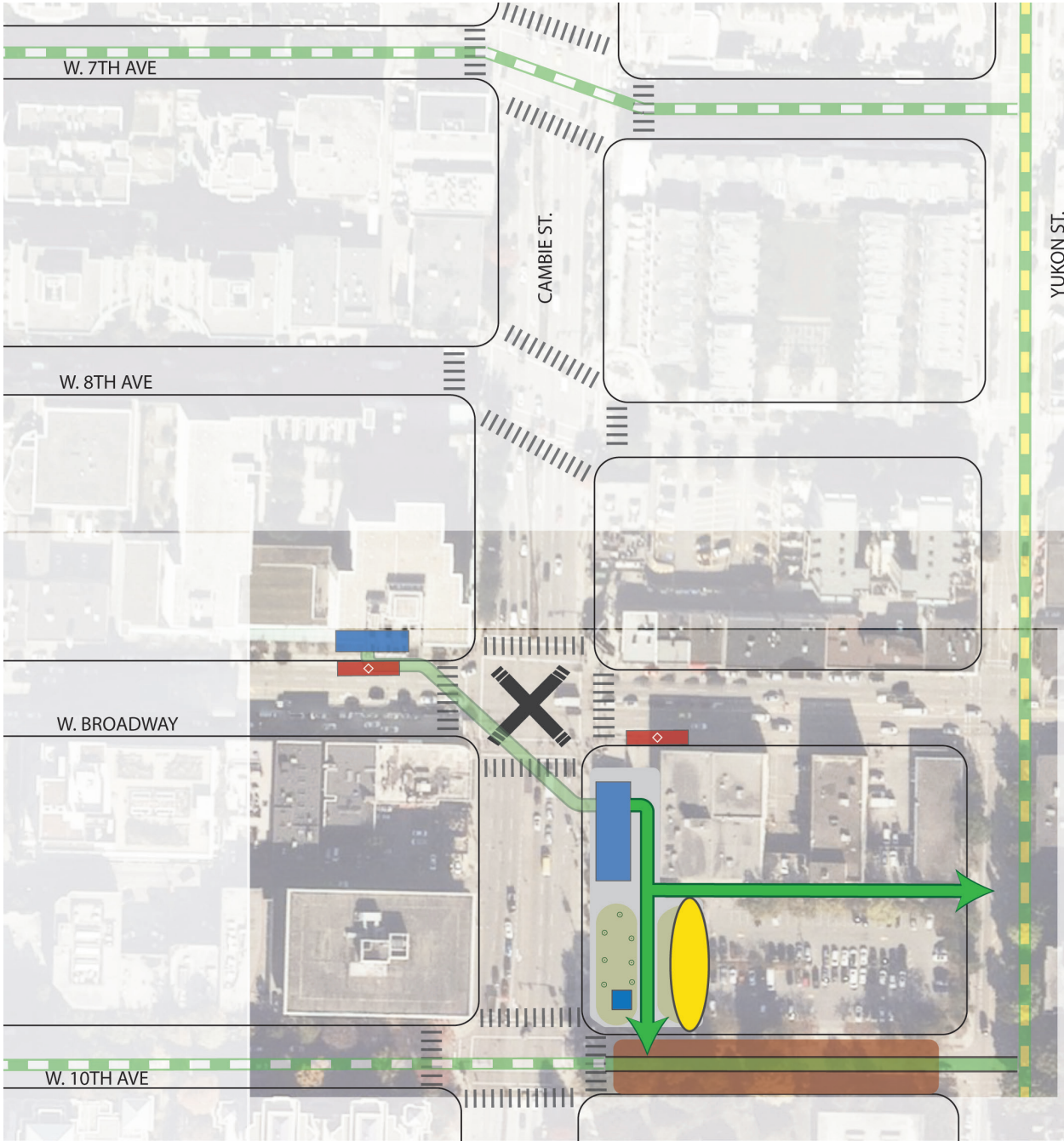


Figure 14. Context map of Cambie Street and Broadway.

Site Analysis

As an arterial road, Cambie Street experiences high traffic volumes. At the intersection of Cambie Street and Broadway there are high motor vehicle volumes (800 - 1,200) and pedestrian volumes (600 - 1200) from every direction during peak commute times (see Appendix G). Although bicycle volumes are relatively low (averaging 45 cyclists per hour), high motor vehicle volumes pose a concern for conflicts between motorists and non-motorists. Along 10th Avenue, which is an endorsed bikeway, there are high bicycle traffic volumes during peak morning and afternoon commute times (an average of 161 cyclists per hour travelling west in the morning, and 139 per hour travelling east in the evening). Similarly, these directions have high volumes of pedestrian traffic, which raises the potential for conflict between cyclists and pedestrians.

The analysis focuses on bike-transit connection from 10th Avenue to Broadway-City Hall Station and includes the following issues:

1.

Crowded intersection at Cambie Street and Broadway increases the potential for bicycle-vehicle conflicts, especially with the upcoming extension of the Millennium Line and an associated increase in pedestrian and cyclist traffic.
3.

Unsafe access to secure bike parking from 10th Avenue as cyclists use the same area that motorists use to enter the parking lot.



Figure 15. Cambie Street and Broadway intersection.



Figure 17. Entrance to the City Hall parking lot.

2.

Lack of available secure bike parking space near the station, with the only form of secure parking being ten lockers located in the parking lot north along 10th Avenue, which are often fully occupied.
4.

The high pedestrian volume along 10th Avenue from residential areas to the west also presents concerns for conflicts between cyclists and pedestrians.



Figure 16. Secure bike lockers at 10th Avenue and Cambie Street.

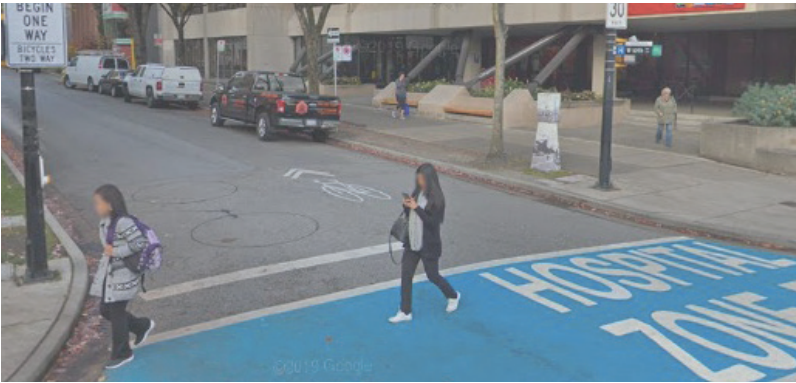


Figure 18. Cross walk on the west-side of 10th Avenue and Cambie Street.

Site Layout

Based on the site analysis, the project team's recommended design interventions for the Cambie Street site include the following:

- Enhance pedestrian safety by utilizing traffic calming treatments and establish reserved bus lanes to improve the safety of bus passengers.
- Provide a bike parkade to ensure that cyclists have access to secure bike parking, and provide a roof over the path to the exit of the SkyTrain station to enhance utility for parkade users.
- Implement an exclusive bike path from Cambie Street to the parking lot exit in order to enhance cyclists' safety and accessibility to the new bike parkade.
- Provide safety treatments such as coloured lanes and appropriate traffic signs to prevent collisions between cyclists and pedestrians.

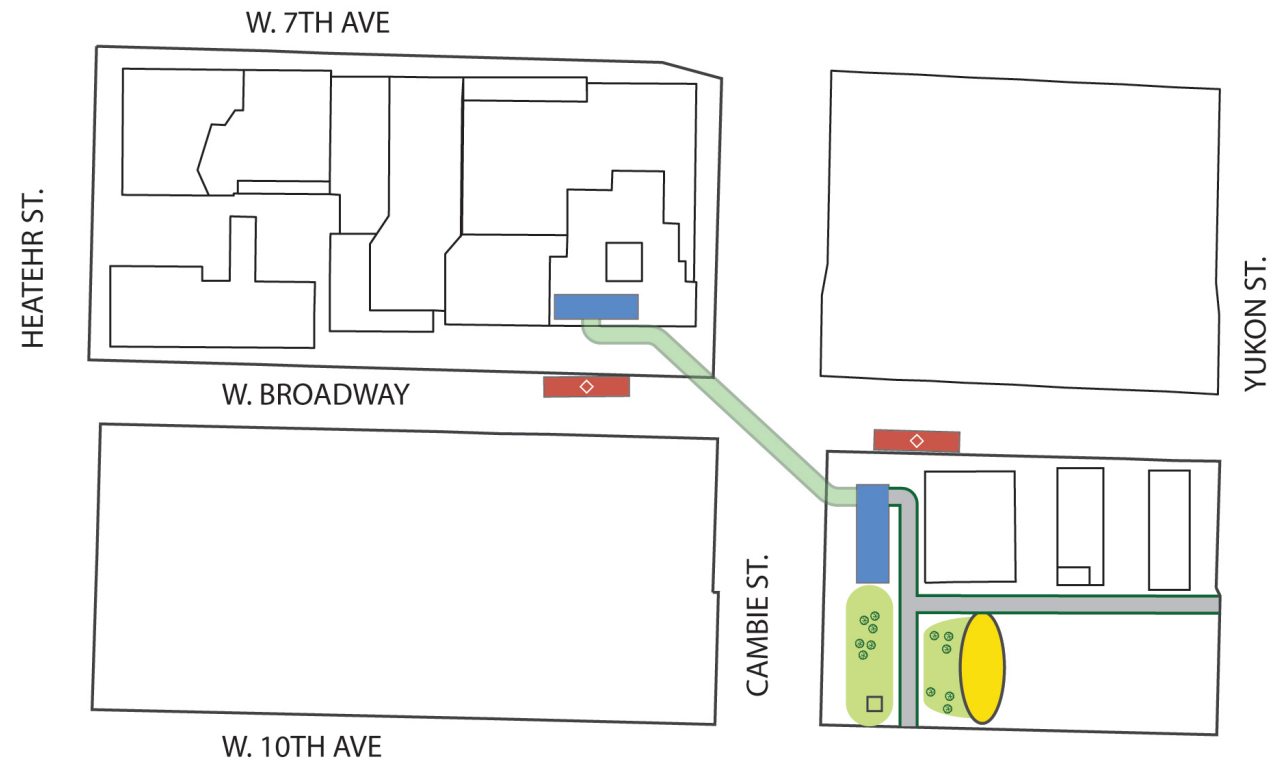
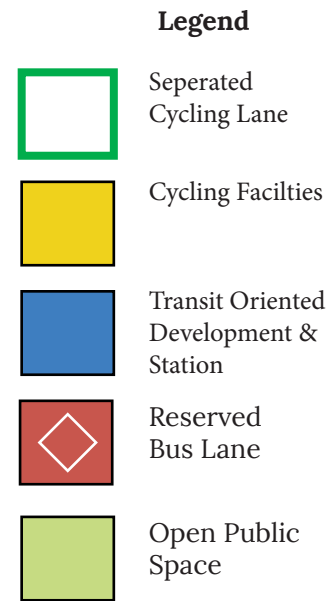


Figure 19. Site layout with design objectives for Cambie Street and Broadway.

Cycling Facilities

There are currently ten bike lockers located in the parking lot north along 10th Avenue near the Broadway-City Hall Station. Bike lockers are an important long-term parking option that provide a high level of security from vandalism and theft as well as from the elements. Although bike lockers provide a safe option for commuter cyclists who may have expensive equipment and long-term parking needs, the problem at this location is that demand currently reaches the supply of lockers. Another issue is that the location of these lockers requires cyclists to cross a busy one-way vehicle lane to gain access. For bike lockers to be the most effective, they should be situated in areas that are easy for cyclists to access.

Transit Facilities

The Broadway-City Hall Station is on a high-demand transit route, with bus routes along the Corridor being the busiest in all of Canada and the United States of America. As mentioned earlier, the Corridor is also an innovation hub, home to Vancouver General Hospital and other world-class health institutions. As part of the MLBE project, the new station at Cambie Street (which is to be fully integrated with the Broadway-City Hall Station) will make connections between the Millennium and Canada Lines faster and more seamless.

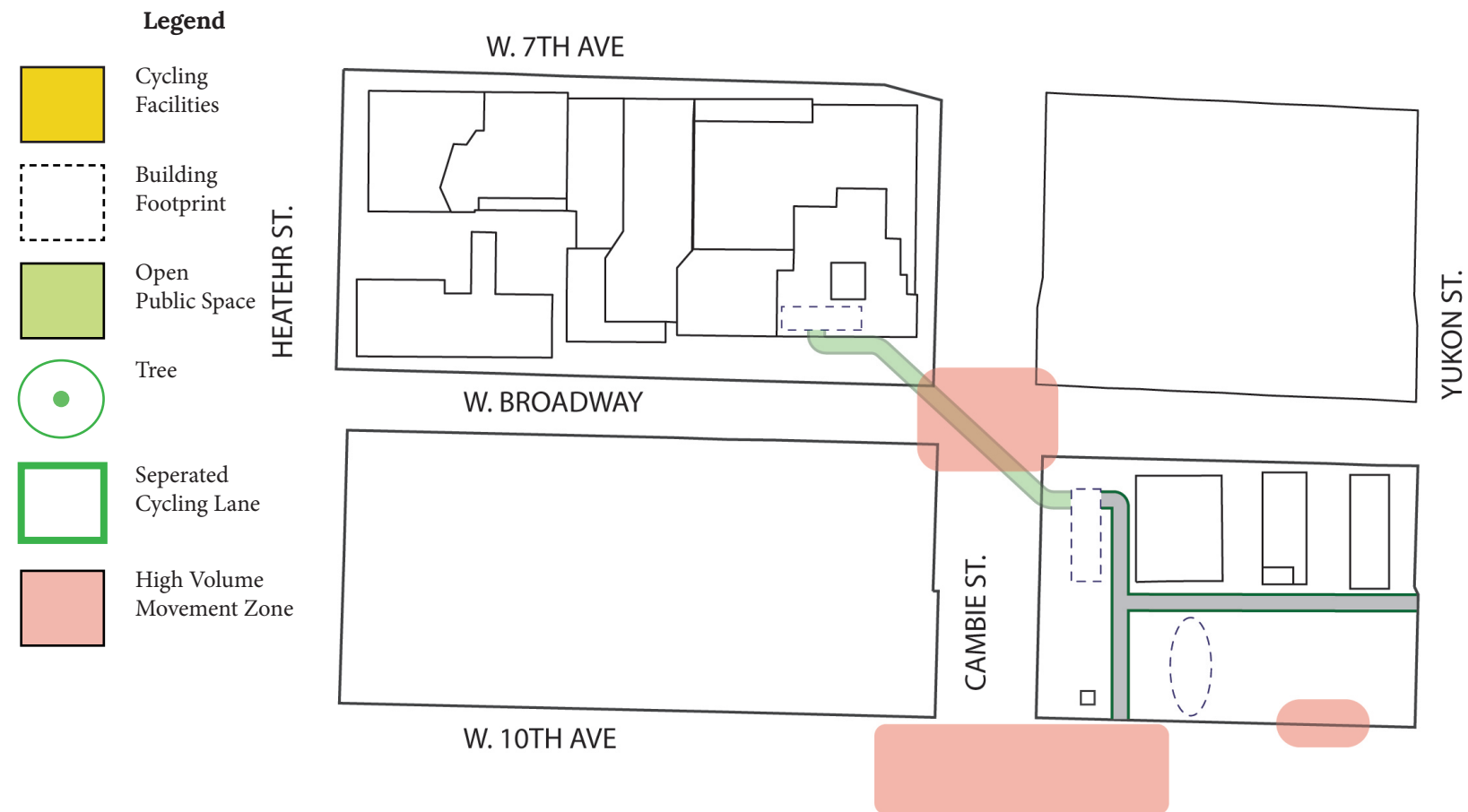


Figure 20. Site analysis for conflict zones at Cambie Street and Broadway.

An aerial photograph of a suburban neighborhood, showing a grid of streets, residential houses, and green spaces. A semi-transparent grey rectangular overlay is centered on the image. The word "Commercial" is written vertically in white, bold, sans-serif font across the center of this overlay.

Commercial

Central Greenway

10th Avenue at Commercial Drive marks the beginning of the east-end of the 10th Avenue bike route. The site itself is notable for its connections to other forms of transit and for several major redevelopments that are occurring nearby.

The intersection between Commercial Drive and Broadway acts as a major transit hub for the region, providing transfer points between the Expo and Millennium Lines in addition to stops for major bus routes including the 99 – Commercial-Broadway / UBC (B-Line) and 20 – Victoria / Downtown. This area also provides a number of connections to alternate bike routes that diverge off of 10th Avenue, including Lakewood Drive, Woodland Drive, and the Central Valley Greenway, acting as a major transportation corridor that connects Vancouver to Burnaby and to New Westminster.

The area surrounding 10th Avenue and Commercial Drive is a mix of development, being comprised primarily of comprehensive development, commercial, and residential zones. Two notable sites in the area include the Commercial-Broadway Skytrain Station and the Safeway site. Major renovations as part of Phase 2 upgrades of the 10-Year Investment Plan were recently completed at the Commercial-Broadway Skytrain Station. Some of these upgrades include a new east platform serving westbound Expo Line trains, the addition of a pedestrian walkway over Broadway, four new escalators and two new elevators, widened entrance ways, and an enhanced lighting design. The Safeway site is scheduled to be demolished and redeveloped, with developers Westbank and Crombie REIT collaborating to build four residential towers of up to 24 stories on top of a two-story commercial podium.

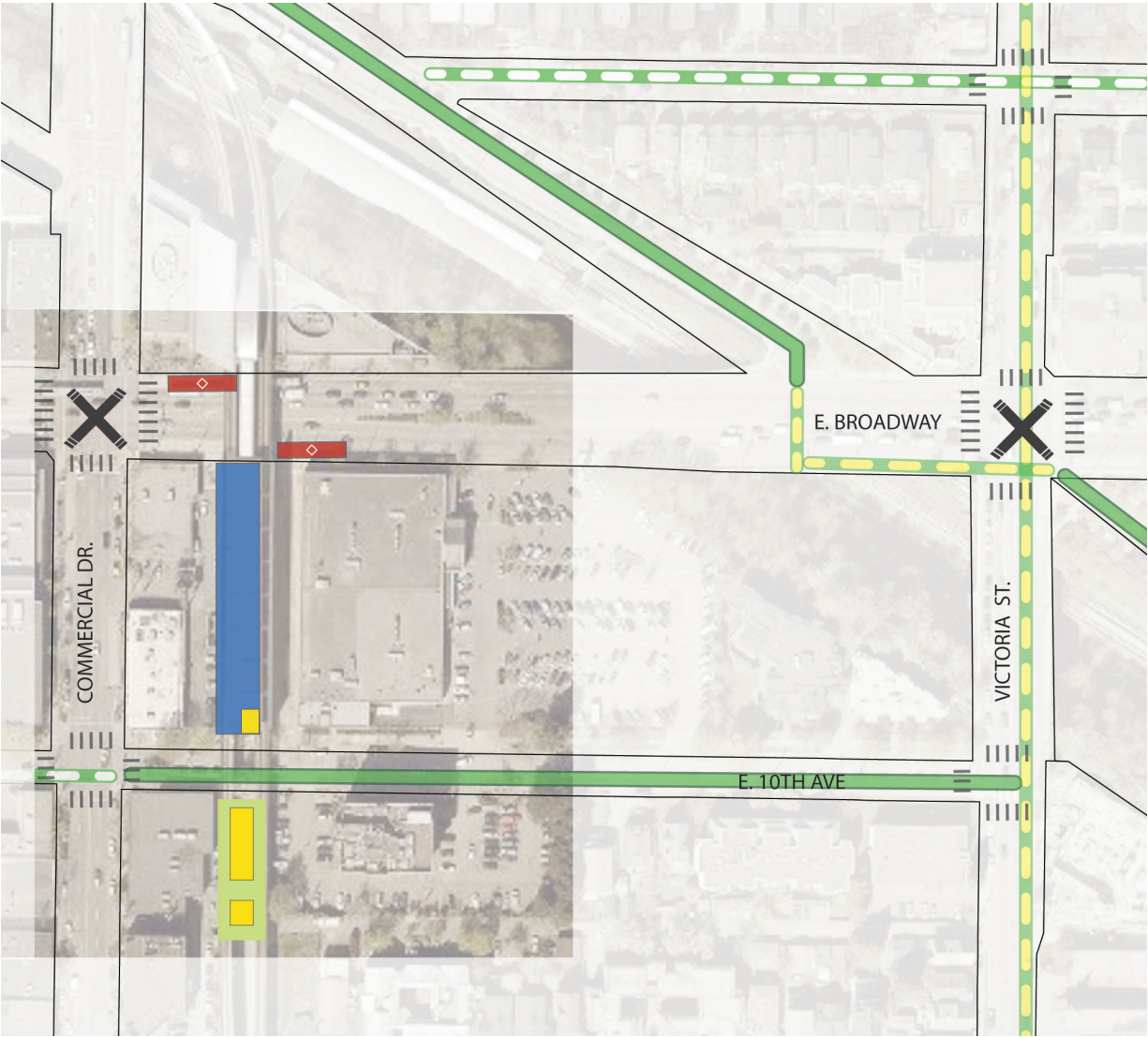
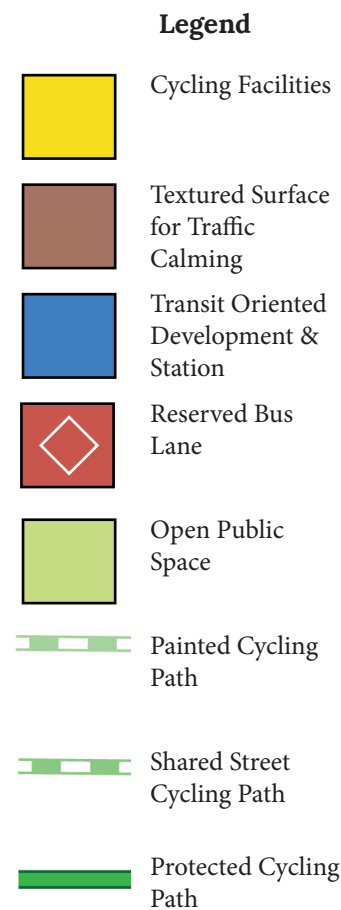


Figure 21. Context map of Commercial Drive and Broadway.

Site Analysis

Commercial Drive is a busy street with high amounts of vehicle traffic. In particular, vehicle volumes traveling westbound from Victoria Drive to Commercial Drive and Broadway reach a count of 2,000 vehicles per hour during peak morning commute times, and similar volumes travelling west during peak evening commute times (see Appendix H). The high vehicle volumes and increased potential for vehicle-cyclist conflicts are not the only issues affecting the 10th Avenue/Commercial Drive site. The analysis focuses on bike-transit connection from 10th Avenue to Commercial SkyTrain Station and includes the following issues:

- 1. Lack of bicycle parking infrastructure at the SkyTrain station and along Commercial Drive, with the demand currently exceeding the supply.



Figure 22. Commercial-Broadway SkyTrain station from 10th Avenue.

- 2. Inconvenient access to bikeshare bicycles - the docking station is located across the street from the SkyTrain station, which makes intermodal connections from bike to SkyTrain more time-consuming and unsafe.



Figure 23. Bike-share station on 10th Avenue.

- 3. Multiple conflict points at the intersection of Victoria Drive and Broadway make crossing unsafe, with cyclists crossing six lanes of vehicle traffic with limited signage and no signal lights.



Figure 24. Intersection facing west at Victoria Drive and Broadway.

- 4. Conflict points are also a concern at the intersection of 10th Avenue and Victoria Drive, where cyclists encounter a sharp 90-degree turn to cross a busy roadway.



Figure 25. Intersection facing east at Victoria Drive and Broadway.

Site Layout

Based on the site analysis, the project team’s recommended design interventions for the Commercial Drive site include the following:

- Provide additional bike parking facilities along Commercial Drive and at the Commercial-Broadway Skytrain Station.
- Ensure new parking facilities are secure, plentiful, and offered in desirable locations that experience high foot traffic.
- Move the existing Mobi bike-share station to in front of the Commercial-Broadway Skytrain Station and expand the capacity to allow for additional bicycles.
- Redesign the bicycle crossing at Broadway and Victoria Drive to allow eastbound cyclists to follow along the northern sidewalk of Broadway until Victoria Drive, where they can then safely cross the road en-route to either 10th Avenue or the Central Valley Greenway.
- Redesign the crossing at 10th Avenue and Victoria Drive to include a cyclist activated signal as well as green bike route pavement markings crossing Victoria Drive.
- Speak with developers Westbank and Crombie REIT to safeguard 10th Avenue from additional traffic volumes by incorporating traffic calming measures in this section.



Figure 26. Site layout with design objectives for Commercial Drive and Broadway.

Cycling Facilities

As part of Phase 2 upgrades of the 10-Year *Investment Plan*, TransLink recently opened a bike parkade at Commercial-Broadway Station. The parkade can accommodate 42 bicycles and is a crucial component of TransLink's goal for seamlessly integrating cycling with transit services. The bike parkade is an alternative option to bike racks (which are less secure to theft and vandalism) and bike lockers (which require a rental commitment that some people may not be able to fulfill).

Transit Hub

The Commercial-Broadway station is a major transportation hub, with an estimated 200,000 passengers passing through the station every day (Ip, 2019). Due to the large volumes of traffic getting on or off the SkyTrain, and transferring between the Expo and Millennium Lines or accessing the 99 B-Line, seamless interactions at the station are crucial for minimizing congestion. One intervention that is part of the Phase 2 upgrades and is helping to improve flow and connections at the station is a new train platform. The new platform enables transit riders to board and exit the westbound Expo Line using the doors on either side of the train. This intervention helps to reduce crowding and to make connections more seamless for passengers, whether they are connecting to the Millennium Line, the 99 B-Line, or accessing bike parking facilities at the station.

Legend

Cycling Facilities

Building Footprint

Open Public Space

Tree

Seperated Cycling Lane

High Volume Movement Zone

Figure 27. Site analysis for conflict zones at Commercial Drive and Broadway.

28



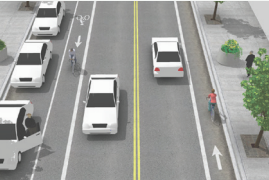

References

- Alibaba. (2019). Bike ramp. Retrieved from https://www.alibaba.com/product-detail/Easy-management-Safety-Bicycle-Facilities-Bike_114900760.html
- Archiproducts. (2019). Powder coated steel bicycle shelter [photo]. Retrieved from http://www.archiproducts.com/en/products/mmcite1/powder-coated-steel-bicycle-shelter-aureo-velo_307561
- Bike PGH. (2019). Several downtown properties get bike parking facelifts. Retrieved from <http://www.bikepgh.org/2012/07/19/several-downtown-properties-get-bike-parking-facelifts/>
- BC Ministry of Transportation and Infrastructure. (2018). Millennium Line Broadway Extension (MLBE) Project: Business Case. In Benefits of the MLBE for the province and region. Retrieved from <https://engage.gov.bc.ca/app/uploads/sites/396/2018/09/Business-Case-FINAL.pdf>
- Bruntlett, M., & Bruntlett, C. (2018). Building the cycling city: The Dutch blueprint for urban vitality. Washington: Island Press.
- Canadian Veggie. (2012). Greater Vancouver bike - Queensborough Loop. Retrieved from <https://canadianveggie.wordpress.com/2012/10/01/greater-vancouver-bike-queensborough-loop/>
- City of Santa Monica. (2019). Bicyclists. Retrieved from <https://www.smgov.net/departments/pcd/transportation/bicyclists/>
- City of Vancouver. (2012). Transportation 2040: In targets. Retrieved from http://www.vancouver.ca/files/cov/Transportation_2040_Plan_as_adopted_by_Council.pdf
- City of Vancouver. (2015). Cycling safety study final report. Retrieved from <https://vancouver.ca/files/cov/cycling-safety-study-final-report.pdf>
- City of Vancouver (2018). 2017 Transportation panel survey. Retrieved from <https://vancouver.ca/files/cov/2017-transportation-panel-survey-final-draft-20180516.pdf>
- City of Vancouver. (n.d.). Traffic count data. Retrieved from http://vanmapp.vancouver.ca/pubvanmap_net/default.aspx
- Cycling in Cities. (2006). Opinion survey. Retrieved from <http://cyclingcities-spgh.sites.olt.ubc.ca/files/2012/08/OpinionSurveyBrochure.pdf>
- Dero. (2019). The next level of parking. Retrieved from <http://www.dero.com/product/dero-decker/>
- Dill, J., Monsere, C., & McNeil, N. (2012). Evaluation of bike boxes at signalized intersections. Accident Analysis and Prevention, 44(1), 126-134. doi:10.1016/j.aap.2010.10.030
- Georgia Straight. (2019). All SeaBus and SkyTrain stations now have hands-free accessibility for those who can't tap a Compass card. Retrieved from <https://www.straight.com/tech/1206401/all-seabus-and-skytrain-stations-now-have-hands-free-accessibility-those-who-cant-tap>
- Harris, M., Reynolds, C., Winters, M., Crompton, P., Shen, H., Chipman, M... & Hunter, G. (2013). Comparing the effects of infrastructure on bicycling injury at intersections and non-intersections using a case-crossover design. Injury Prevention, 19(5), 303-310.
- Martens, K. (2004). The bicycle as a feeding mode: Experiences from three European countries: Transportation research part D. Transport and Environment, 9(4), 281-294.
- Martens, K. (2007). Promoting bike-and-ride: The Dutch experience. Transportation research part A. Policy and Practice, 41(4), 326-338.
- Massachusetts Department of Transportation. (2018). Chapter 4: Intersection design. Retrieved from https://www.mass.gov/files/documents/2017/10/26/SeparatedBikeLaneChapter4_Intersections.pdf
- National Association of City Transportation Officials. (2013). Urban street design guide. Retrieved from <https://nacto.org/publication/urban-street-design-guide/>
- National Association of City Transportation Officials. (2014). Urban bikeway design guide (2nd ed.). Retrieved from <https://nacto.org/publication/urban-bikeway-design-guide/>
- National Association of City Transportation Officials. (2016). Global street design guide. Retrieved from <https://nacto.org/publication/global-street-design-guide/>
- Nederlandse Spoorwegen. (2018). Using the OV-fiets. Retrieved from <https://www.ns.nl/en/door-to-door/ov-fiets>





- Neutral Path. (2019). Nightstand and racks guide ideas. Retrieved from <http://www.neutralpath.net/pretty-charlowe-nightstand-3/rack/22480/decker-2-tier-bicycle-parking-with-pull-down-trays.html>
- Pan, H., Shen, Q., & Xue, S. (2010). Intermodal transfer between bicycles and rail transit in Shanghai, China. *Transportation Research Record: Journal of the Transportation Research Board*, 21(44), 181-188.
- Pucher, J., & Buehler, R. (2009). Integrating bicycling and public transport in North America. *Journal of Public Transportation*, 12(3), 5.
- Rotary Foundation. (2017). Rotary safe ride program. Retrieved from <http://fmrotaryfoundation.org/projects/rotary-ride-safe-program/>
- Suraci, D. (2018). Bicycle and transit integration: A practical transit agency guide to bicycle integration and equitable mobility. In *The bicycle as a tool for transit*. Retrieved from https://www.apta.com/resources/mobility/Documents/Bike_Transit_Integration_V6.compressed.pdf
- Taylor, D., & Mahmassani, H. (1996). Analysis of stated preferences for intermodal bicycle-transit interfaces. *Transportation Research Record: Journal of the Transportation Research Board*, 15(6), 86-95.
- Town of Herndon. (2016). Case studies for a cycle track on the east side of Herndon Parkway for 2,000 feet south of the Washington and Old Dominion Railroad Regional Park trail. Retrieved from <https://www.herndon-va.gov/home/showdocument?id=6167>
- Techguides. (n.d.). Outdoor bike rack. Retrieved from <http://techguides.co/outdoor-bike-rack/>
- TransLink. (2017). SeaBus gets a makeover: An update on rehabilitation work. Retrieved from <https://buzzer.translink.ca/tag/seabus-washroom/>
- TransLink. (2018a). Setting the stage for a regional Major Bikeway Network. Retrieved from <https://buzzer.translink.ca/2018/07/>
- TransLink. (2018b). Update on rapid transit projects. In *Millennium Line Broadway Extension*. Retrieved from <https://www.translink.ca/About-Us/Media/2018/April/Update-on-Rapid-Transit-Projects.aspx>
- TriMet. (2019). Reserved bike lockers [photo]. Retrieved from <http://trimet.org/bikes/lockers/available.htm>
- Wardman, M., Tight, M., & Page, M. (2007). Factors influencing the propensity to cycle to work. *Transportation Research Part A: Policy and Practice*, 41(4), 339-350.
- Weigand, L. (2008). A review of the literature: Intersection treatments to improve bicycle access and safety. In *A brief history of bicycle facility design*. Retrieved from <https://ppms.trec.pdx.edu/wmedia/1223584239DKJTTZE.pdf>
- Wongm's Rail Gallery. (2019). Parkiteer Cage beside a bike locker at Watergardens station. Retrieved from https://railgallery.wongm.com/melbourne-station-bikes/F122_5509.jpg.html

Appendices


Appendix A: Traveling to the Transit Station - Roads

Intervention	Indicators	Specifications	Benefits	Drawbacks	Vignette
Shared lane markings	S ○ A ○ C ○ D ● C ●	<ul style="list-style-type: none"> Minimum 11 ft far from curb side (with a parking lane), minimum 4 ft far from curb side (without a parking lane) May not be substitute for bike lanes, cycle tracks, or other separation treatments 	<ul style="list-style-type: none"> Encourages bicyclists to position themselves safely in narrow lanes Alerts motor vehicle drivers to the potential presence of bicyclists. Requires no additional street space. 	<ul style="list-style-type: none"> Exposure to vehicles 	
Speed humps	S ○ A ○ C ○ D ● C ●	<ul style="list-style-type: none"> 3 to 4 inches high and 12 to 14 feet long 	<ul style="list-style-type: none"> Decreases motor vehicle speeds 	<ul style="list-style-type: none"> Exposure to vehicles 	
Conventional bike lane	S ○ A ○ C ○ D ○ C ●	<ul style="list-style-type: none"> Desired 6 ft wide; minimum 3 ft wide. 6-8-inch line (vehicle lane); 4-inch line (parking lane) 	<ul style="list-style-type: none"> Enables bicyclists to ride at their preferred speed conditions. Increases total capacities of streets carrying mixed bicycle and motor vehicle traffic. 	<ul style="list-style-type: none"> Proximity to vehicle lanes Little Space for bicyclists to pass other bicyclist 	
Buffered bike lane	S ○ A ○ C ○ D ○ C ●	<ul style="list-style-type: none"> Minimum 18-inch buffers; desired 7 ft wide where side-by-side biking 	<ul style="list-style-type: none"> Provides greater shy distance between motor vehicles and bicyclists. Provides space for bicyclists to pass another cyclist 	<ul style="list-style-type: none"> Requires additional space 	

Legend: S - Safety; A - Accessibility; C - Convenience; D - Directness; C - Cost

Intervention	Indicators	Specifications	Benefits	Drawbacks	Vignette
Contra-flow bike lane	S ● A ● C ● D ● C ●	<ul style="list-style-type: none"> Desired 6 ft -Wide; minimum 3 ft wide. 6-8-inch line (vehicle lane) 	<ul style="list-style-type: none"> Provides connectivity and access to bicyclists traveling in both directions. Decreases trip distance, the number of intersections encountered, and travel times for bicyclists 	<ul style="list-style-type: none"> Requires additional space 	
Left-side bike lane	S ● A ● C ○ D ● C ●	<ul style="list-style-type: none"> Desired 6 ft wide; minimum 3 ft wide. 	<ul style="list-style-type: none"> Avoids potential right-side bike lane conflicts on streets (bus, rush hour parking). Improves bicyclist visibility by motorists (on the driver's side) 	<ul style="list-style-type: none"> Proximity to vehicle lanes 	
One-way protected cycle track	S ● A ● C ● D ○ C ●	<ul style="list-style-type: none"> Desired minimum 5-7 ft wide, with a parking buffer desired minimum 3 ft wide (desired minimum 11 ft parking lane and buffer combined wide) At transit stops, consider wrapping the cycle track behind the transit stop zone to reduce conflicts with transit vehicles and passengers 	<ul style="list-style-type: none"> Dedicates and protects space for bicyclists Prevents double-parking Low implementation cost (using existing pavement and drainage) 	<ul style="list-style-type: none"> Requires additional space 	
Raised cycle track	S ● A ● C ● D ○ C ○	<ul style="list-style-type: none"> Travel surface: desirable 6.5 ft wide (desired minimum 5.5 ft wide) 	<ul style="list-style-type: none"> Minimizes maintenance costs due to limited motor vehicle wear Keeps motorists from easily entering the cycle track. 	<ul style="list-style-type: none"> Requires additional space High construction cost 	

Legend: S - Safety; A - Accessibility; C - Convienance; D - Directness; C - Cost

Intervention	Indicators	Specifications	Benefits	Drawbacks	Vignette
Two-way cycle track	S ● A ● C ● D ● C ○	<ul style="list-style-type: none"> Desired minimum 5-7 ft wide, with a parking buffer desired minimum 3 ft wide (desired minimum 11 ft parking lane and buffer combined wide) At transit stops, consider wrapping the cycle track behind the transit stop zone to reduce conflicts with transit vehicles and passengers 	<ul style="list-style-type: none"> Dedicates and protects space for bicyclists Prevents double-parking Low implementation cost (using existing pavement and drainage) 	<ul style="list-style-type: none"> Requires additional space 	

Legend: S - Safety; A - Accessibility; C - Convienance; D - Directness; C - Cost

Indicator Definitions

Safety - Refers to the visibility of a cyclist, the seperation of the cyclist from traffic, and the intervention's effect on reducing traffic speeds.






Accessibility - Refers to ease of cycling for all ages and abilities.

Convenience - Refers to a sufficient width of roadways and the level of comfort for cyclists.
















Directness - Refers to if an intervention assists or disadvantages a cyclists in traveling to their destination and the ability for cyclists to wayfind using the intervention.

Cost - Refers to the relative cost to other similar interventions.


Appendix B: Traveling to the Transit Station - Intersections

Intervention	Indicators	Specifications	Benefits	Drawbacks	Vignette
Bike box	S ● A ○ C ● D ● C ●	<ul style="list-style-type: none">10-16 ft deep20-25 ft Ingress lane	<ul style="list-style-type: none">Increases visibility of bicyclistsReduces signal delay for bicyclists	<ul style="list-style-type: none">Exposure to vehiclesRoutine pavement maintenance	
Intersection crossing mark	S ● A ● C ● D ● C ●	<ul style="list-style-type: none">Match width and positioning of the leading bike lane	<ul style="list-style-type: none">Raises awareness for both bicyclists and motorists to potential conflict areas.Reinforces that through cyclists have priority over turning vehicles or vehicles entering the roadway	<ul style="list-style-type: none">Routine pavement maintenance	
Two stage turn queue box	S ● A ● C ● D ● C ●	<ul style="list-style-type: none">Typically within an on-street parking lane, or between the bicycle lane and the pedestrian crossing	<ul style="list-style-type: none">Improves bicyclist ability to safely and comfortably make left turns.Provides a formal queuing space for bicyclists making a two-stage turn	<ul style="list-style-type: none">Exposure to vehiclesRoutine pavement maintenance	
Median refuge island	S ● A ● C ● D ● C ○	<ul style="list-style-type: none">Desirable 10+ ft wide (6 ft minimum)Length: 6+ ft	<ul style="list-style-type: none">Provides a protected space for bicyclists to wait for an acceptable gap in traffic.Reduces the overall crossing length and exposure to vehicle traffic.	<ul style="list-style-type: none">May collect road debris and require frequent maintenance	
Through bike lane	S ● A ○ C ○ D ● C ●	<ul style="list-style-type: none">Desirable 6 ft wide (4 ft minimum)Dotted white lines 6 inch wideDotted lines signifying the merge area begin a minimum of 50 ft before the intersection (100 ft before if high-speed)Vehicle turn lane not less than 9 ft wide	<ul style="list-style-type: none">Leads to more predictable bicyclist and motorist travel movementsAlerts motorists to expect and yield to merging bicycle trafficReduces the risk of 'right hook' collisions at intersections	<ul style="list-style-type: none">Exposure to vehiclesRoutine pavement maintenance	

Legend: S - Safety; A - Accessibility; C - Convienance; D - Directness; C - Cost

Intervention	Indicators	Specifications	Benefits	Drawbacks	Vignette
Combined bike lane/turn lane	S  A  C  D  C 	<ul style="list-style-type: none"> Type 1: combined lane 9-13 wide with shared bike markings Type 2: bicycle area 4 ft wide minimum, combined lane 9-13 wide Type 3: the transition to the mixing zone begin a minimum 70 ft in advance of the intersection 	<ul style="list-style-type: none"> Encourages motorists to yield to bicyclists when crossing into the narrow right-turn lane. Reduces motor vehicle speed within the right turn lane. Reduces the risk of ‘right hook’ collisions at intersections 	<ul style="list-style-type: none"> Exposure to vehicles Routine pavement maintenance 	
Speed management (curb extension, edge island, neighbourhood traffic circle, raised intersection)	S  A  C  D  C 	<ul style="list-style-type: none"> Minimum clear width 12 ft for bi-directional travel Traffic circles or raised intersections are applicable for minor intersections 	<ul style="list-style-type: none"> Decreases motor vehicle speeds Establishes and reinforces bicycle priority on bicycle boulevards by discouraging through vehicle travel 	<ul style="list-style-type: none"> Installation Cost Vegetation should be regularly trimmed to maintain visibility and attractiveness 	   

Legend: S - Safety; A - Accessibility; C - Convenience; D - Directness; C - Cost

Intervention	Indicators	Specifications	Benefits	Drawbacks	Vignette
Volume management (channelized right-turn/ right-on island, diverter, diagonal diverter)	S ● A ● C ○ D ● C ○	<ul style="list-style-type: none"> Minimum 10 ft clear space between bollards or features 4 ft minimum contraflow bike lane or 5-6 ft opening between vertical curbs Length of a partial closure should about 30 ft 	<ul style="list-style-type: none"> Establishes and reinforces bicycle priority Improves bicyclist comfort on a corridor and benefits pedestrians and residents 	<ul style="list-style-type: none"> Installation Cost Vegetation should be regularly trimmed to maintain visibility and attractiveness 	

Legend: S - Safety; A - Accessibility; C - Convienance; D - Directness; C - Cost

Indicator Definitions

Safety - Refers to the visibility of a cyclist, the predicatablity of the route, and the volume and speed for the route.





Accessibility - Refers to ease of cycling for all ages and abilities.

Convenience - Refers to a sufficient width of roadways and the level of comfort for cyclists.





Directness - Refers to if an intervention assists or disadvantages a cyclists in traveling to their destination.

Cost - Refers to the relative cost to other similar interventions.

Appendix C: Traveling to the Transit Station - Wayfinding

Intervention	Indicators	Specifications	Benefits	Drawbacks	Vignette
Bike signal heads	S ● A ● C ● D ● C ○	<ul style="list-style-type: none">• Shall be placed in a location clearly visible to oncoming bicycles• Installed at signalized intersection• A supplemental “Bicycle Signal” sign plaque should be added below the bicycle signal head to increase comprehension	<ul style="list-style-type: none">• Separate bicycle movements from other mods• Provide priority to bicycle movements in intersections	<ul style="list-style-type: none">• Need to design coordinated signal timing for all modes (bicyclists: 12-15 mph, vehicles driving downtown: 15-20 mph, transit: 60 second cycling length)	
Signal Detection and Actuation	S ● A ● C ● D ● C ●	<ul style="list-style-type: none">• Loop (induction loop embedded in the pavement)• Video (video detection aimed at bicyclist approaches and calibrated to detect bicyclists)• Push-button (user-activated button mounted on a pole facing the street)• Microwave (miniature microwave radar that picks up non-background targets)	<ul style="list-style-type: none">• Improves efficiency and reduces delay for bicycle travel• Increases convenience and safety of bicycling	<ul style="list-style-type: none">• Inductive loop detector sensitivity settings need to be monitored and adjusted over time	 
Active Warning Beacon	S ● A ● C ● D ● C ●	<ul style="list-style-type: none">• User-actuated amber flashing lights that supplement warning signs• Irregular flash pattern (Rectangular Rapid Flash Beacons)• Installed bike route at unsignalized intersections	<ul style="list-style-type: none">• Offers lower cost alternative to traffic signals, using solar power• Significantly increases drivers' yielding behavior at crossings	<ul style="list-style-type: none">• No significant issues	

Legend: S - Safety; A - Accessibility; C - Convenience; D - Directness; C - Cost

Intervention	Indicators	Specifications	Benefits	Drawbacks	Vignette
Coloured bike facilities	S ● A ● C ● D ● C ●	<ul style="list-style-type: none"> Within bike lanes, cycle tracks, or bike boxes May be used to supplement shared lane markings for added visibility 	<ul style="list-style-type: none"> Increases the visibility of bicyclists. Discourages illegal parking in the bike lane 	<ul style="list-style-type: none"> Maintaining markings should be a high priority. Should be maintained to be free of potholes, broken glass, and other debris 	
Confirmation signs	S ● A ● C ● D ● C ●	<ul style="list-style-type: none"> Every ¼ to ½ mile on off-street facilities and every 2 to 3 blocks along bicycle facilities, unless another type of sign is used. Should be placed soon after turns to confirm destination(s). 	<ul style="list-style-type: none"> Familiarize users with the bicycle network. Overcome a “barrier to entry” for infrequent bicyclists 	<ul style="list-style-type: none"> Need periodic replacement due to wear. 	
Turn signs	S ● A ● C ● D ● C ●	<ul style="list-style-type: none"> Near-side of intersections where bike routes turn (e.g., where the street ceases to be a bicycle route or does not go through). Pavement markings can also indicate the need to turn to 	<ul style="list-style-type: none"> Identify the best routes to destinations. Overcome a “barrier to entry” for infrequent bicyclists 	<ul style="list-style-type: none"> Need periodic replacement due to wear. 	
Decision signs	S ● A ● C ● D ● C ●	<ul style="list-style-type: none"> Near-side of intersections in advance of a junction with another bicycle route. Along a route to indicate a nearby destination. 	<ul style="list-style-type: none"> Identify the best routes to destinations Overcome a “barrier to entry” for infrequent cyclists 	<ul style="list-style-type: none"> Need periodic replacement due to wear. 	

Legend: S - Safety; A - Accessibility; C - Convienance; D - Directness; C - Cost

Indicator Definitions

Safety - Refers to the visibility, predicatablity, and seperation from traffic of a bicyclist relative to traffic.


Accessibility - Refers to ease of cycling for all ages and abilities.

Convenience - Refers to a sufficient width of roadways and the level of comfort for cyclists.



















Directness - Refers to the the ability for cyclists to wayfind using the intervention.

Cost - Refers to the relative cost to other similar interventions.



















Appendix D: Arriving at the Transit Station

Intervention	Indicators	Specifications	Benefits	Drawbacks	Vignette
Bike lockers	S ● A ● C ● D ● C ●	<ul style="list-style-type: none">Constructed of solid, opaque, theft-resistant materialLockable door that opens the full width and height of the locker"Tamper-proof" hinges on the doorsEdges secured with no exposed fittings or connectorsWithin sight of building or parking security, where such exists, an elevator, or an entranceWeather-proof if located where exposed to the elementsDesigned to accommodate a maximum of one bicycle	<ul style="list-style-type: none">Securely protects bicycles and related components (ie. helmets, bags, lights, clothing)	<ul style="list-style-type: none">Requires a level surface and clearance for locker doors (space-inefficient)Requires security measure to ensure only bicycle-related content is stored-If stored outdoors, cyclists are not protected from the weather	


Legend: S - Safety; A - Accessibility; C - Convenience; D - Directness; C - Cost

Intervention	Indicators	Specifications	Benefits	Drawbacks	Vignette
Bike racks	S  A  C  D  C 	<ul style="list-style-type: none"> Two points of contact between bicycle and rack Industrial grade materials that resist rusting, corrosion, vandalism, etc. Secure, theft-resistant anchoring to the ground Easily detectable as a bike rack Highly visible/detectable (sufficient bulk and height) Colour consistent with street furniture colour No “wheel bender” designs No hazardous projections along pedestrian/cyclist direction of travel (sufficient room to navigate around racks) 	<ul style="list-style-type: none"> Provides more bike parking than lockers over a smaller area (space-efficient) Compatible with a variety of bike sizes and styles 	<ul style="list-style-type: none"> Bikes are more likely to be stolen or damaged from failed theft attempts because they are not enclosed Relative security of the bike is in the hands of the cyclist Vulnerable/exposed to weather (although shelter options exist) 	
Vertical and double-decker bike racks	S  A  C  D  C 	<ul style="list-style-type: none"> Support the bicycle without it being suspended on the wheels Stacked racks should provide access without the need to lift the bicycle entirely off the ground 	<ul style="list-style-type: none"> Space-efficient Vertical racks can require up to 50% less space than horizontal parking 	<ul style="list-style-type: none"> Two points of contact with the bicycle frame is not achieved, but bicycle is stabilized through wheel tray Security concern with not being able to lock the frame directly to the rack Many vertical racks do not offer a way to secure the bicycle with a U-lock Can be challenging to use for people with long, heavy, or large bicycles 	
Staple racks/ inverted ‘U’	S  A  C  D  C 		<ul style="list-style-type: none"> Space and configuration flexibility (can be installed almost anywhere and spaced in a way that works for large or unconventional bicycles) Generally very cost-effective 	<ul style="list-style-type: none"> Requires a rack for every two bikes Round-tubed versions may be vulnerable to cutting 	

Legend: S - Safety; A - Accessibility; C - Convenience; D - Directness; C - Cost

Intervention	Indicators	Specifications	Benefits	Drawbacks	Vignette
Coat hanger	S  A  C  D  C 		<ul style="list-style-type: none"> Allows the frame and one wheel to be locked with a U-lock Adequate space between loops allows for multiple bikes to be parked 	<ul style="list-style-type: none"> Bicycle handlebars tend to catch Requires a relatively large area for installation Not suitable for “big bikes” Do not fit a wide variety of bicycle frames Difficult to lock two bikes (one on each side) 	
Hoop and post	S  A  C  D  C 		<ul style="list-style-type: none"> Can be retrofitted to parking meter posts if needed Slightly easier and less expensive to install because of single base 	<ul style="list-style-type: none"> Do not fit a wide variety of bicycle frames Difficult to lock two bikes (one on each side) 	
Underground parking facility	S  A  C  D  C 	<ul style="list-style-type: none"> Solid, opaque walls (all solid interior walls should be painted) Entire interior visible from the entry door Door and frame constructed of steel Motion-activity security light enclosed in tamper-proof housing Separate lock and key or programmed entry system, with locks high security Security window for permanent visual access Lighting provides vertical illumination at floor level of a minimum of 160 lux 	<ul style="list-style-type: none"> Provides space for non-conventional bikes (ie. cargo bikes, tandems, heavy e-bikes) Creates more open space outside of the station 	<ul style="list-style-type: none"> Expensive to build and likely comes with a cost to the user; moving walkways should also be installed to give easy access 	

Legend: S - Safety; A - Accessibility; C - Convienance; D - Directness; C - Cost

Intervention	Indicators	Specifications	Benefits	Drawbacks	Vignette
Bike cages	S ● A ● C ● D ● C ●	<ul style="list-style-type: none"> Extend from floor to ceiling, with expanded metal mesh and door Walls and doors reinforced by full-height solid steel bars Supports should be attached to floor and ceiling with tamper-proof or concealed bolt heads Industrial grade chain-link should be No. 7 gauge or heavier Lockset or programmable entry should be placed in a steel plate box welded to the door structure Doorway should be detailed to prevent access to the latch from lockside with bolt cutters 	<ul style="list-style-type: none"> Increased storage capacity while also enhancing level of security (restricted right of entry and strong metal or mesh walls prevent attempts to cut through) 	<ul style="list-style-type: none"> Once inside the cage an individual has access to all of the bikes (surveillance and monitoring proper usage is important) Enclosed space - adequate lighting and cameras are required for safety and security 	





Legend: S - Safety; A - Accessibility; C - Convenience; D - Directness; C - Cost

Indicator Definitions













- Safety - Refers to the safety of the bike and the level of security for commuters against theft.
- Accessibility - Refers to ease of use of the parking facility (is the design and procedure for locking the bike understandable for cyclists of all ages and abilities); also refers to if the design supports all types of bicycles (including electric bicycles).
- Convenience - Refers to the amount of parking available for each facility type and the visibility of each facility (ensuring

- that each cyclist can easily locate the parking as they approach the destination).
- Directness - Refers to the location of the facility in relation to the primary entrance of the building (option of bike parking should be more favourable than car parking to encourage cycling); also refers to the location of the facility in relation to the path of travel that cyclists are most likely to take.
- Cost - Refers to the relative cost to other similar interventions.

Appendix E: Boarding Transit

Intervention	Indicators	Specifications	Benefits	Drawbacks	Vignette
Bicycle shops	S ● A ● C ● D ● C ●	<ul style="list-style-type: none">• Storefront either within or attached to the station• Utility hookups• Lighting requirements	<ul style="list-style-type: none">• Allows cyclists to have both minor and major repairs performed on their bicycles, in addition to basic tune-up services and sales• Option to leave their bike with shop staff and then pick up later• Establishes additional security presence in stations• Helps to promote biking awareness and the community	<ul style="list-style-type: none">• Requires a storefront with sufficient storage space• No guarantee that a tenant will rent out the space and set up shop• Potential for site to sit vacant if there are no interested businesses	
Bathrooms	S ● A ● C ● D ● C ●	<ul style="list-style-type: none">• Sinks• Toilets• Stalls• Hand-dryers	<ul style="list-style-type: none">• Benefits all transit users• Commonly requested item• Increases overall comfort and satisfaction with transit	<ul style="list-style-type: none">• Typically must be designed and built during the initial station construction• Requires frequent maintenance• May require staffing for security purposes• Question of who pays for the associated costs	
Tune-up stations	S ● A ● C ● D ● C ●	<ul style="list-style-type: none">• Tools• Bicycle pump• Stand	<ul style="list-style-type: none">• Allows cyclists to perform quick tune-ups on their bicycle• Improves overall safety• Easy and affordable to implement	<ul style="list-style-type: none">• Protection from vandalism and theft an issue• Requires maintenance to ensure proper functioning• May require additional education for people to learn how to use	
Bike-stair access ramp	S ● A ● C ● D ● C ●	<ul style="list-style-type: none">• Ramp constructed of durable material, such as metal or concrete	<ul style="list-style-type: none">• Easy to retrofit stations• Efficient with space• Wheels guided by secure chanel• Easy to use	<ul style="list-style-type: none">• Important to consider the type of material being used, as metal and concrete have different properties and advantages to disadvantages	

Legend: S - Safety; A - Accessibility; C - Convienance; D - Directness; C - Cost

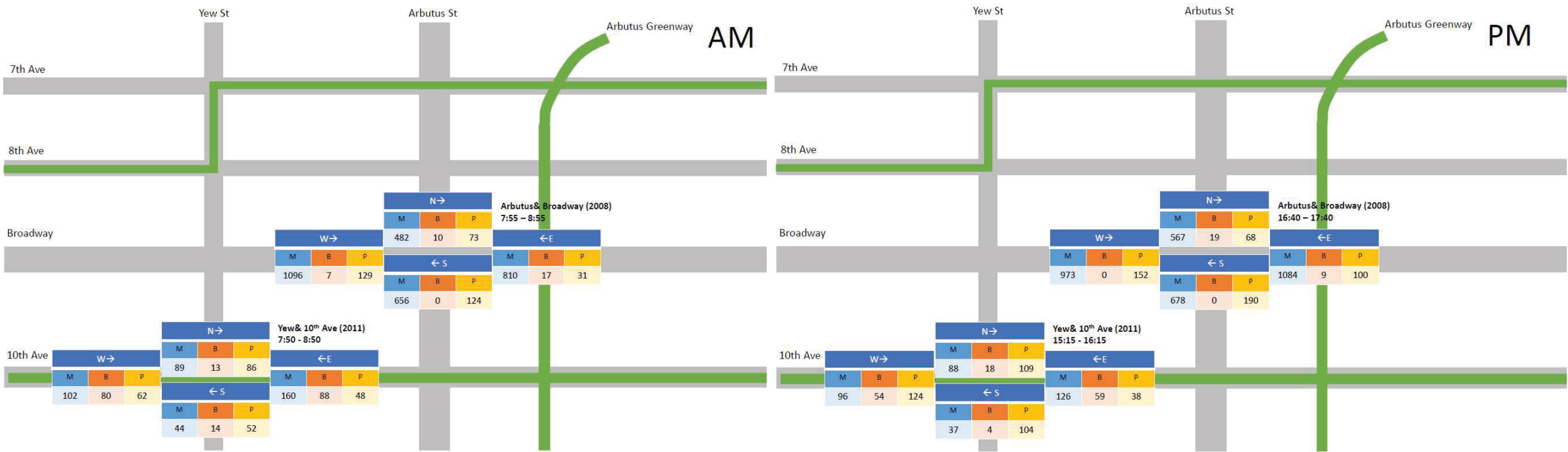
Intervention	Indicators	Specifications	Benefits	Drawbacks	Vignette
Elevators	S  • A  • C  • D  • C 	Elevator Two or more floors	<ul style="list-style-type: none"> Benefits other users, including those with wheelchairs and strollers Can be built to match the station's demand 	<ul style="list-style-type: none"> Requires a considerable amount of space Costly to implement Requires ongoing maintenance Prone to vandalism 	
Accessible entry gates	S  • A  • C  • D  • C 	Double-wide fare gate	<ul style="list-style-type: none"> Benefits other users, including those with wheelchairs and strollers 	<ul style="list-style-type: none"> Occupies twice the space of one fare gate 	

Legend: S - Safety; A - Accessibility; C - Convenience; D - Directness; C - Cost

Indicator Definitions

- Safety - Refers to the safety of a bicyclist when entering the station until they board a train and the ability of an intervention to lower conflicts with other transit users.
- Accessibility - Refers to suitability of the intervention for all ages and abilities.
- Convenience - Refers to the ease of use of a the facility through the intervention, the comfort provided by the intervention, and the ability for the intervention to reduce barriers.
- Directness - Refers to if an intervention assists or disadvantages a cyclists in traveling to their destination and if the intervention provides continuity from roadway to platform.
- Cost - Refers to the relative cost to other similar interventions.

Appendix F: Peak Hour Traffic Volume - Arbutus Street



• Legend

Bikeway

• Traffic Counts

Direction from which traffic come		
W→		
M	B	P
302	15	86

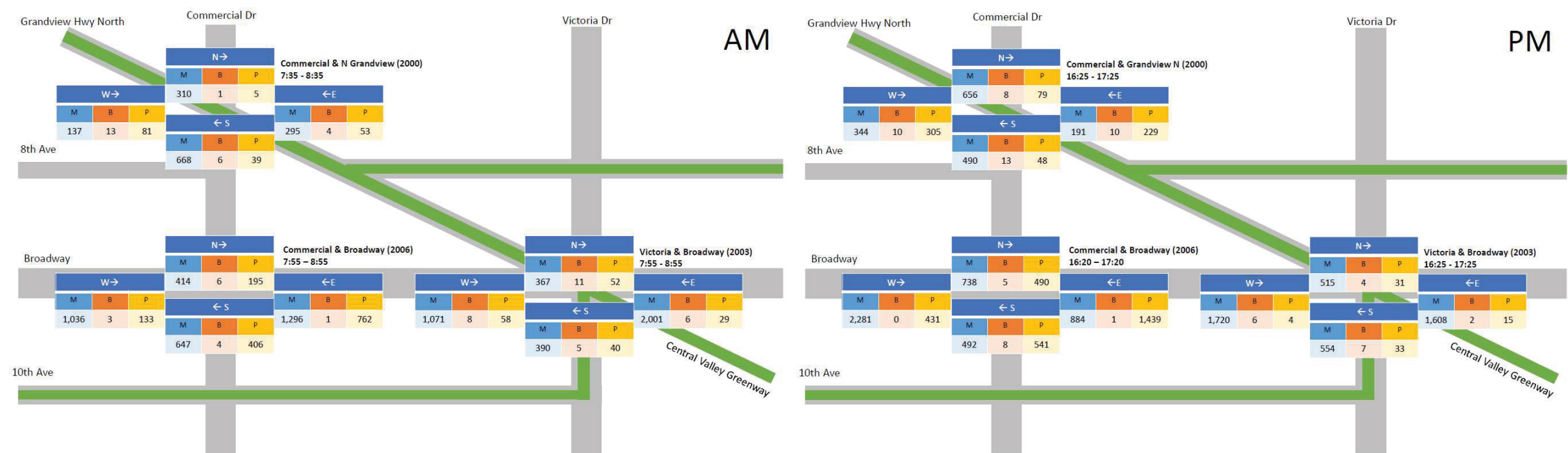
Mode: M (motor vehicle), B (bike), P (Pedestrian)

Traffic counts

Appendix G: Peak Hour Traffic Volume - Cambie Street

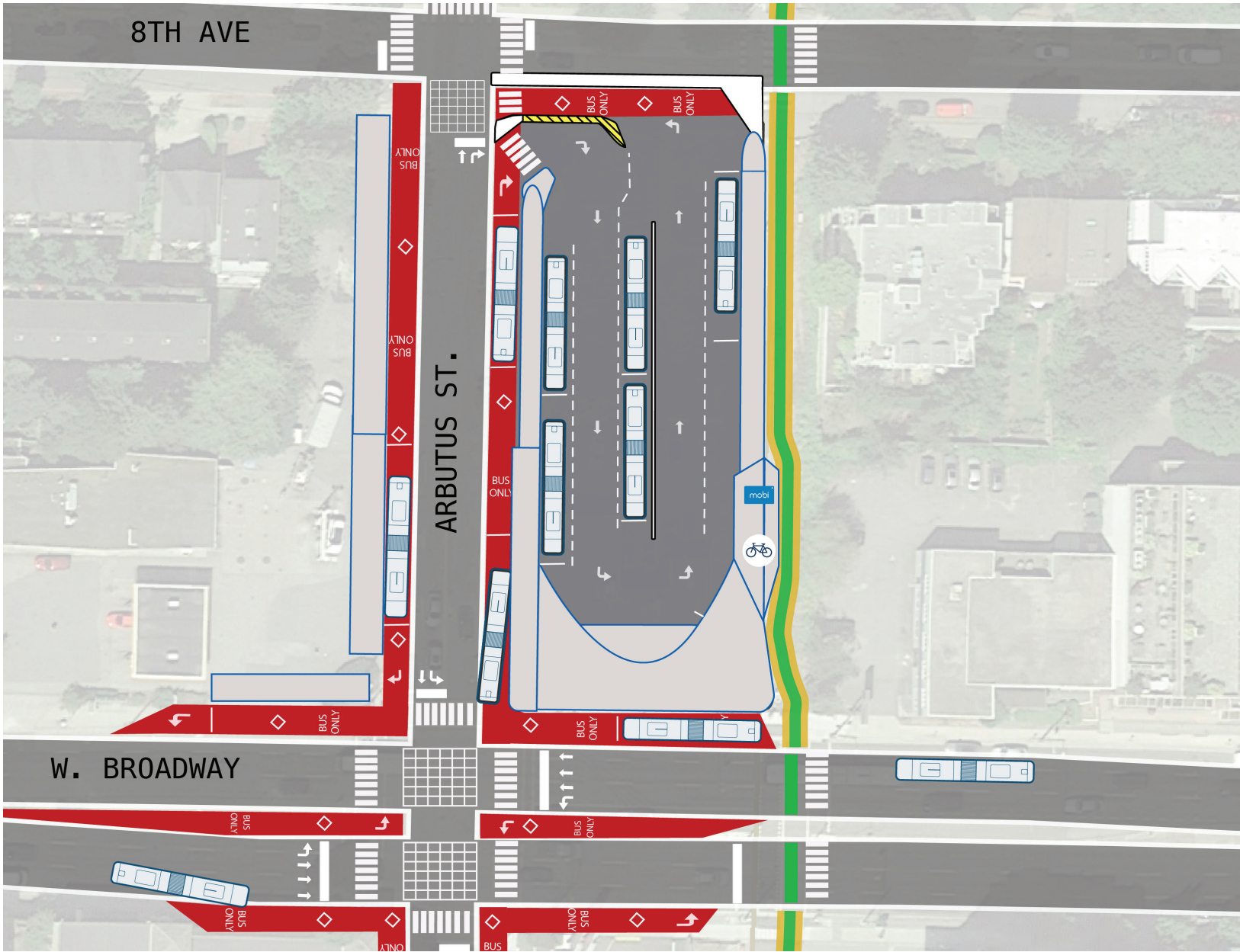


Appendix H: Peak Hour Traffic Volume - Commercial Drive

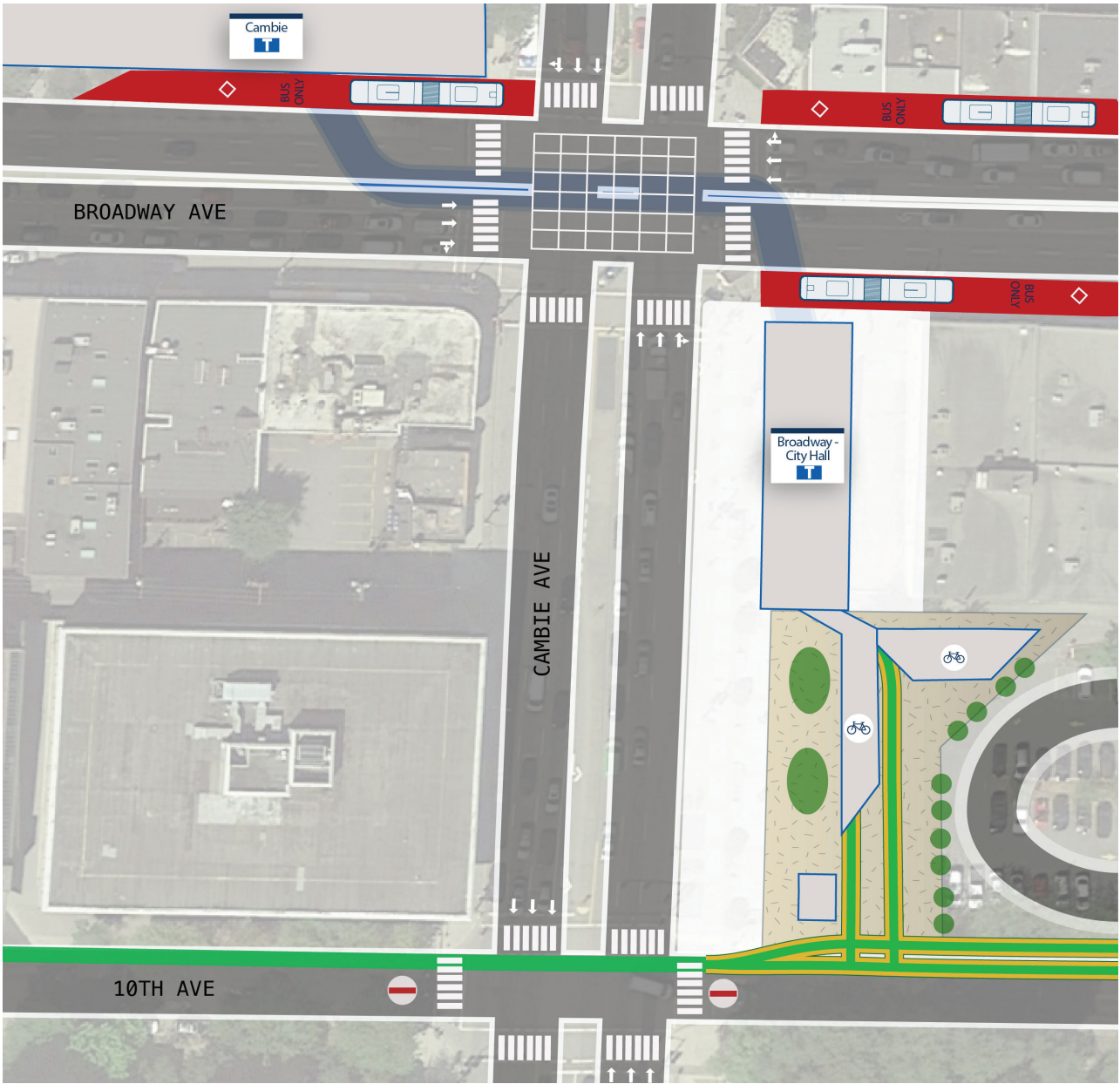


- Legend
 - Bikeway
- Traffic Counts
 - W→ Direction from which traffic come
 - M B P Mode: M (motor vehicle), B (bike), P (Pede)
 - 302 15 86 Traffic counts

Appendix I: Interim Alternatives - Arbutus Street



Appendix J: Intern Alternatives - Cambie Street



Appendix K: Interim Alternatives - Commercial Drive

