Cycle Highways in Metro Vancouver

A Case for Their Implementation and Next Steps Toward Their Development in the Region

Photo credit: Cycle Superhighways, Capital Region of Denmark

bikehub.ca

Executive Summary

"Cycle highways are the highest quality bike routes, covering long distances (5km+) and providing regional connections between major destinations. They are direct, paved, protected, lit, of ample width, and with intersections prioritizing people cycling. This, along with clear signage, branding, and regular maintenance, ensures cycle highways are safe, comfortable, and easy to use for people of all ages and abilities at all times of the day and year."

The Dutch first explored the concept of cycle highways in the 1970s; however, cycle highways only received significant media attention when London, England opened their first routes in 2010. Now, various regions have implemented cycle highways including the Netherlands, Denmark, Belgium, London, and parts of Germany. In the Capital Regional District in Denmark, 167km of cycle highways exist, and a network of 746km is planned for implementation by 2045. In the Netherlands, there is a national goal of developing 675km of cycle highways across the country by 2025.

- **Average trip lengths on cycle highways in Denmark are 11km**
- **On the Rijnwaalpad (Netherlands) people cycling ride 16km in under 45 minutes without having to stop once**
- **The first two cycle highway routes implemented in London saw increases in cycling of 83% and 46%**

Oftentimes the implementation of cycle highways is motivated by the goals of making cycling a more appealing and competitive transportation mode, reducing climate impacts, and reducing congestion. Benefits include improving transportation affordability and enhancing individual and public health.

This report outlines the demand and benefits of cycle highways in Metro Vancouver and gives recommendations to begin the process. This report delivers:

- A two-part working definition for cycle highways with relevance to Metro Vancouver
- Recommendations for taking the next steps towards their development in the region
- Suggested routes for consideration to upgrade into cycle highways

Currently, Metro Vancouver faces numerous challenges within the realm of mobility and transportation. These include:

- **Population growth, densification, and congestion** – congestion leads to losses of $1.7 billion annually
- **Climate Change** - Transportation accounts for 45% of greenhouse gas emissions in the region
- **Equity** - One in three homes spend more than 70% of before tax income on housing and transportation
- **Major Events** - Covid-19 induced half of transit users to shift into private car/active transportation; the invasion of Ukraine has caused historical fuel price increases

Traffic modelling on the 675km of proposed cycle highway routes in the Netherlands found improved mobility nationally; commuters are estimated to save 3.8 million hours per year and with e-bike usage, 9.4 million hours

Motivation to address these issues and increase cycling are echoed at the municipal, regional, and provincial levels through Transport 2050, Climate 2050, the Metro 2050 Regional Growth Strategy and Context Statements, CleanBC, and various provincial level initiatives. Specifically, Transportation 2050 outlines the implementation of 850km of traffic protected bikeways across the region as part of the Major Bikeway Network (MBN), which shares many objectives with cycle highways. Although other regions face similar challenges, cycle highways have been implemented successfully with positive results.

We have already seen notable developments in bike infrastructure in Metro Vancouver over the past decade – between 2009 and 2019, the regional bikeway kilometers nearly tripled. This has been accompanied by a 35% increase in commuter ridership across the region (2006 to 2016). Cycling is the fastest growing mode of transportation in the region. However, people cycling continue to face barriers, including discomfort with facilities and the disjointedness of the network.

The All Ages and Abilities Burrard Street Bridge bike lane sees on average 3,100 people cycling per day and is considered the busiest bike lane in North America

However, when looking at the cycle infrastructure network across the region through the lens of accessibility (i.e. the comfortable for most network), two things become evident. First, already 65% of the region lies within 400m of a comfortable for most bike routes. Secondly, there are notable gaps in the network's interconnectivity, and just under half of cycling routes in the region are considered comfortable for most. This means that people cycling often face variable levels of comfort and risk and must navigate between different infrastructure types, such as from separated bike facilities into vehicle traffic or vice versa. The safety of a region's cycling facilities is an important gauge of the quality of the cycling infrastructure. However, fatalities of people cycling have increased within Metro Vancouver over the past decade. Yet, the rate of fatalities has remained roughly steady, increasing in line with more people cycling. However, in order for cycling to appeal to broad demographics and further grow the number of people cycling across the region, interconnectivity, accessibility, and safety concerns need to be addressed.

41% of people in Metro Vancouver want to cycle more.

Working Two-Part Definition

A working definition for cycle highways was informed by a literature review and included objectives and design characteristics.

The objectives of cycle highways are to provide:

- The highest quality bike routes that protect and prioritize people cycling along the entire route
- Direct connections between major destinations and a backbone of the regional cycling network
- The ability to maintain consistent speeds and avoid frequent stops
- Safety and comfort for all ages and abilities, day and night, throughout the year
- Connections greater than 5km in length to facilitate long distance and multimodal travel
- Readily identifiable and intuitive routes

Design characteristics of cycle highways include:

1. **Directness** – aim for the most direct route; reduce and avoid detours.
2. **Longer Lengths** – generally greater than 5km long.
3. **Connections Between Major Destinations** – may include residential, employment, amenities and commercial areas, and education facilities.
4. **Capacity for Speed** – structure and shape allow for higher speeds and speed maintenance.
5. **Mode-Separation and Path Types** – largely mode separated; interventions to limit conflict when not.
6. **Intersection Treatments and Minimal Stops** – minimize stops through intersection treatments.
7. **Consistent and Ample Widths** – allow for passing or riding alongside one another.
8. **Consistent and High-Quality Paving** – smooth and maintained.
9. **Lighting** – appropriate for riding in low-light conditions and at night.
10. **Minimizing and Alleviating Gradients** – avoid steep inclines and prioritize mild grades.
11. **Clear Signage and Branding** – ensures it is readily identifiable and intuitive to use.
12. **Regular Maintenance and Winter Service** – ensures reliability at all times of the year.
13. **Service Stations** – may include bike pumps, drinking water, bike parking.

As cycle highways cross municipal and provincial jurisdictions, it will be crucial for an agreement to be made between stakeholders to ensure successful implementation. The implementation of cycle highways is desirable, both to directly address urban mobility needs and health, economic, and equity issues.

Cycle highways contribute to making cycling for transportation accessible but also attractive and appealing, and effectively increase cycling rates. Cycling is associated with improved health, environmental benefits, and economic gains. Health benefits include physical, mental, and social well-being. Health benefits present rather quickly and in diverse segments of the population, including e-bike users and translate to reduced healthcare costs. Environmental benefits of cycling are largely realized from a modal shift away from fossil fuel burning modes of transportation. Economic benefits are at both the individual and societal levels. Cycling is an affordable form of transportation and

E-bike sales are growing dramatically, and perfectly complement cycle highways. People on e-bikes ride further and are more likely to use a cycle highway.

A cost-benefit analysis in Denmark found on their cycle highway network expansion found a 23% rate of return on investment; the single most important factor was associated health benefits.

people who ride bikes stimulate the local economy. Economic benefits are realized through infrastructure as well: cycling infrastructure is cheap compared to automobile roads and creates more jobs per dollar spent.

Cycle tourism is a growing tourism market with significant economic value. For example, on the South Island of New Zealand, cycle tourism is associated with a direct expenditure of $76 million per annum and a total economic output of $160 million, comparable to the cruise ship industry. The economic potential of cycle tourism can also be capitalized on in British Columbia; already $38 million has been realized from

In Québec 10% of its population is estimated to identify as a cycle tourist and to attract cycle tourism developed La Route Verte (4345km), where people spend $95.4 million annually.

mountain bike tourism on the Sea-to-Sky corridor alone. However, to attract wider demographics of cycle tourist, fitting infrastructure must be provided. As the characteristics embodied by cycle highways overlap with those preferred by cycle tourists, an additional opportunity is created via their implementation.

Additionally, e-bikes and micro mobility are quickly growing in Metro Vancouver and warrant their integration into our transportation networks; the Provincial Government is already responding via amending legislation and facilitating e-motility sharing pilot programs. E-mobility has the potential to address many urban mobility needs and make travelling 15km accessible; this is considered an ideal distance to justify cycle highways. Companies already use bikes for delivery purposes, and the City of Vancouver has recently pledged to create an e-bike cargo delivery hub. However, to realize their potential in transportation and accommodate their growth, supporting infrastructure must be provided. Overall, between cycle highways and e-mobility, we see a positively reinforcing and beneficial relationship:

- Cycle highways incentivize the adoption of e-mobility
- E-mobility adds value to cycle highways, making them accessible to wider segments of the population and increasing travel distances

Lastly, the importance of equity in transportation and cycle infrastructure planning is being increasingly realized. Bicycles, considered an equitable form of mobility, have the potential to address transportation inequity. However, they cannot be successful without supporting infrastructure. Canadian cities, such as Winnipeg and Victoria, have already included equity considerations in their cycle network planning and it is urged that Metro Vancouver do the same. Previous research conducted on bike infrastructure in the City of Vancouver has shown disparities in access, which have been unaddressed by recent investments. An equity-informed design and implementation of cycle highways can contribute and for this reason, equity considerations were included in the GIS analysis included in this report. Greater transportation equity is realized due to facilitating bike use, one of the cheapest and most accessible transportation modes; Equity in bike infrastructure is contributed by the design of cycle highways: long-distance functional connections of high-quality that are safe and comfortable for a variety of users.

20% of the users on Rijnwaalpad, an cycle highway built in the Netherlands, reported buying an e-bike because of the route.

Recommendations for Next Steps

Investigation of cases where cycle highways were successfully implemented (Denmark, the Netherlands, and England) and greenways/trails in North America (United States of America and Canada) has helped inform priorities to begin the process of developing cycle highways in Metro Vancouver. These include:

Create a Shared Vision to Guide the Project

Clearly outline the visions and goals of the project. This is important to garner support and receive widespread backing. Visions and goals for implementing cycle highways have included increasing bike modal share in transportation, fostering greater commuter distances travelled by bike, and reducing vehicle traffic and highway congestion.

Conduct an Evidence-Led Analysis to Inform the Design of a Network

A proposed network is stronger than individual routes. Ensure that the proposed network and routes are backed by research. Informed decision-making gives the project credibility. Traffic modelling and cost-benefit analyses provide additional support. In Denmark, universities conduct research (i.e. traffic flows) informing plans; similar could be done in Metro Vancouver. The Strategic Cycling Analysis (London) clearly outlines an evidence-led approach to cycle highway route planning. This can be used to guide a similar analysis across Metro Vancouver.

Connect Interested and Invested Individuals

Individuals who are interested in the creation of cycle highways need to connect with each other. People currently invested in the project should look towards getting more people on board. This helps grow momentum for the project and push a vision. Individual connections may include advocacy groups, interested citizens, politicians, and government employees.

Establish a Group to Engage and Host Discussions Between Stakeholders

A group to host discussions and foster collaboration between stakeholders is of utmost importance. This working group is comprised of stakeholders focused on the development of cycle highways across the region. Stakeholders may include municipal, regional, and provincial representatives, transportation authorities, and advocacy groups. Within Metro Vancouver, TransLink and HUB Cycling may be considered to work together to spearhead creating and hosting a collaboration between municipalities.

Secure Funding from Higher Levels of Government

Cycle highway projects address regional issues, such as air pollution and traffic congestion, and cross jurisdiction boundaries. Funding from higher levels of government help overcome limitations of municipal budgets, while also serving Provincial and Federal goals. Within British Columbia, the Provincial Government has previously been involved with funding the development of the Galloping Goose and Lochside Regional Trails. A regional cycle highways project in Metro Vancouver should look to the Provincial Government and the Ministry of Transportation and Infrastructure for support and funding.

Capitalize on Upgrading Pre-Existing (Cycling) Infrastructure

Investments can be made more effective and planning costs can be reduced if routes do not need to be started from scratch. Pre-existing cycling routes with good ridership are good candidates for upgrading to a cycle highway; this is especially true when considering where to locate pilot routes. The upgrades required to meet the standard of a cycle highway needs to be conveyed to municipalities clearly to simplify the process.

Suggested Routes for Cycle Highway Upgrades

The GIS analysis conducted aims to serve as a data-informed preliminary analysis to propose favourable routes to consider for future cycle highway construction. Routes across Metro Vancouver were assessed by directness, length, connections to major destinations, gradient, number of intersections and stops, and road type/posted speed limit. Proposed routes and corridors were investigated, as well as querying the software for additional routes of possible interest.

Our analysis concluded that the following should be given consideration to upgrade to cycle highways:

- BC Parkway (plus extension along 10th Avenue to the Arbutus Greenway)
- BC Parkway
- Central Valley Greenway
- Adanac + Francis Union Bikeway (plus extension from Downtown Vancouver to the North Shore)
- Tri-Cities to the North Shore

These proposed routes transcend jurisdiction boundaries, have pre-existing bike infrastructure, and already have people cycling along with them. These reasons overlap with the justification for early cycle highway routes in Denmark, the Netherlands, and London, England. In terms of transportation equity, these routes also link disadvantaged areas; of note is the BC Parkway, connecting regions that could benefit from improved transportation such as North Surrey, parts of Burnaby, and the south and east parts of Vancouver. Additionally, the BC Parkway and the Central Valley Greenway also mirror aspects of TransLink's 2018 Major Bikeway Network (MBN) and Adanac + Francis Union Bikeway (plus extension) and Tri-Cities to the North Shore closely follow the updated MBN adopted in 2022. Municipalities seeking funding for bicycle projects get additional consideration from TransLink when routes are part of the MBN. For these reasons, as well as performing well on our ranking scheme, these routes are suggested for consideration for implementing initial cycle highway routes in the region.

The results of the cycle highway route analysis found notable overlap with TransLink's MBN. Many of the intentions of TransLink's MBN and the goals of cycle highways align. For these reasons, their integration is suggested. For example, TransLink's MBN proposes cycling infrastructure route paths across Metro Vancouver; their implementation could take the form of the high-quality, accessible, and attractive design of cycle highways. In the Netherlands and Denmark, both cycling infrastructure and cycle highways are held to a consistent and high standard. This leads to the simplicity of use. Comparatively, London has gone through many iterations of cycling network plans, of different standards and under different names, complicating the process. In Metro Vancouver we already see complexity in our bike infrastructure, such as the 'comfortable for most, some, few, and very few' and the 'All Ages and Ability' designations. Aligning the MBN with cycle highways is likely to elevate the execution of both and ensure simplicity in outcomes for users across the region.

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How To Use This Report

The Cycle Highways in Metro Vancouver report appeals to a wide range of readers, including members of the public, academics, politicians, decision-makers and city staff. The report is organized to allow a quick skim of the key details all the way to a deeper dive into the results and research as detailed below.

Key takeaways - The stand-alone **report highlights** and excecutive summary in the main report provide takeaways of the most important information about cycle highways. The introduction, and conclusion and recommendations also provide a good summary and wrap-up for the whole report. Readers can start here to get the high level overview.

Summaries - Each section in the report has a short summary, pulling together the highlights and key details. Readers can read the summary before jumping into a section, or just read the summary.

Main Report Body - Readers who want more details and information on sections of interest after reading the summaries can dive into the main body of the text. The report body is full of a rich array of information, details and examples.

Additional Background Details - Several sections have more in-depth details in the Supplemental Background section. These included further information on Route Preferences, Cycle Highway Design Characteristics, detailed background on the Case Studies and additional details on the Route Analysis.

Introduction

In recent years, cycle highways have been implemented as means of addressing climate change concerns, increasing physical activity and health, and reducing traffic and congestion. These long-distance cycle infrastructures cross city borders and make connections at a regional scale. The nature of a cycle highways project calls for a coordinated effort between multiple levels of government and various stakeholders in order to be realized.

Metro Vancouver is currently facing challenges including population growth, congestion on roadways, and equity issues in transportation and mobility. This compounds with goals to mitigate greenhouse gas emissions of the transportation sector and increase the number of trips made by sustainable and active transportation modes. In Metro Vancouver we have already seen notable investments in cycling infrastructure - between 2009 and 2019, the regional network has almost tripled in size – and this has been accompanied by an increase in ridership. However, cycling within the region still faces barriers, including low perceived comfort levels of many of the available facilities and discontinuity in the network across the region.

Introduction

Cycle highways are a high-quality, long-distance, and cycling focussed infrastructure that have been found to contribute to increased perceived levels of safety as well as increasing bike ridership levels. They have been implemented successfully in many regions, most commonly in Northwestern Europe, including Denmark, London, the Netherlands, Belgium, and parts of Germany. In the Capital Regional District in Denmark, 167km of cycle highways exist (2018) and a network of 746km is planned for implementation by 2045; the Netherlands has a national goal of developing 675km of cycle highways across the country by 2025. This form of high quality and continuous infrastructure has been found to appeal successfully to broad demographics of people cycling. They also make cycling a more competitive mode of transportation and help realize longer distance travel by bike. This impact on ridership and long-distance bike travel further compounds with the growth of e-bikes and micro mobility, already occurring in urban centres and across Canada.

The development of cycle highways can be viewed as advantageous in many respects, both in addressing urban mobility needs as well as transcending beyond its function as transportation infrastructure. Through their provision, they contribute to making cycling for transportation accessible, attractive, and appealing. They thereby directly address issues pertaining to the decarbonization and democratization of urban mobility. Cycle highways have also been found to impact both individual and population level health positively, and have economic benefits to proximal businesses and at the government level, including stimulating tourism and addressing environmental concerns by alleviating vehicle dependence.

The aim of this report is to create a basis of understanding and clarity to the concept of 'cycle highways,' delineate the demand for this type of infrastructure in the region, outline what building cycle highways would mean for the region, and create a foundation to begin the process towards their successful implementation within Metro Vancouver.

This report focuses on illustrating the concept of a cycle highway through defining their goal and design characteristics, and their numerous associated benefits with reference to the context of Metro Vancouver. With the objective of informing priorities and recommendations for the early steps towards the construction of cycle highways in Metro Vancouver, case studies of regions with well-established cycle highways are investigated. An analysis of the Metro Vancouver region aims to highlight possible candidates for cycle highways routes.

This report includes five main sections. First, the demand for cycle highways in Metro Vancouver is outlined, including the challenges faced within the region, the current cycle conditions in the region, and previous research pertaining to user preferences for cycle infrastructure. This is followed by a literature review with the goal of bringing clarity to the concept of a cycle highway, aimed at illustrating their purpose and considerations for their implementation in the region. Benefits of implementing cycle highways, including increased bike ridership levels, health, environmental, and economic benefits, examples of cost-benefit analyses, the potential for fostering cycle tourism, the role of e-bikes and micro mobility, and equity considerations in bike and transportation planning are then outlined. This is followed by a detailed investigation of successful cases, including cycle highways in Europe (Denmark, the Netherlands, and England) and greenway/trails projects in North America (the U.S.A. and Canada), and focuses on their early developments. Lastly, a GIS analysis investigating routes with good potential for development into cycle highways and informed by regional transportation equity considerations are included. The report wraps up with a conclusion section and recommendations for the early and next steps towards developing cycle highways in Metro Vancouver.

Metro Vancouver's Demand for Cycle Highways

Metro Vancouver's Demand for Cycle Highways

Section Summary

The demand for cycle highways in Metro Vancouver can be summarized by regional challenges and goals, the current cycling conditions, and the preferences and unmet needs of people cycling in the region.

A. Challenges and Goals

Various challenges are faced by the region of Metro Vancouver in the realm of mobility and transportation. Motivation and direction to address these challenges by increasing cycling are echoed at the municipal, regional, and provincial level. The implementation of high-quality and functional cycle facilities can facilitate this. Other regions around the world facing similar challenges to Metro Vancouver have already implemented cycle highways.

Transportation and mobility across Metro Vancouver have faced challenges and will continue to in the future. These include:

- *Population growth, densification, and congestion*
  - Region is largely reliant on cars
  - Congestion means lost time, increased prices for consumers, and pollution/greenhouse gas emissions
  - Congestion losses are estimated to be $1.7 billion annually
- *Climate Change*
  - 70% of personal trips are made by car
  - Transportation accounts for 45% of greenhouse gas emissions in the region
  - To meet Climate 2050 goals, urgent action is required
- *Equity*
  - People outside urban centres are often car reliant and have fewer transportation options
  - One in three homes spend more than 70% of before tax income on housing and transportation
- *Major Events*
  - Climate commitments in British Columbia have been made since 2007
  - Covid-19: half of transit users shift into using the private car and active transportation modes
  - The 2022 invasion of Ukraine has caused historic fuel price increases

To create a more resilient region for the future, there is a need to address these issues of our mobility networks. Addressing these issues by increasing the provision of bike infrastructure and promoting active transportation is supported by TransLink, cities across Metro Vancouver, and the Provincial Government:

- *Transport 2050*
  - Goal to increase bike-friendly infrastructure
  - Proposes 'Major Bike Network,' 850km of traffic-protected bikeways connecting urban centres
  - Integration of electric bikes and micro mobility

- *Climate 2050*
  - Climate neutrality by 2050

- *Metro 2050 Regional Growth Strategy and Context Statements*
  - Goals to increase sustainable transportation and cycling
  - Direct commitment from numerous regions to increasing cycling/cycle infrastructure

- *Province of British Columbia Initiatives*
  - CleanBC supports legislated climate target of 40% reduction in greenhouse gas emissions by 2030 and highlights importance of modal shift to cycling
  - Updating policy and legislation; pilot programs for shared e-mobility

B. Current Cycling Conditions

In recent years, the bikeway network throughout Metro Vancouver has expanded considerably. Investments have contributed to the regional network almost tripling in size between 2009 and 2019 to a total of 4,600km. This growth has contributed to a 65% increase in daily commuter trips taken by bike. A notable of example highlighting the potential of cycling is the protected All Ages and Abilities Burrard Street Bridge bike lane, which sees an average of 3,100 people cycling over it daily; it is considered the busiest bike lane in North America.

However, when looking at the cycle infrastructure network across the region through the lens of accessibility, specifically the comfortable for most network, two things become evident. Firstly, already 65% of the region lies within 400m of a comfortable for most network. Secondly, however, there are notable gaps in interconnectivity of the network; just under half of the regional network is considered comfortable for most. This means that people cycling often must face varying levels of comfort and risk along their route as they navigate between different infrastructure types, such as from separated bike facilities into vehicle traffic or vice versa.
The safety of a region's cycling facilities is an important gauge of the quality cycle infrastructure and oftentimes we see an increased modal share of cycling correlate with reduced fatality rates of people cycling. However, in Metro Vancouver, the average number of annual collisions involving people cycling has increased. Route comfort and perceived risk of cycling impacts who chooses to ride their bike across the region. Navigating between facilities of differing comfort levels deters risk averse individuals, and effectively a notable part of the population from employing cycling to meet their daily transportation needs.

In Metro Vancouver, cycling for transportation is already growing and infrastructure investments have led to increased ridership. To continue this trajectory, I will be crucial to address issues pertaining to interconnectivity, accessibility, and safety to broaden the appeal of cycling and engage wider demographics. Cycle highways have been found to address these issues and increase ridership.

C. Preferences and Needs of People Cycling

TransLink has found that 42% of the Metro Vancouver population would be interested in cycling more. However, the presence of bike-specific infrastructure and how it is designed influences people's decision whether to cycle for transportation and how often.

In Metro Vancouver, it has been found that people are willing to travel 400m to access bike infrastructure and it has been found that people cycling prefer:

a) Designated bike routes
b) Routes that avoid traffic
c) Aesthetically pleasing routes
d) Easy routes to ride

There are also clear preferences to which types of bike infrastructures (facilities) are most preferred by people cycling in Metro Vancouver; the top preferences were:

1. Paved off street paths for bikes only
2. Paved off-street multiuse paths
3. Unpaved off-street multiuse paths
4. Cycle paths nest to major street, separated by barrier

Generally, facilities that are preferred by people cycling correlate with perceived safety. However, in Metro Vancouver there is significant incongruence between the types of routes people cycling prefer to ride and where they are riding, highlighting gaps in the current infrastructure in meeting the needs of people cycling.

When HUB Cycling asked Bike to Work Week participants whether they supported the construction of a cycle highway network linking town centres throughout Metro Vancouver, 92.9% of respondents said 'Yes' and 89.5% stated that they 'definitely-' or 'likely would use it'. The most prioritized aspect of a cycle highway was directness; this was followed by having limited stopping.

Although many demographics comprise people who cycle, findings regarding preferences infrastructure preferences are quite consistent. It has been highlighted that these commonalties make things straightforward in guiding future bike-infrastructure development. The preferences found amongst people cycling in Metro Vancouver are in line with what a cycle highway has to offer.

Metro Vancouver: Regional Challenges and Goals

Within Metro Vancouver, transportation and mobility have faced obstacles in the past and will continue to face challenges in the future.

Within Metro Vancouver, transportation and mobility have faced obstacles in the past and will continue to face challenges in the future. The Metro Vancouver region, already collaboratively planning and delivering regional scale services, has developed the Metro 2050 Regional Growth Strategy and the Climate 2050 Strategic Framework. These, along with TransLink's Transport 2050 plan, show cohesive and shared goals toward regional action on themes including population growth, vehicle congestion, climate change and greenhouse gas emissions, equity issues, covid-19, and bike infrastructure. The Provincial Government further supports active transportation and reducing the impacts of the transportation sector through numerous initiatives, including the CleanBC road map highlighting the importance of cycling. This section focuses on outlining the context-specific demands for cycle highways in the region of Metro Vancouver.

Projected Population Growth, Densification, and Congestion

The region of Metro Vancouver is a land-constrained region and is projected to continue growing at a rate of 35,000 people annually.[1] The influx of approximately 1 million new residents by 2050 means increased densification within our urban environment.[2] A continually growing population means increasing pressure on our transportation networks and infrastructures. Specifically, within a region largely reliant on cars, this puts increased volumes of vehicles on our roadways, requiring continual maintenance and costly upgrades. Increased vehicle volumes mean our roadways will face capacity issues, and Transport 2050 highlights the issue of congestion throughout the region: congestion affects nearly everyone in Vancouver and includes not only those travelling by car but also those travelling by bus, bike, and on foot. The effects of congestion include individual frustration, lost time, increased air pollution, and greenhouse gas emissions. Lost time for goods movers, such as food, lead to extra costs and end up being paid for by the consumer at the grocery store.[2] However, these visible costs of congestion are further accompanied by hidden costs, which include people refraining from taking trips, stifling the benefits of city living.[3] Overall congestion leads to notable economic losses for the region. These losses are estimated to be $1.7 billion annually and are projected to continue growing if not addressed.[4]

Climate Change

In the Metro Vancouver region, transportation is the largest source of greenhouse gas (GHG) emissions and accounts for approximately 45% of the total emissions in the region.[5] The emissions are largely contributed by cars and light trucks and currently 70% of personal trips in the region are made by car, contrasting 13% by walking and cycling, and 14% by transit.[5] It has been estimated that changing 15% of vehicle trips per year to active transportation/transit would mean a 92,000 tonne reduction in emissions.[6] However, these regional GHG emissions have remained relatively constant for the past decade and we continue to fail to induce any dramatic reductions.[2] Continued failure to reach our environmental targets means more work down the road and at higher costs.[2] Climate 2050 highlights that significant efforts, including infrastructure investments, need to be made towards shifting transportation to non-vehicular modes.[5] These urgent actions are required by every level of government to help tackle the significant environmental impact of our transportation sector and help meet the region's goal of climate neutrality by 2050.[2]

Equity

Equity issues are also faced within the region of Metro Vancouver and are intertwined with our transportation networks and infrastructure. Metro Vancouver has been deemed unaffordable, with expensive housing compounding with lower incomes, relative to comparable cities.[2] Region wide, almost one in three households spend over 70% of their before tax income on the costs of housing and transportation.[2] In search of affordable housing, people tend to be pushed out of the urban centres, and, as these areas often have fewer transportation options, people are required to rely on cars. Additionally, areas where transportation investments are made see increases in housing prices and desirability, inducing displacement and gentrification and oftentimes harming the most vulnerable populations.[2] The gap between people with safe travel options, affordable living, discrimination-free mobility, and being able to go the places they need continues to be an issue.[2] TransLink highlights that continued improvement in transportation across the region is required to help address these issues.[2] Equity issues are further expanded on in section IV.E. The Potential for Cycle Highways to Address Transportation Inequity.

Major Events

The aforementioned challenges within Metro Vancouver - population growth and densification, climate change, and equity - have contributed to major forces that have transformed our region.[2] These include the oil crisis of the 1970s: it created supply shortages and a four-fold increase in gas prices, markedly impacting the cost of living.[2] This was followed by multiple economic recessions (1981-82,1990-92, 2008-9) triggering across-sector job losses and widening the wealth gap.[2] In light of climate change and the worsening environmental crisis, strong climate commitments have been made in British Columbia since 2007.[2] Lately, Metro Vancouver, along with the rest of the world, has been facing the global COVID-19 pandemic. The pandemic has contributed to another economic recession (2020), increased remote work, and home deliveries, as well a major shift in transportation patterns across the region.[2] Transportation patterns have shifted notably away from public transit – by approximately half - and into the private car or active transportation modes.[2] In addition, the pandemic has exacerbated the inequalities within our regional transportation networks. TransLink highlights that this is a crucial moment in time to shape how we live for generations to come and stress that "By 'future-proofing' the transportation system we can contribute to a more resilient region, helping us weather whatever tomorrow's shocks and disruptions may be."[2] Most recently, the invasion of Ukraine has doubled gas prices, which impacts the price of many other items including food. [245]

Transport 2050 and Bike Infrastructure

Increasing bike infrastructure and ridership are considered an effective way to help address the aforementioned issues.[7] Within the Regional Transportation Strategy (Transportation 2050), there is a clear intention towards increasing bike-friendly infrastructure.[2] Most notably, this includes the vision of implementing an 850km network of 'traffic-protected bikeways' that connect every urban centre and serve as active transportation options comfortable for most users.[2] TransLink highlights that the Major Bike Network (MBN), shown drawn in dark blue, along with the Greenways network (Figure 1), will become the backbone of the region's future cycling network and make cycling more convenient throughout the region.[2] This comes along with better integration of electric bikes and micro mobility devices within transportation infrastructure.[2]

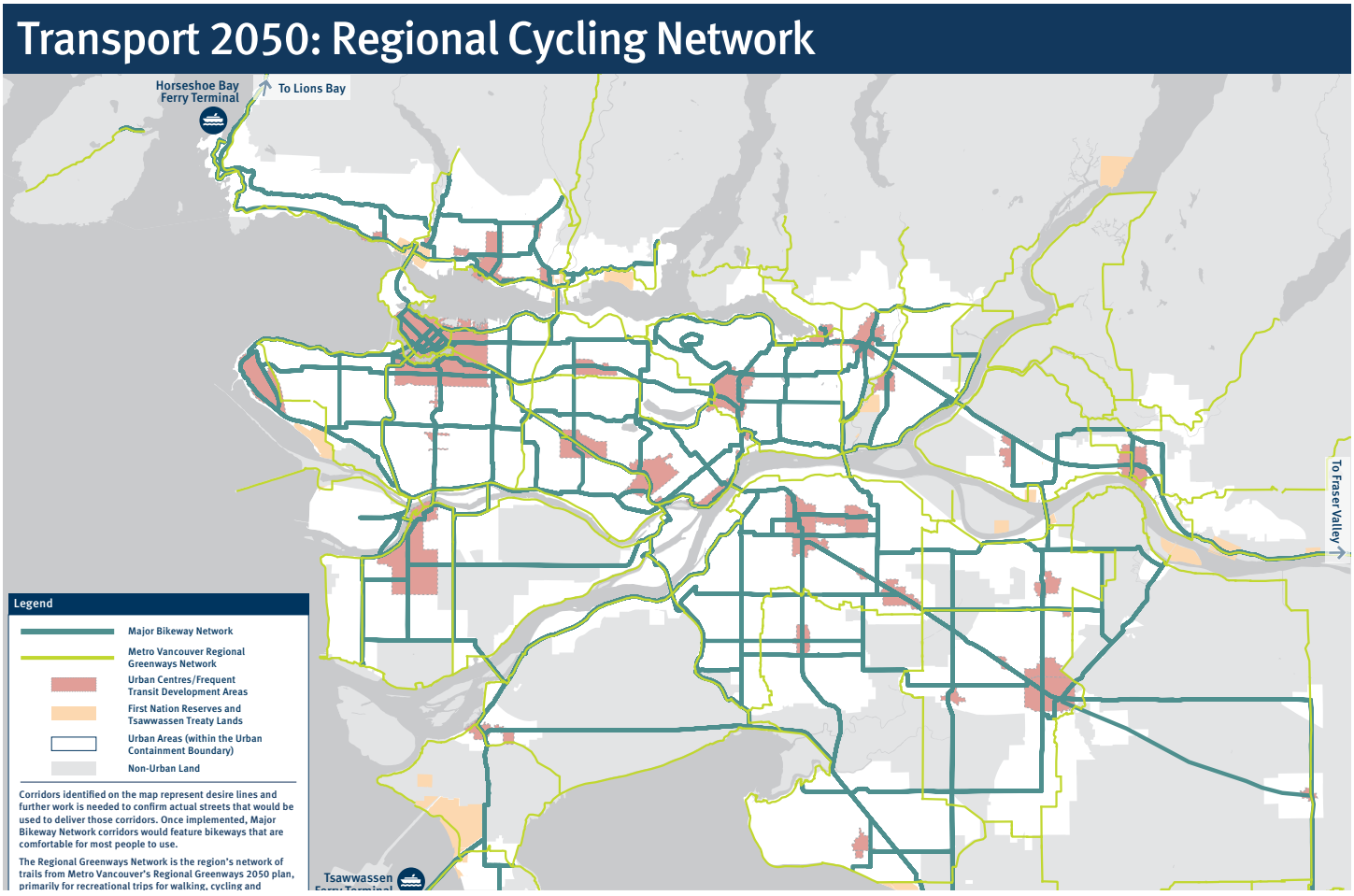


Figure 1: Map of the Regional Cycling Network 2050, including the Major Bikeway Network (MBN) and the Regional Greenway Network[2]

Metro 2050 Regional Context Statements

Regional Context Statements identify the relationship between the regional growth strategy of Metro Vancouver and the Official Community Plan of a municipality. Each member jurisdiction within Metro Vancouver is obliged to adopt a Regional Context Statement as part of their Official Community Plan (Section 866, Local Government Act) and be accepted by the Metro Vancouver Board. For example, the Regional Growth Strategy includes goals focusing on transportation, such as '5 Support Sustainable Transportation Choices' which is supported by the strategy '5.1 Coordinate land use and transportation to encourage transit, multiple-occupancy vehicles, cycling and walking.' Goal 3, "Protect the Environment and Respond to Climate Change and Natural Hazards", is linked to transportation by the strategy '3.3 Encourage land use, infrastructure, and human settlement patterns that reduce energy consumption and greenhouse gas emissions, create carbon storage opportunities, and improve air quality'.[1]

Member jurisdictions subsequently decide how they integrate these goals within their community plan and, as obliged by the Local Government Act, they must show how they contribute to meeting each goal. In summary, both at the regional level and within jurisdictions throughout Metro Vancouver, we see direct commitments made to improving cycling infrastructure through Metro Vancouver's Regional Growth Strategy and each jurisdiction's response to the Regional Growth Strategy, namely with reference to '5.1 - Coordinate land use and transportation to encourage transit, multiple-occupancy vehicles, cycling and walking'.

Within the Context of British Columbia

At the provincial level, British Columbia further supports active transportation with the goal of doubling the trips taken by active transport by 2030.[8] The Provincial Government provides support through funding, education, research, and changes to policy and legislation.[8] This is further supported by CleanBC, which supports the legislated climate targets of a 40% reduction in greenhouse gas emissions by 2030 (from 2007 levels) and includes a roadmap, providing a clear pathway to meet this target.

Funding from the Provincial Government has helped build over 100 projects since 2014.[8] This includes funding for indigenous and local governments in the form of infrastructure grants, planning grants, and a community safety enhancement program, as well as for individuals and businesses in the form of e-bike rebates. The province is also active in informing and encouraging active transport via Bike to work and school weeks, the EveryoneRides Grade 4&5 program, and working with partners including the BC Healthy Communities Society, HealthyFamiliesBC, BC Recreation and Parks Association, BC Health Communities, Bike to Work, and DASH. Research is also conducted by the Provincial Government, including the Active Transportation Report Card[9], an active transportation population survey[10], and the creation of an active transportation design guide. The British Columbia Active Transportation Guide includes guidance for the consideration, construction, and post-implementation of various types of cycling facilities.[11] Policy and legislation is being updated to support active transportation choices further and can be tested via pilot projects (e.g. North Vancouver e-bike share, Richmond e-scooter share).

The CleanBC roadmap highlights the impact of the transportation sector and includes focusing on five areas to reduce emissions, one of which is increasing cycling levels via a modal shift.[12] It is highlighted that one of the best ways to reduce greenhouse gas emissions is choosing transport that is the least energy-intensive (i.e. walking, bike, transit) and, therefore, aims to continually increase the share of trips by these modes: 30% by 2030, 40% by 2040, and 50% by 2050.[12] Furthermore, in 2023, the government plans to produce a Clean Transportation Action Plan which will support the current CleanBC strategy and set out new actions for reducing transportation emissions by 27-32% by 2030.[12]

Metro Vancouver: Current Cycling Conditions

Within this section, the current cycling context within Metro Vancouver will be summarized, including ridership, the various bikeway route types, the connectivity and accessibility of the network, and safety and perceived risk. Much of the information in the following section has come from a recent report compiled by TransLink and HUB Cycling in 2019, *Benchmarking the State of Cycling* in Metro Vancouver.[13]

Regional Ridership Levels

In recent years, the bikeway network throughout Metro Vancouver has expanded considerably. Between 2009 and 2019, it has almost tripled, increasing from 1,700 to 4,600 lane kilometers of bikeways.[13] A notable example of these investments is the protected All Ages and Abilities Burrard Street Bridge bike lane, which sees an average of 3,100 people cycling pass over it per day and is considered the busiest bike lane in North America.[14]

Investments in bike infrastructure in the region have contributed to increasing bike ridership. We have seen a 35% increase in commuter ridership across the region, from 1.7% in 1996 and 2006 to 2.3% in 2016.[13] We have also seen the number of daily commuter trips taken by bike increase by 65% between 2006 and 2016.[13] The regional cycling rate of 2.3% in Metro Vancouver is also notably higher than the national average of 1.4% and also stacks up well within North America.[13]

Overall, when looking at the share of commuters biking to work, there was an increase between 2006 and 2016 across Metro Vancouver. Twenty-three jurisdictions now boast a ridership rate above 2%, a notable increase from the three jurisdictions in 2006 (Table 1). For the most part, the five regions realizing decreases in the share of people cycling to work registered relatively small reductions. The City of Vancouver saw the highest increase in cycling trips in the region, increasing from 3.7% to 6.1% of commute trips.[13]

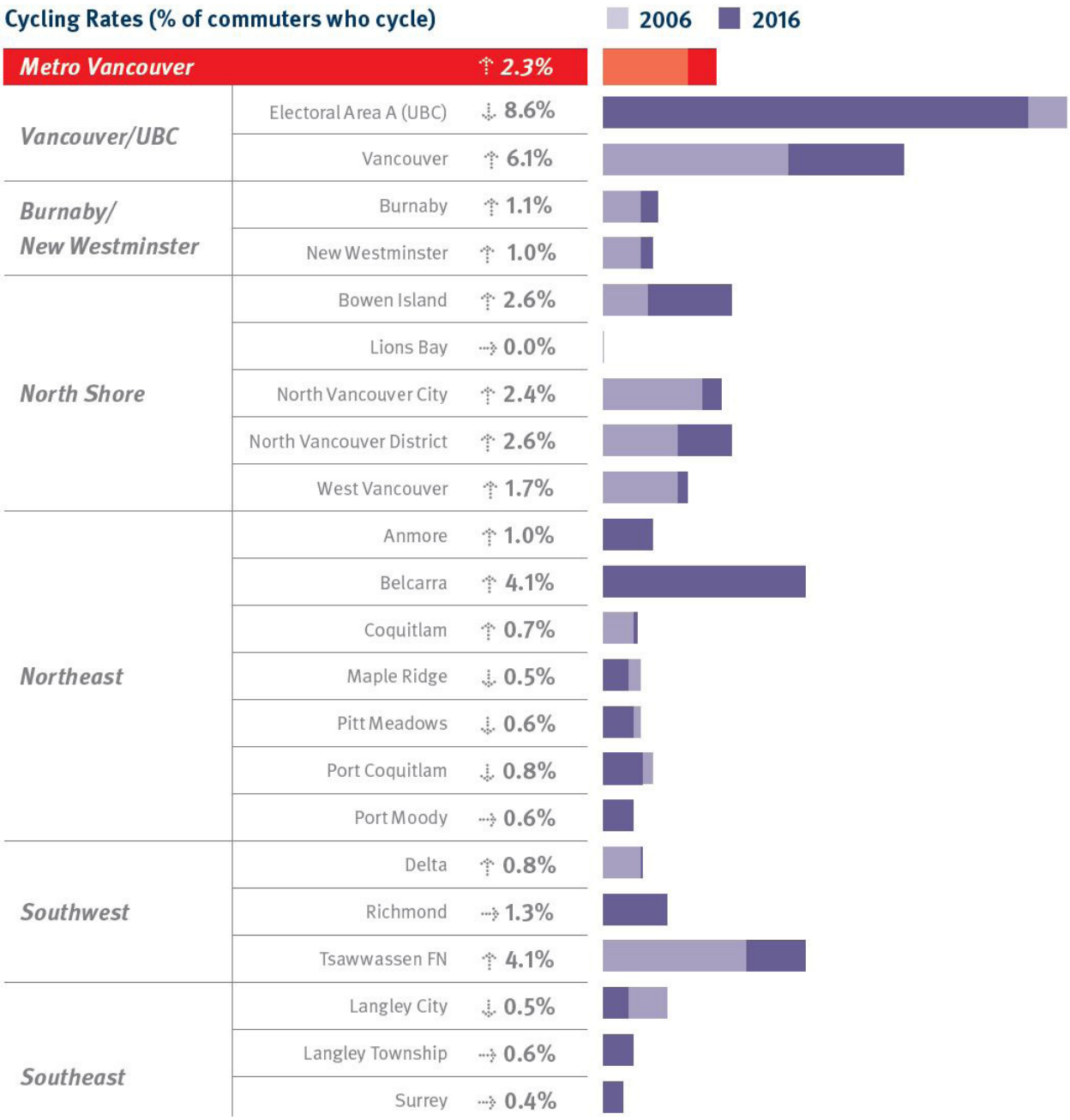


Table 1: Cycling Rates, defined as the percentage of commuters who cycle[13]

Route Types and Comfort Levels

The 4,600 km regional bike network in Metro Vancouver is composed of various bikeway facility types, ranging from separated off-road facilities to shared roadways between motor vehicles and people cycling. Bikeway facility type ridership has been associated with different rider types, based on factors such as individual comfort level with risk and perception of safety.[13] The categories of bikeways facilities found in Metro Vancouver, including bike paths, protected bike lanes, multi-use paths (MUPs), shared roadways, bike lanes, and bike-accessible shoulders, are shown and described below (Figure 2).

Figure 2a: Glossary of Bikeway Facility Types found in Metro Vancouver[13]

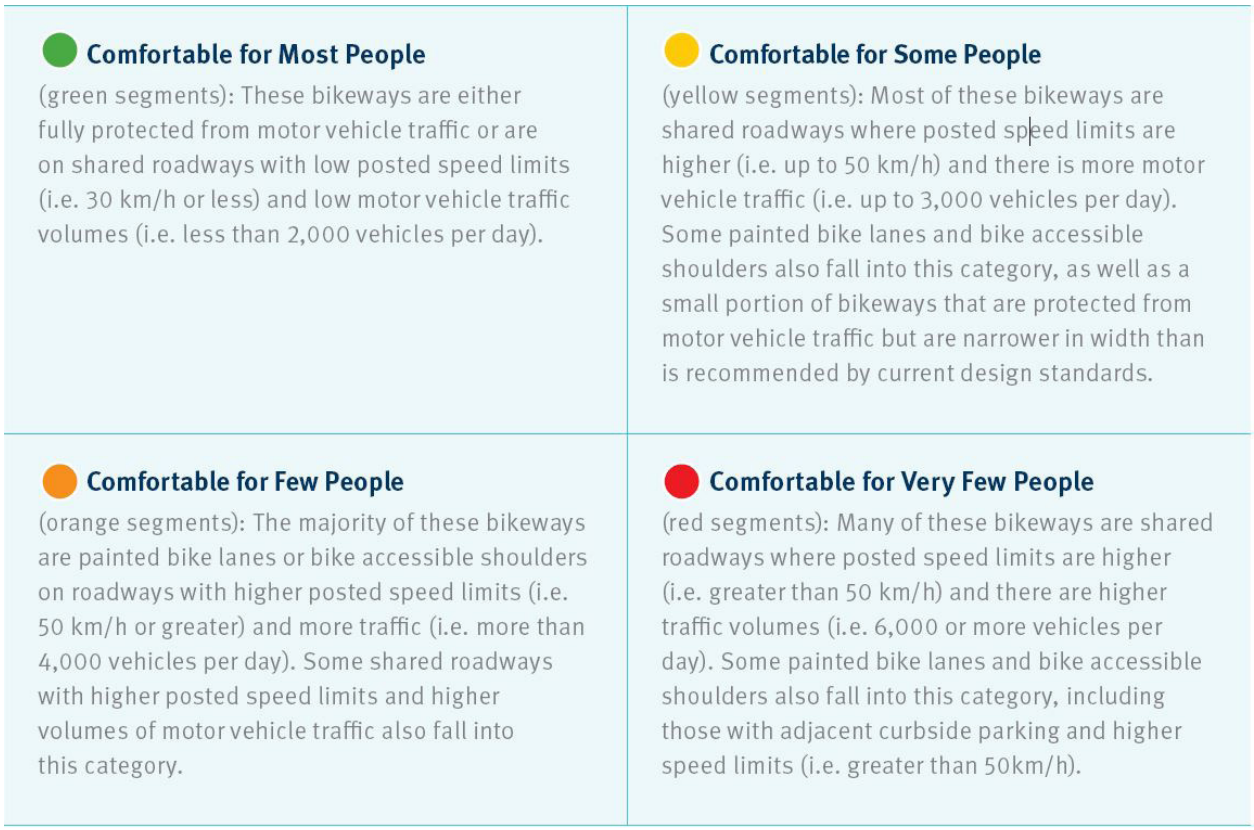


Figure 2b: Bikeway comfort category descriptions, including Comfortable for Most, Some, Few, and Very Few[13]

In the report Benchmarking the State of Cycling in Metro Vancouver[13], HUB Cycling and TransLink draw attention to the comfort level associated with cycling routes throughout the Metro Vancouver Region. The Bikeway Classification System[13] consists of four categories based on the level of perceived comfort of the person cycling along the route; these include: Comfortable for Most (CfM), Comfortable for Some (CfS), Comfortable for Few (CfF), and Comfortable for Very Few (CfVF). These categories are based on bikeway facility types, in addition to exposure to motor vehicle traffic, posted speed limits, volume of motor vehicle traffic, and the presence of on-street parking (Figure 2). For example, on routes deemed as CfM, people cycling are either fully protected from traffic or, when they ride on shared roadways, there are low posted speed limits and low traffic volumes. Comparatively, and at the opposite end, routes deemed as CfVF are often either painted bike lanes or bike accessible shoulders that reside on roadways with higher posted speed limits and higher traffic volumes. The colours corresponding to each comfort level can be seen associated with each Bikeway Facility Type (Figure 2).

Cycle Route Network

When looking at Metro Vancouver, we see a network of routes displaying intermittent consistency and quality throughout the region. However, this network has significant sections that are only reasonably accessible to people confident in cycling and who are not risk-averse; these individuals make up a small proportion of the people who could be potentially cycling in Metro Vancouver. The map below illustrates the cycling routes in Metro Vancouver by associated comfort level (Figure 3).

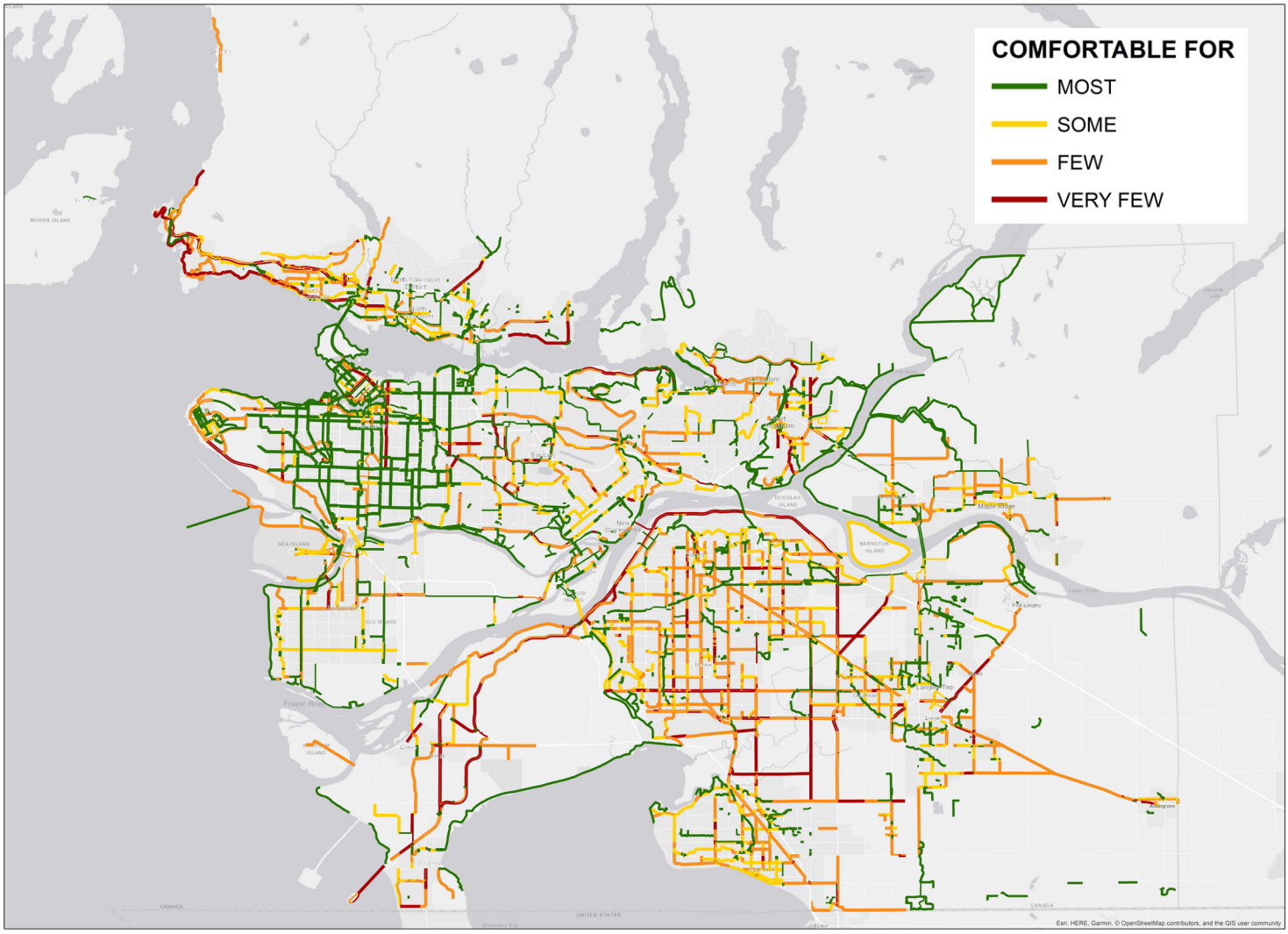


Figure 3: Metro Vancouver Bikeway Facilities by Level of Comfort[13]

If we look closely, we find that almost half of the bikeway network is considered CfM (46%) and just over half (54%) is considered CfS, CfF, and CfVF (Figure 3).[13] This highlights issues pertaining to the approachability for new riders to cycling as transport within the region and suggests that more than half of the current bike network could benefit from upgrades in order to create more comfortable routes appealing to a greater proportion of the population.[13]

When further breaking down the levels of comfort by facility type, it is apparent that the comfort levels lie disproportionately across the facility types (Figure 4). The bike paths and protected bike lanes, which are all considered comfortable for most, constitute a small fraction – only 3% - of the bike network in Metro Vancouver.13 It is also shown that MUPs are the most common route type (37% of regional routes) and are predominantly rated as CfM.

However, most routes (60%) are shared roads, bike lanes, and bike-accessible shoulders. The small subset of the routes on shared roads, typically on quiet residential streets with low posted speed limits (i.e. 30km/h), is rated as CfM; the rest of the routes on shared roads are considered CfS, CfF, and CfVF. This is largely due to higher posted speed limits and higher motor vehicle traffic volumes. Lastly, bike lanes and bike-accessible shoulders, often with higher exposure to motor vehicle traffic, are considered CfS, CfF, and CfVF, highlighting these route types being largely associated with rider discomfort. These routes make up 28% of the Metro Vancouver Bike Network.

Figure 4 highlights MUPs, due to their prevalence within the region along with the associated perceived comfort levels. However, it must be noted that as volumes increase, mixed spaces for pedestrians and people cycling, travelling at different speeds, increase injury risk. Careful design can ameliorate some of this risk, but separated cycling and walking paths have been shown to be safer.[15]

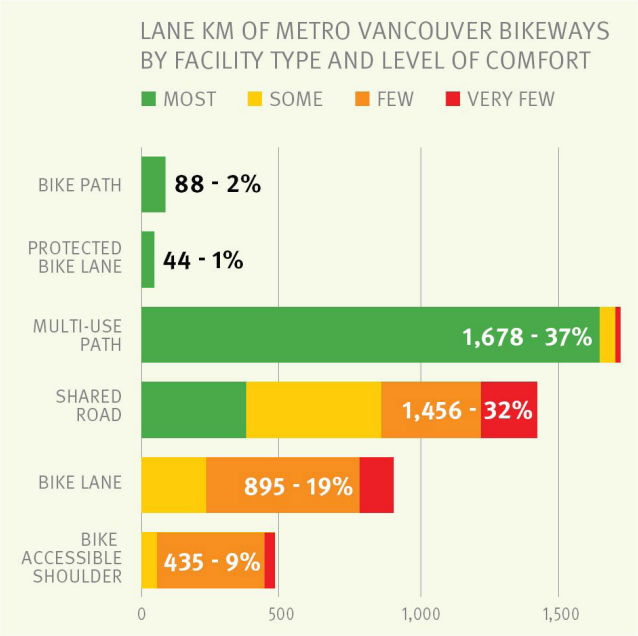


Figure 4: Lane km of Metro Vancouver Bikeways by facility types and level of Comfort[13]

Furthermore, as we shift the perspective and view the regional bike network in Metro Vancouver with consideration of comfort levels and accessibility for the majority of people cycling, the network becomes disjointed. The map below (Figure 5) depicts only the bikeways in the network deemed CfM (green) and we see a notably less continuous and connected network compared overall network (Figure 3). Albeit, quite notably, 65% of the region lies within 400m of one of the CfM routes.[13] We also see an absence of a continuous and connected CfM network between different cities within the Metro Vancouver Region. For example, the City of Vancouver shows a widespread and interconnected CfM network. However, this is largely missing in other parts of the region. A fragmented network is less likely to link homes to important destinations, thus directly impacting its utility and impact.[13] It is predicted that by better meeting the need of people cycling, there would be a positive effect on bike ridership or, as it is also known, bicycle mode share.[13]

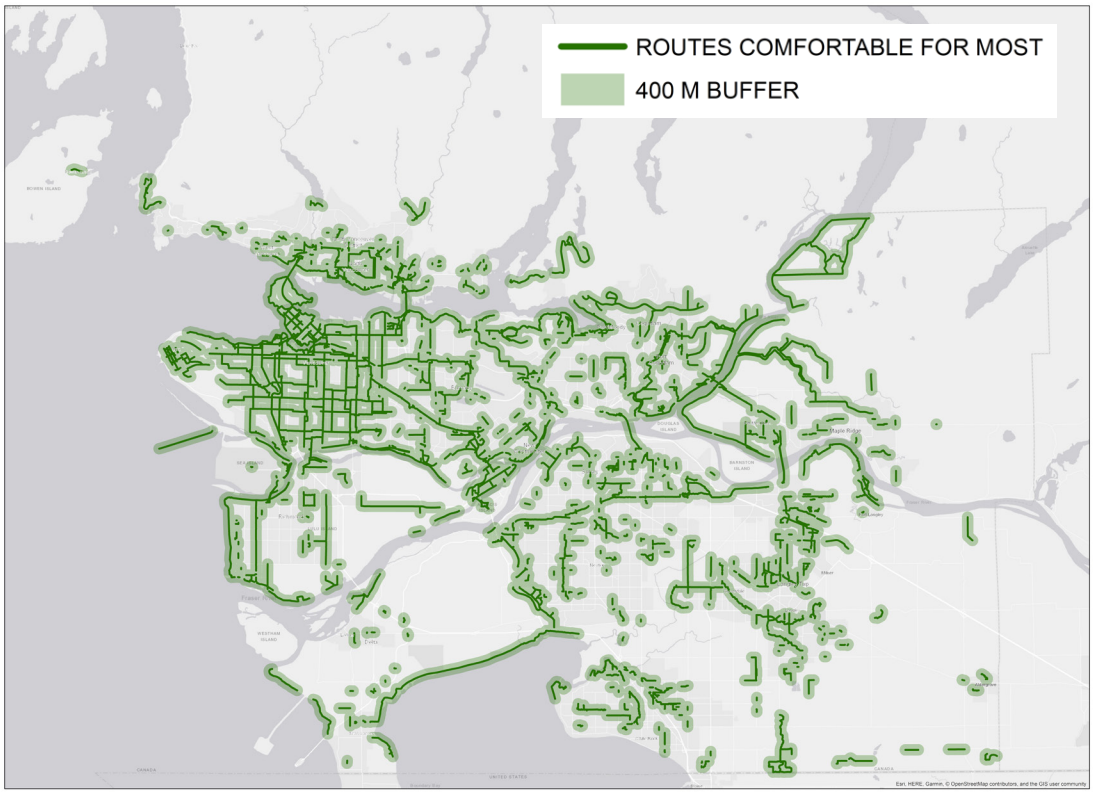


Figure 5: Comfortable for most network and 400m buffer region throughout Metro Vancouver[13]

Collision Levels and Safety

Safety statistics are an important metric and gauge of the quality of a region's cycle infrastructure. Generally, when looking at areas in North America and Europe, we see increased cycling modal share correlate with reduced fatality rates for people cycling (Table 2).[13] Metro Vancouver, reporting on total vehicle collisions involving injury to a person cycling, found 810 reported on average annually prior to 2008.[13] Although this increased to 1,076 annual collisions between 2008 and 2017, the rate remained steady.[13] As shown in Table 2, the rate is higher compared to European countries. This highlights a need for safety improvements in our cycle infrastructure across the region. As outlined in the Regional Cycling Strategy (2011), ongoing investment to improve the cycle network will be required to meet the goal of reducing the number of people cycling injured and killed by 50%.

	BICYCLE MODE SHARE	CYCLIST DEATHS PER 100 MILLION KM CYCLED
Netherlands	26%	1.1
Denmark	18%	1.6
Germany	10%	1.6
France	3%	2.0
Canada	1.3%	2.4
USA	0.5%	5.5

Table 2: Bicycle mode share and cyclist deaths (per 100 million km cycled) for the Netherlands, Denmark, Germany, France, Canada, and the USA[13]

The perception of the safety of cycling within the region is further highlighted when comparing the share of bicycle trips made by females versus that of males. Females, tending on average to be more risk-averse, have been found to be a useful indicator of perceptions of safety, comfort, along with equity of the transportation system.[13,16,17] In North America, bike trips made by men surpass that of women 3:1.[13] In contrast, we see close to 50%, and sometimes greater, the share of trips made by females in Northern European cities with extensive networks of protected cycle facilities.[13] In Vancouver, 35% of commute trips by bike are made by females (2016), increasing from 27% in 1996.[13] However, there is also a greater reported increase in females cycling to work than males.[13] This shows that the cycle network in Metro Vancouver is moving in the right direction in offering cycle infrastructure that appeals to a wider demographic.

Metro Vancouver: Preferences and Needs of People Cycling

Background and Connection to Cycle Highways

It has been shown that the road and bike-specific infrastructure influences how people travel.[18]

In order to attract people to cycling as transportation, it is important that infrastructure is designed to a high standard and with the user preferences and needs in mind. Although there is limited research specifically regarding user preferences of cycle highways, the concept for cycle highways (III. Cycle Highway Definition) effectively integrates many of the user preferences found to affect cycling behaviour, and there are clear findings as to what types of physical attributes people cycling prefer.

It must be considered that individuals cycling are not a homogenous group and therefore do not all make the same route choices. However, the importance of facilities was found to be consistent across people who cycle regularly and infrequently and between work and non-work trips.[18] TransLink has identified that 42% of the population in Metro Vancouver are interested in cycling more but are deterred for various reasons. The single greatest reported concern was riding their bike in motor vehicle traffic.[19] Additionally, the potential of engaging the near market in Metro Vancouver, being those who cycle already some, by better catering to these patterns and preferences is approximated to be 500,000.[18,20] The near market is a good audience for change and by engaging them, there can be an impact on the cycling mode share.[19,20]

Cycle highways are considered a route type and can comprise many facility types, as described.[21] In combination with cycle highways being considered the backbone of the cycling network, this means that care should be taken in the selection of the facilities included along the route. Careful selection of facility types ensures that high-quality design standards are met and ensure user satisfaction. User satisfaction generally pertains to themes such as safety, comfort, and ease of use. For example, an ample width allows for various speeds and volumes while ensuring safety.

As cycle highways are a high-quality type of cycle infrastructure that integrates people cycling centrally in their planning and addresses many of the aforementioned themes considered preferable in cycle

infrastructure, their implementation is suggested. Previous research conducted on upgrading cycle routes to cycle highways in Copenhagen, Denmark, found that people cycling reported much higher levels of satisfaction due to surfacing and lighting and higher levels of traffic security and personal security.[22]

In the following sections, research into user preferences of cycle infrastructure, including within Metro Vancouver, will be summarized, along with the results of a HUB Cycling survey on Metro Vancouver residents regarding their expressed preferences pertaining to cycle highways.

Research Findings

Both the built environment and accessibility to bike infrastructure have been found to affect people's travel patterns, such as whether people ride their bike or not and how often; simply, the presence of bike infrastructure has been found preferable for those who are biking.[18,23,24]

The presence of bike infrastructure was investigated in Edmonton, where they compared the relative burden of three different route types on people cycling: mixed traffic, on-street bike lanes, and multi-use off-street bike paths.[24] People found that cycling on mixed traffic routes is more onerous than on dedicated bike infrastructure.[24] And, even though people cycling prefer to take shorter routes, the average person cycling perceived cycling 1 minute in mixed traffic to be similar to 4.1 minutes in a separated bike lane and 2.8 minutes on a multi-use off-street bike path.[24] This shows that it is clear that the benefits of cycle-focused infrastructure perceived by people cycling is greater than the time savings of a more direct route; there was the highest preference shown for separated bike lanes. It has also been stressed that both safety and travel time may influence individuals' initial decision to cycle over other travel modes.[23]

Research in Metro Vancouver has investigated facility type preferences of people cycling and reasons influencing their route choice across.[18] The reasons affecting route choice are summarized below and have been categorized into four broad categories:[18]

a) Preferring designated bike routes

- Always following a designated bicycle route
- Not minding going an extra distance to remain on a bike route, especially those that are aesthetically pleasing
- Downtown, roads with bike lanes are selected over those without bike lanes
- Taking safest routes instead of shortest routes

b) Selecting a route to avoid traffic

- Selecting a route with less traffic and fewer cars
- Selecting a route along a dyke to avoid traffic
- Selecting a route through an alley to avoid a busy arterial
- Longer routes are selected to avoid a dangerous on-ramp

c) Selecting aesthetically pleasing routes

- Select route with better scenery
- Ride through parks during the day, but not at night
- Takes (unpaved) route through the park on the way home
- Preference for shade

d) Selecting easier routes to ride

- Avoids climbing steep hills and turns to avoid hills
- Turns to avoid or narrow or rough roads

Within Metro Vancouver, how long people are willing to travel in order to access bike infrastructure was investigated by Teschke and colleagues.[18] They found that people were willing to ride up to 400m to access bike infrastructure.[18] However, they also found that three-quarters of the trips made by individuals were only 10% longer than the shortest route between the origin and destination.[18] This highlights that although people cycling may consider bike infrastructure of high quality to be favourable, they do not want to compromise with a more circuitous route.

When further investigating cycle infrastructure, specifically route preferences, a survey of Canadians found that when individuals were asked where they wanted to ride their bike, the two features they deemed most important were to be away from traffic, citing reasons such as safety, noise, and air pollution, and to be near pleasant scenery.[25] In terms of the infrastructure type itself, off-street bike paths and MUPs were preferred.[25] Generally, the most preferred route types correlated with more safe route types (Figure 6).[25]

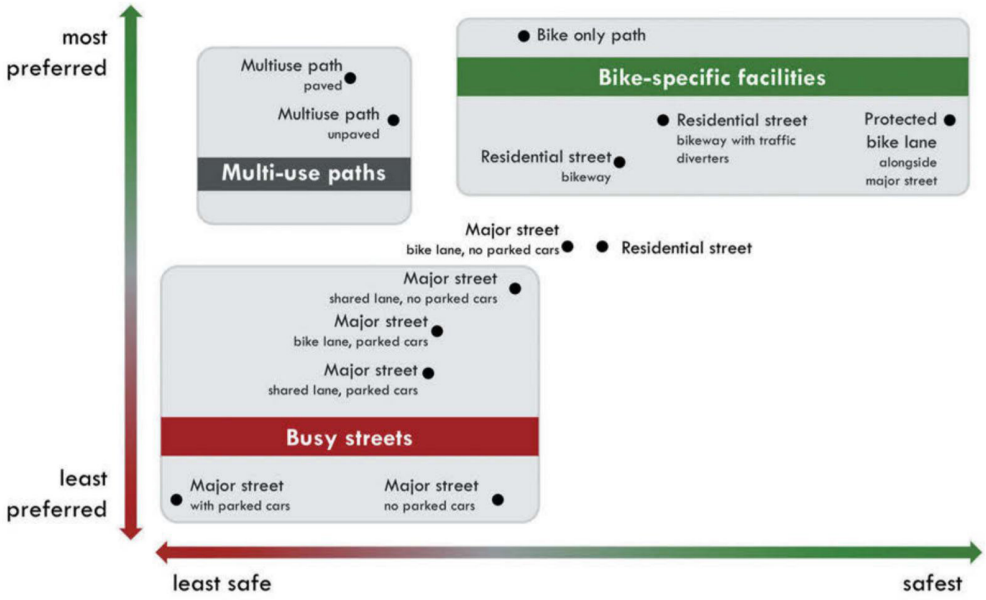


Figure 6: Route safety compared to user preferences of route types, including busy streets, multi-use paths, and bike-specific facilities[25]

For more information on Route Preferences, see the Supplemental

As shown by the research and shown in Figure 6, preferred cycling facilities generally correlate with those perceived as safer. However, the mixed modes present on MUP's have a negative impact on the safety of all users. In Metro Vancouver, the most used infrastructure type that is separated from traffic is off-street, both paved and unpaved, MUPs. However, even though they are an often-cited preferred infrastructure by people cycling, MUPs are categorized as less safe when compared to bike-specific facilities (Figure 6).[26] The factors of MUPs that contribute to reduced safety levels relative to cycle-specific facilities have been investigated and are found to often be within the realm of design.[26] Off-street paths including MUPs are more likely to be curvy and have poor sightlines, more likely to have obstacles (e.g. bollards, posts, and street furniture), less likely to have lighting, have inter-mixed pedestrians, people cycling, and other user groups and also less likely to be paved.[26] Crashes on these routes when unpaved are more likely to involve uneven surfaces, and when paved, are more likely to include obstacles; however, to their benefit, almost never include a motor vehicle.[26] Designers of off-street paths should make them comfortable and inviting, but also safer, for people cycling; this is because they are considered attractive more so than on-street routes.[26] Cycle highways, and their associated design characteristics, address many of the safety concerns outlined for MUPs, including high-quality paving, capacities for speed, lighting, and consistent and ample widths.

Research Takeaways

- **42% of people in Metro Vancouver want to cycle more; the single greatest reported concern is cycling in motor vehicle traffic**
- Route choice preferences in Metro Vancouver include designated bike routes, routes that avoid traffic, aesthetically pleasing routes, and routes that are easier to ride
- People are willing to travel up to 400m to access bike infrastructure
- Perceived benefit of bike focussed infrastructure is greater than time savings of more direct route; however, 3/4 trips in Metro Vancouver were only 10% longer than the shortest route
- Traits of the most preferred bike facilities included:
  - Off-street
  - Paved
  - Mode separation
  - Traffic calming
  - Marked bike routes

- Generally, the most preferred routes correlate with those perceived as safer
  - Mixed-use paths are a preferred facility, but mixed modes negatively impact the safety of all users; safety concerns can be largely addressed through design.

In Metro Vancouver, there is a lack of congruency between what routes people report that they prefer to ride and where they actually ride. This highlights a gap in addressing the needs of people cycling. However, the preferences for infrastructure were relatively consistent across how often people cycled and between genders. These findings and commonalities inform and simplify future development in bike infrastructure across the region. The design of cycle highways largely addresses these concerns and therefore supports their implementation.

Bike to Work Week - Survey Responses

Bike to Work Week (BTWW) is a biannual event encouraging people to cycle to work instead of going by car. Participants are encouraged to log their trips online and fill out a survey at the end of the week to share bike-related information and preferences with HUB Cycling. The following section summarizes the survey-takers responses to questions relevant to cycle highways.[26]

A total of 593 individuals (n=593) filled out the survey and responses were collected between June 22, 2021, and July 6, 2021. Respondents were comprised of 52.1% Women, 45.5% Men, and 0.5% Non-binary (1.9% Prefer not to say). The age of respondents was predominantly composed of those between ages 29-39 (22.1%), 40-49 (22.9%), and 50-59 (22.3%). This was followed by those ages 20-29 (14.0%) and 60-69 (12.5%); those 'under 20' (4.4%) and '70 and over' (1.9%) comprised a small fraction of respondents. Most respondents reported their ethnic background as Caucasian (70.8%), followed by Chinese (14.9%) (7.1% Prefer not to say). Small percentages were represented by Latin American (3.2%), South Asian (2.7%), Filipino (1.5%), Japanese (1.2%), and less than 1% was reported by each of the following groups: Aboriginal, Afro-Canadian, Korean, Middle Eastern, South-east Asian, and West Asian. Respondents reported being from various locations across Metro Vancouver. The largest reported group was Vancouver (57.5%), followed by Burnaby (11.0%), North Vancouver (District) (7.1%), Richmond (4.5%), and North Vancouver (City) (4.0%). New Westminster, Surrey, West Vancouver, and Coquitlam were reported by 2.4%, 2.2%, 1.9%, and 1.9% of individuals, respectively. The remaining cities reported were fractionally represented, relatively speaking.

Respondents answered various questions regarding their commuting patterns, including which mode of transport they predominantly used, the length of their commutes, and whether they used e-bikes. When asked, “What is your primary mode of transport?” the bike was reported most often (53.1%), followed by personal vehicle (26.1%), transit (10%), walking (8%); carshare, and other together comprised 2.5% of respondents. Typical commutes to work were reported to be most commonly between 11 and 20km (return trip), closely followed by 6-10km. The distribution of responses is shown in Figure 9. 9.1% of respondents reported that they either did not commute or worked from home. The use of e-bikes was reported by 13.3% of respondents.

Figure 9: Work commuter distances as total distance travelled to and from work (round trip)

Respondents were asked whether they generally supported the construction of a cycle highway network, whether they would use them, and to rank the most desired aspects of a cycle highway. When respondents were asked, “Do you support the construction of a network of Bicycle Highways linking town centres throughout Metro Vancouver?” overwhelming support was reported, with 92.9% of respondents stating ‘Yes’ (6.1% were ‘unsure’ and 0.8% responded ‘no’). When respondents were asked to predict the likelihood they would use a cycle highways network, 89.5% stated they ‘Definitely would use’ or ‘Likely would use’ it.

Over 90% of survey respondents were in favour of building cycle highways in Metro Vancouver

Respondents were asked to rank the following traits: direct, visible from motor vehicle highway, exposure to green or wild space, reduced noise/pollution, and limited stopping. Overall, the most important was deemed to be directness (ranked 1st by 41.1% of respondents and 2nd by 26.5% of respondents). The second most important trait was limited stopping (ranked most important by 18.0%, and second most important by 30% of respondents). Other factors ranked included visible from motor vehicle highway, exposure to green or wild space, and reduced noise/pollution. Their comparative rankings are shown in Figure 10.

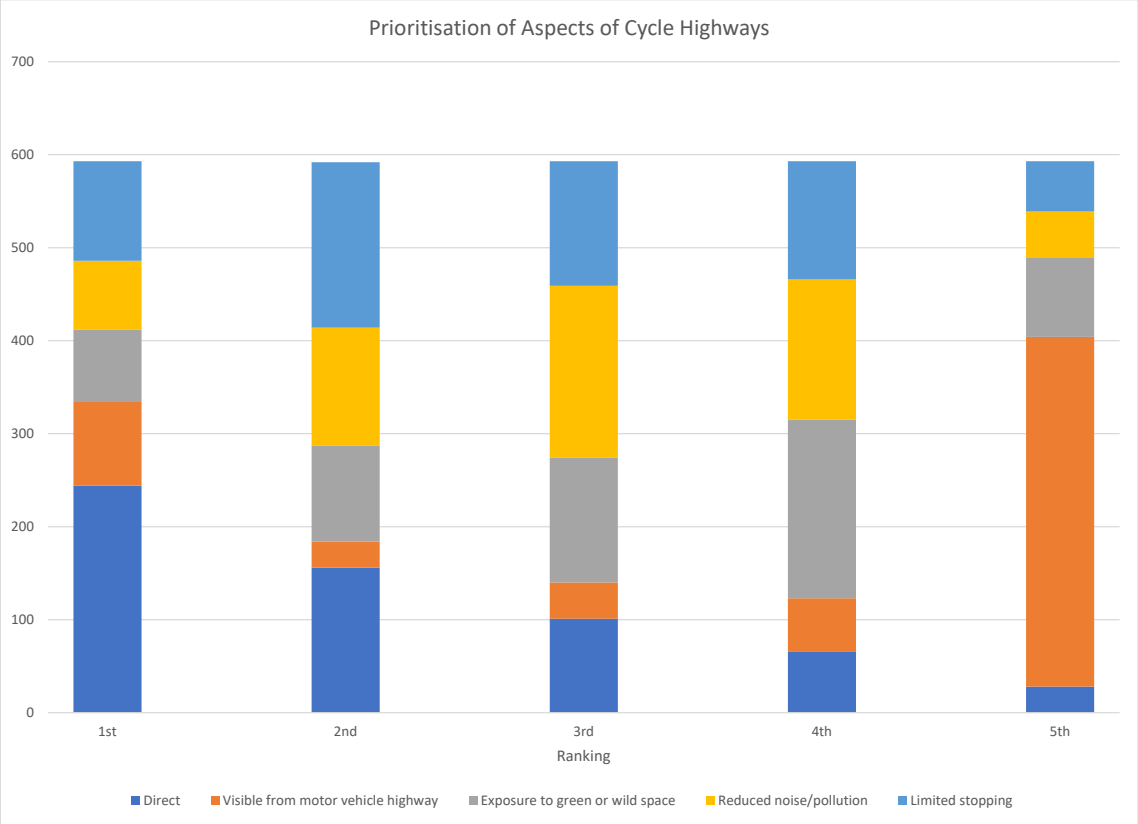


Figure 10: Prioritization of Aspects of cycle highways (n=593), ranking aspects from most important (1st) to least important (5th)

From these results, there are a few notable takeaways. Firstly, the typical commutes to work (total return trip) were most reported to be between 11 and 20km (26.6%); 21 - 30km was reported by 12.6% of respondents. Interestingly, this group together comprises just over a third of respondents (39.2%) and shares the average commuter distance with the average distance travelled on the cycle highways in the Capital Region of Denmark (11km one way).[27] However, these distances are currently being ridden by people cycling in Metro Vancouver in the absence of high-quality interconnected infrastructure. This displays the potential cycle highways have for, via addressing user needs, increasing ridership of these distances. Secondly, when respondents were asked to prioritize aspects of a cycle highway, the first was directness and, second, limited stopping. These factors are consistent with traits of cycle highways in other regions, and their integration into the design of cycle highway routes should be prioritized. Lastly, reduced noise/pollution and exposure to green or wild space were prioritized over being visible from motor vehicle highways. None of these three traits have been found to define cycle highways in other regions but generally pertain to user preferences of pleasant and aesthetically pleasing routes. These factors are suggested to be taken into consideration over placement on highways.

It must be noted that the sample of people who completed the BTWW survey is likely a skewed representation of the opinions held across Metro Vancouver. Individuals who participated in BTWW are a sub-sample of those living in the region and likely possess higher cycling levels than the average person. That being noted, the opinions shared from participants regarding preferences for cycle highways can also be considered valuable, as a large segment of the group sampled uses bikes as their primary mode of transport (53.1%).

Cycle Highway Definition

Photo credit: Cycle Superhighways, Capital Region of Denmark

Cycle Highway Definition

Background

The concept of cycle highways was first experimented with by the Dutch, creating demonstration routes in Tilburg and The Hague in the 1970s. However, it was not until much later that the designs for cycle highways became more clearly delineated. Media attention surrounding cycle highways increased notably when London, England opened its first routes in 2010.[28] We now see cycle highways in places including the Netherlands, Copenhagen, Belgium, London, and Germany. However, cycle highways are a new concept and lack a clear and agreed-upon definition; their design and purpose are still evolving.[28–30]

According to the European Cycling Federation (ECF), the five widely agreed upon criteria for high-quality cycling infrastructure and applied to cycle highways are:

1. Safety,
2. Coherence,
3. Directness,
4. Comfort,
5. Attractiveness.[29]

Additional criteria and characteristics, however, have yet to be agreed upon.[29] It has been stressed that without a clear definition – which is contributed to by the variety of languages employed in describing the concept of cycle highways – it becomes difficult to assess performance and transfer knowledge regarding successes and failures. For example, a cycle highway in the Netherlands is referred to as a snelfietsroute, in Germany a radschnellweg, and in London were once called cycle superhighways and are now referred to as cycleways. For the purpose of this section, when 'cycle highways' are referred to, it will include translations of the phrase, such as those mentioned above.

Additionally, there needs to be some flexibility in the design of cycle highways, making concessions for local contexts, limitations, and possibilities. Practitioners have warned against approaching cycle infrastructure with the same logic as car infrastructure.[28,31] Cycle highways need to balance the uniform, predictable, and regulated engineering of highways with the diverse, vibrant, human-scale design of pedestrians spaces.[28] Overall, the needs of people cycling differ from that of an automobile driver, and the idea of a 'highway' means something different and has a different connotation to a person cycling than a driver.[28]

In order to help gauge how cycle highways are defined, Liu and colleagues[28] asked practitioners in parts of Europe where cycling developments are mature what main concepts they used to describe and define cycle highways. Although responses varied among practitioners, responses were found to be relevant to 3 general themes: A) political context, jurisdiction, and funding, B) infrastructure and environmental quality, and C) directness, efficiency, and competition with other modes.[28] They also highlight that practitioners give two types of cycle highway definitions, the first of which pertains to goals, and the second relates to execution. Generally, policies outline the vision and goals that cycle highways should meet and the design manuals are the translation into a physical design.[28]

Within the context of Metro Vancouver, it will be crucial to establish an agreement on the definition of a cycle highway between various stakeholders, such as the municipal and provincial governments, along with transportation authorities. A definition of what a 'cycle highway' means within the region can help manifest a commonly shared vision and help guide the process.

HUB Cycling Short 'Elevator Pitch' Definition

The research in part C. Cycle Highway Working Definition and Cycle Highway Design Characteristics (Supplemental Background) informed discussions between members of the Cycle Highway Working Group . These discussions led to an abbreviated definition, summarizing the important goals and design characteristics, and follows below:

> **"Cycle highways are the highest quality bike routes, covering long distances (5km+) and providing regional connections between major destinations. They are direct, paved, protected, lit, of ample width, and with intersections prioritizing people cycling. This, along with clear signage, branding, and regular maintenance, ensures cycle highways are safe, comfortable, and easy to use for people of all ages and abilities at all times of the day and year."**

Cycle Highway Working Definition

A two-part working definition for the concept of cycle highways, in line with previous research on regions that have defined cycle highways, is proposed below.[28] The two parts consist of, first, the vision/goal and objectives of a cycle highway (1) and second, the characteristics pertaining to its design (2).

First, the objective (1) was created through research into the objectives other regions had for their cycle highways. These were amalgamated and further developed by collaboration, discussions, and feedback with the Cycle Highway Working Group to ensure context relevancy. The aim of this portion of the definition is to best delineate the goals and objectives relevant to the construction of cycle highways within the Metro Vancouver region, as well as throughout the province.

1. The objectives of cycle highways are to provide:

- The highest quality bike routes that protect and prioritize people cycling along the entire route
- Direct connections between major destinations and a backbone of the regional cycling network
- The ability to maintain consistent speeds and avoid frequent stops
- Safety and comfort for all ages and abilities, day and night, throughout the year
- Connections greater than 5km in length to facilitate long-distance and multimodal travel
- Readily identifiable and intuitive routes

The objectives of cycle highways, as outlined above, are contributed to and achieved by design characteristics. The characteristics outlined below result from investigating how others, both researchers and planners, have previously defined 'cycle highways.'

[a] A group meeting monthly to discuss topics relevant to cycle highways in Metro Vancouver; includes members from HUB Cycling and TransLink.

2. Design characteristics of cycle highways include:

1. Directness
2. Longer Lengths
3. Connections Between Major Destinations
4. Capacity for Speed
5. Mode separation
6. Intersection Treatments and Minimal Stops
7. Consistent and Ample Widths
8. Consistent and High-Quality Paving
9. Lighting
10. Minimizing and Alleviating Gradients
11. Clear Signage and Branding
12. Regular Maintenance and Winter Service
13. Service Stations

The characteristics outlined above are described in detail in the Background Supplement under Cycle Highway Design Characteristics

Although the above definition has been broken into two separate parts they do not operate independently of one another; the validity of the goals and objectives is supported and upheld by the presence of various design characteristics. For example, 'the ability to maintain consistent speeds and avoid frequent stops' is directly supported by design characteristics including intersection treatments, consistent and ample widths, consistent and high-quality paving, minimizing and alleviating gradients, and being designed with a capacity for speed. The objective 'safety and comfort for all ages and abilities, day and night, throughout the year' is directly supported by including the following in the design: mode separation, consistent and ample widths, lighting, minimizing and alleviating gradients, and regular maintenance and winter service. Connections between various design characteristics and the objectives outlined above are further described in the next section.

Finally, it must be noted that this working definition, both parts a) and b) is suggestive in nature and requires further work on defining certain aspects and ensuring context sensitivity. For example, 'ample widths' will have to be quantitatively defined within the Metro Vancouver region. Some numbers and references are provided to act as a reference point for the characteristics outlined in the subsequent section.

Facility Type vs. Route Type

Previous research into the definition of cycle highways within the context of North America has brought attention to the difference between route type and a facility type.[21] The difference between the two is clarified below:

Facility type: describes the form, often differentiated by the degree of separation bikeway has from other modes of travel. For example, painted bike lanes or multi-use paths.[21]

Route type: describes the function, such as direct, long-distance connections. This is similar to the hierarchy of roadway rankings (arterial, collector, access routes). For example, cycle highway.[21]

The objectives of cycle highways, outlined in the previous section, contribute to describing their function as a route type. Effectively, a cycle highway may also have segments of different facility types, for example, multi-use paths or painted bike lanes. These variations in facility type are in part due to cycle highways covering longer distances, thus needing to be sensitive to the local contexts that they pass through while at the same time meeting design and quality standards.[21]

In North America, currently, there is comprehensive guidance for facility design; however, an absence of defining the function of a bikeway within the greater context of bike infrastructure. It has been highlighted that this needs to be considered throughout the planning stages of a cycle highway.[21] The aforementioned objectives contained within the cycle highway working definition aim to contribute some clarity towards defining the function of a cycle highway within North America.

Galloping Goose and Lochside Trail in Greater Victoria, B.C.
Photo credit: B.C. Provincial Government

How Metro Vancouver Can Benefit from Cycle Highways

How Metro Vancouver Can Benefit from Cycle Highways

Section Summary

Numerous benefits have been associated with cycle highways and have been realized in regions that have already implemented them. Benefits include improved health, environmental impact reduction, and economic gains. Cycle highways have been assessed via traffic modelling and cost-benefit analyses and return positive results. They also have the potential to stimulate of bike tourism and have been found to have a synergistic effect with the growth of e-bikes and micro mobility. Lastly, cycle highways contribute to addressing transportation inequity.

A. Benefits of Cycling

Increased cycling is associated with health benefits, including improved physical, mental, and social-well-being. Physical health benefits include improved cardio and heart health, reduced incidence of chronic disease, reduced risk of various cancers, and reduced likelihood of being overweight or obese. Furthermore, benefits have been found to present rather quickly and are found across diverse segments of the population, including e-bike users. The mental health of people who cycle include higher reported happiness levels, reduced stress risk, and improved executive functioning. Social benefits of cycling include social interaction and are largely associated with bike-friendly street design. Individual physical, mental, and social health benefits are intertwined and effectively contribute to population level health outcomes. In Denmark, it was found that “those who did not cycle to work experienced a 39% higher mortality rate than those who did”.

Environmental benefits of cycling are largely associated with a modal shift away from fossil-fuel burning modes of transportation. This means reduced pollution and improved air quality. The United Nations Environment Program highlights the potential for reducing greenhouse gases in the transport sector is ‘staggering’ and requires a shift to environmentally efficient transport modes; cycling consumes zero fossil fuels per kilometer ridden.

Economic benefits of cycling are realized at the individual and societal level. Cycling is considered an affordable form of transportation and people who ride bikes also are more likely to visit shops and spend money. Businesses proximal to a newly built bike lane in New York saw a 49% increase in retail sales. Economic benefits are also realized though infrastructure: bike infrastructure is relatively cheap compared to automobile roads, creates more jobs per dollar spent.

B. Decision Support Models: Traffic Modelling and Cost-Benefit Analyses

To justify the construction of cycle highways, regions have employed decision support models, such as traffic modelling and cost-benefit analyses, to estimate associated benefits. A traffic modelling study conducted across the Netherlands on their 675km of proposed cycle highway routes was found to

improve mobility nationally and effects were expected to compound with the increasing use of e-bikes. Through traffic-jam reductions, the network is estimated to save commuters 3.8 million hours per year; with e-bike usage this more than doubles to 9.4 million hours. An analysis on the 101km cycle highway in Germany looked at effects on traffic in the region and compared costs to benefits; reductions in car trips and positive cost-benefit were found, even for the conservatively estimated scenario. A cost-benefit analysis on the proposed cycle highway network in Denmark found, in the most beneficial scenario, a 23% rate of return on investment. The least beneficial scenario showed a positive rate of return 6%. Infrastructure investments in public transportation and motorways often return between 3% and 10%. Although the magnitude of benefits vary, findings are consistently positive. These analyses highlight the benefits of implementing cycling highways within a region.

C. Cycle Highways Can Stimulate Tourism

Cycle tourism has been identified as an important and growing tourism market with significant economic value in many places around the world, however, North America has been comparatively slow. For example, EuroVelo, a network of pan-European cycle routes, sees 5.3 million visitors annually. Although the ratio of residents to tourists on local cycling routes is approximately half-half, the economic return is largely contributed - 77% - by cycle tourists. Cycle tourism in Europe has been assessed to be worth €44 billion. Comparatively, on the South Island of New Zealand cycle tourism is associated with a direct expenditure of $76 million per annum and a total economic output of 160 million, comparable to the cruise ship industry.

Canadians show interest in cycle tourism, representing themselves sizably internationally, and some provinces have already begun to realize cycle tourism. Within Québec, 10% of the population identifies as a cycle tourist. Québec has also invested in developing a bike network, La Route Verte, of 4345km to help facilitate cycle tourism. People cycling along this route alone spent $95.4 million. Meanwhile, in Ontario, cycle tourism has been included in their provincial cycling strategy. A combination of local and international visitors in Ontario engaging in cycle tourism are estimated to spend $428 million. Within British Columbia we also have an opportunity to capitalize on the economic potential of cycle tourism. Interest has been shown at the provincial level but requires further development of a cohesive vision. Already $38 million is realized from mountain bike tourism on the Sea-to-Sky corridor alone. However, for cycle tourism to appeal to wider demographics, infrastructure investments are required.

Investment into high quality bike infrastructure and cycle highways have been found to help grow tourism. It has been highlighted that cycle tourism routes need to be safe, direct, comfortable, and cohesive, just like cycle highways. The preferences of cycle tourists and the infrastructure supporting cycle tourism are largely addressed by cycle highways, creating an additionally opportunity via their implementation.

D. The Growth of E-bikes and Micro Mobility: Added Value to Cycle Highways

E-bikes and micro mobility are quickly growing in popularity, both in Canada and worldwide. In 2020, Canada ranked 6th globally in total value of e-bike imports and, per capita, Canada imports more than the U.S. This growth is further compounded by increasing numbers of mobility share companies facilitating usage and access. Although Canada has lagged behind other parts of the world in adopting micro mobility sharing, things are quickly changing. Alberta and Québec are amending legislation and are being closely followed by Ontario and British Columbia. Notably, the micro mobility share company Lime has stated that Calgary's e-scooter pilot held the highest number of rides per device globally.

Similar e-bike and micro mobility growth is also being seen in Metro Vancouver. This is supported by Provincial Government e-bike rebates for individuals and cargo e-bike pilot programs for businesses. In addition, the province started investigating e-mobility for safe travel in April 2021 and has prompted e-mobility share pilot programs, including the e-bike share in North Vancouver and e-scooter share in Richmond.

Around the world micro mobility is also being capitalized on at the business level by employing cargo bikes and have been found to increase delivery efficiency within the urban space. Research from the UK has found that cargo bikes make delivery times within cities 1.61 faster and are cheaper to operate. Within the U.S., UPS, DHL, and FedEx have already been using cargo bikes for almost a decade and Toronto and Montreal already see cargo bike pilot programs. In Metro Vancouver, we already see numerous companies employing bikes for delivery purposes, including Eeco, Uber Eats, and Door Dash and the City of Vancouver has recently pledged to create an e-bike cargo delivery hub.

However, to realize the potential and accommodate the growth of e-bike and micro mobility for transportation, accommodating infrastructure needs to be provided. Their rapid emergence and projected growth warrants integration into our transportation networks.

We also see two-way positively reinforcing effect between e-bikes, and other forms of micro mobility, and cycle highways. The adoption of e-bikes and micro mobility is incentivised by the availability of accommodating infrastructure; 20% of the users on of the first cycle highway built in the Netherlands reported buying an e-bike because of the route. And, secondly, the growth of e-bikes mean that cycle highways become accessible to wider segments of the population and increase travel distances. Transportation and planning models in the Netherlands assume a reach of 7.5km for the conventional bike, however, this is doubled to 15km for the e-bike. “Even without the e-bike, the concept of the cycle superhighway can be a game changer. But with the e-bike it makes it even stronger” – Sjors Van Duren, on Cycle Highways in the Netherlands.

E. The Potential for Cycle Highways to Address Transportation Inequities

The importance of equity in transportation and cycle infrastructure planning is being increasingly realized. Numerous studies have found inequitable transportation in urban areas and often correlating with areas with lower-socioeconomics and minorities. Impacts of transportation planning decisions can be significant and diverse. Bicycles are considered a most equitable from of mobility and have potential to address inequities in transportation, however, cannot be successful in the absence of equitable and supporting infrastructure.

Planning for equity in bike transportation must consider the distribution and accessibility of the network, in addition to the types of facilities implemented. Previous research conducted in the City of Vancouver found that bike infrastructure investments between 2001 and 2016 did not address disparities in access: areas with more children or Chinese residents were found to have comparatively less access and areas with a higher proportion of university-educated adults had higher levels of bike infrastructure access.

Cities in Canada, including Winnipeg, Saskatoon, and Victoria, have already began including equity analyses and considerations in their cycle network planning. It is urged that Metro Vancouver take equity issues into greater consideration and better integrate them in policy and planning. Concerns have been raised that due to an auto-oriented community design and absence of transportation frequency,

disproportional impacts are realized by racialized, low-income, and female populations. This also negatively impacts health, and access to employment, education, and recreation.

An equity-informed design and implementation of cycle highways contributes to addressing equity concerns in both transportation planning and specifically bike infrastructure planning. Greater equity in transportation is realized due to facilitating bike use, one of the cheapest and most accessible modes of transportation. Equity in bike infrastructure is contributed by the embodied design of cycle highways, including being long-distance functional connections of high-quality, that are safe and comfortable for a variety of users.

Benefits of Cycling

The supply of transportation infrastructure and its influence on mode choice consequently determines our lifestyle, health, traffic safety, the appearance of our cities, environmental impacts, and costs to individuals and the overall economy.[7]

An increasing modal shift to cycling has been associated with improved health of the population, including physical, mental, and social well-being. These benefits expand to reducing the environmental impact of transportation, including decarbonizing our mobility. These effects, in addition to direct costs of infrastructure, include job creation and tax revenue, which lead to economic gains for society. A brief overview of the benefits of increasing bike ridership will be described in the following subsections, i. Health, ii. Environment, and iii. Economic.

Health

Cycling, a form of moderate intensity physical activity, has been linked to promoting general health and contributing to disease prevention.[32–34] Furthermore, the three aspects of overall health, including physical, mental, and social well-being,[35] are each positively contributed to by cycling. The World Health Organization concludes that there are large gains to be made by increasing routine physical activity and that increasing walking and cycling can be a very effective strategy in order to achieve these gains.[36] The potential contribution of cycling to health is further supported by the fact that cycling is accessible to a large segment of the population. Specifically, commuter cycling means that people can integrate activity into their daily routine rather than having to find additional time for exercise.[37] Health benefits from transportation cycling have been found across diverse segments of the population[38] and include e-bike users.[39]

Participation in cycling comes with good cardio benefits without excessive body strain,[37] in addition to being associated with reduced accident levels and fatalities[7,34]. Physical health benefits found in people cycling include better heart health and reduced risk of coronary heart disease[40], reduced breast cancer risk (up to 34%)[41], and a reduced colon cancer risk[42]. Specifically, commuter biking has been associated with reduced incidence of chronic diseases, reduced incidence of metabolic disease, and a reduced likelihood of being overweight or obese.[43] Additionally, the various positive effects realized by commuter cycling present themselves relatively quickly. This is shown clearly with a 'one-month' bike to work challenge in Copenhagen: two participants experienced a 3 and 4 year reduction in body age.[44] Health benefits and improvements were also found within a 4-week period for those commuting by e-bike.[39]

However, beyond physical health benefits, cycling has been found to improve mental health and people who cycle have been found to be happier than those travelling by other modes. Bicycle commuters have a significantly reduced risk of stress than non-bike commuters.[45] Cycling has also been shown to improve executive function and well-being.[46] Emotional well-being of people who cycle has been consistently reported, including relaxation, fun, enjoyment, and social interaction.[38] Additionally, those who commute by bike have the highest reported satisfaction of their trip to work compared to those commuting by other modes.[47] It's predicted that commuter satisfaction of people who cycle is in part due to it being less affected by external factors (e.g. congestion and crowding), which do notably and negatively affect car and transit modes.[47,48] Overall, research attributes positive mental health benefits of commuter cycling to four factors: 1) high level of commuting control and 'arrival time reliability, 2) enjoyable sensory stimulation, 3) positive feelings from moderate intensity exercise, and 4) increased opportunity for social interactions.[49]

Social aspects of health are also positively contributed to by cycling. Cycling and social benefits are largely linked through the design of streets and the urban space, namely human-scale design that supports cycling and walking and discourages car use. This is highlighted by the Dutch concept of a woonerf, or 'living street,' designed around the interest of pedestrians and people cycling. These types of spaces provide space for children to play and are based around a concept of shared space. Overall, an increase in the quality of urban life is found via improved social capital and community livability, as well as increased social interaction and reduced crime.[36,38] This is echoed by Litman, who has quantified full costs and benefits for various transportation modes for application in planning and policy.[50] Furthermore, improved cycle infrastructure expands to improving social equity within communities.[51,52]

Physical, psychological, and social health are intertwined with each other and contribute to overarching health outcomes; for example, social isolation and depression are considered risk factors for cardiovascular disease.[38] Net outcomes and impacts of cycling have also been assessed. Research in Copenhagen, Denmark found that "those who did not cycle to work experienced a 39% higher mortality rate than those who did."[53] These population-level benefits are also found in the Netherlands, where the high bike modal share is attributed to preventing 6500 deaths annually and contribute increasing life expectancy by half a year.[54]

Health Benefits and Cycle Highways

In Belgium, the health impact of two bicycle highways was investigated.[55] A conservative estimate, which did not include congestion, noise, and CO_2 reductions, of the benefit: cost ratios for health impacts and infrastructure costs found that mostly all scenarios returned a benefit:cost ratio above 1.[55] Overall, it was concluded that increased physical activity had the strongest effect when compared to other impacts.[55]

A cost-benefit analysis conducted on the cycle superhighway network expansion in Denmark found that "the single most important factor is the external health benefits," is defined as societal benefits of healthier people who will work and live longer and result in reduced expenses to the health care system.[56] Overall, the network expansion has been calculated to have a positive rate of return on investment.[56]

Environmental

Numerous environmental benefits are also realized by increasing cycling and are largely due to the modal shift away from modes of transportation associated with the burning of fossil fuels. Comparative to most other transportation modes, cycling is a pollution-free (zero fossil fuels burned per kilometer-ridden), environmentally sustainable mode of transport which makes negligible contributions to congestion. The United Nations Environment Program (UNEP) highlights that the potential for reducing greenhouse gases in the transport sector is 'staggering' and needs to include shifting to more environmentally efficient modes of transport.[57] A modal shift from motoring to cycling would improve air quality both at street and district level, as well as for the environment generally.[37] An increase in cycling is associated with reduced pollution and cleaner air[7,32,34] and reduced noise pollution,[32,7] all of which further contribute to the aforementioned health effects.

Economic

The economic benefits from cycling, and increased levels of cycling, are realized by both the individual, as transportation cost savings, as well as the societal level, in the form of government expenses and stimulation of proximal businesses. In principle, people who ride bikes, buy bikes and bike-related goods, are more likely to visit local shops, and also make notable contributions in the form of tourism, meaning jobs and tax revenue for communities.[58] Cycling is an affordable mode of transportation and has a relatively low cost compared to other modes of transport, especially when compared to the private car. This means that people who bike also save money; they have more money to spend, they save on health insurance costs, and they alleviate the need for the development of relatively expensive and space inefficient vehicle parking.[58]

These economic benefits are also realized in terms of infrastructure; the implementation of cycle infrastructure is relatively cheap, and its maintenance is a fraction of that of automobile roads.[32,59] Portland built their cycle network at a cost equivalent to one mile (1.6km) of urban freeway.[60] In addition, cycling infrastructure was found to create the most jobs per dollar spent and more than pedestrian and multi-use trails.[61] In Baltimore, bike projects create twice as many jobs as road projects (per dollar spent).[58] These benefits also extend to businesses adjacent to cycle infrastructure developments; in New York, businesses along the street of the newly built protected bike lane saw a 49% increase in retail sales (3% was seen borough-wide).[62] This is echoed in San Francisco, where two-thirds of merchants report new bike lanes having an overall positive impact on their business.[63]

Economic impact studies have found notable returns from those engaging in cycling. In Portland, the bicycle industry supports 2,300 jobs, a total added value to the local economy of $133 million, and $27 million in taxes[64] and in Boulder, Colorado $52 million is made annually, along with 330 full time jobs[58]. In the UK, cycling contributes £5.4 billion to the economy, triple that of the UK steel industry (£1.6b), and double as many full-time jobs, 64,000.[65] Summaries of the economic benefits, specifically pertaining to cycle highways, have also been quantified via cost-benefit analyses (see IV.B. Decision Support Models: Traffic Modelling and Cost-Benefit Analyses).

Photo credit: Cycle Superhighways, Capital Region of Denmark

Decision Support Models: Traffic Modelling and Cost-Benefit Analyses

The overall benefits of cycle highways can be illustrated through models, such as traffic models, which show the effect of investments on cycling and car usage, and cost-benefit analyses that assess the wider impact of the investment on health, worker productivity, and the environment.[66] Within this section, three decision support models will be briefly summarized: i) a traffic modelling study was conducted on the planned 675km of cycle highways to be implemented across the Netherlands, ii) a cost-benefit analysis, based on two possible scenarios, of the 101km cycle highway in Germany, and iii) a cost-benefit analysis on the proposed cycle highway network in the Capital Region of Denmark.

The National Cycle Highway Network in The Netherlands

In the Netherlands, cycle highways have the purpose of congestion alleviation at the national level, and traffic modelling has been conducted (Goudappel Coffeng, 2011) to highlight the potential cycle highways have.[67] The combined effect of the additional 675km of planned cycle highways routes and the increase in electric bikes is expected to improve mobility nationally.[67] The increase in the cycle highway network infrastructure has been estimated to contribute to a decrease in traffic jams throughout the country, saving 3.8 million hours per year; when this is combined with electric bike usage, travel time saved by car exponentiates to 9.4 million hours.[67]

The results of the Goudappel Coffeng study, estimating the prognosis for 2020 from the base year of 2008 with 675km of additional cycle highways and, additionally, a 50% in e-bike usage is summarized below (Table 4). An increase in the trip percentage of 3.3% is expected with a catchment of 800,000 inhabitants. This potential is realized because a cycle highway increases the average speed by bike from 15 to 18km/h.[67] They highlight that cycle highways, when combined with electric bikes, are able to reach their full potential, increasing the average speed from 18 to 24km/h.[67] On cycle highways, by increasing travel speed, it means that journey times can be decreased and travel distances can be increased.[67] They conclude that cycle highways in combination with electric bikes make cycling an attractive transport mode for suburbs and nearby villages that are within 3 to 20km from city centres.[67]

Change % in number of trips	With cycle highways	With cycle highways & 50% electric bicycles
Car	- 0.7%	- 1.6%
Public transport	- 0.9%	- 2.7%
bicycle	+ 1.3%	+ 3.3%

Table 4 Change in number of trips by cycle highways. Source: Goudappel Coffeng

Saving in hours of travel time by car per day	With cycle highways	With cycle highways & 50% electric bicycles
Morning rush hour	7,000	17,400
Evening rush hour	7,900	19,600
Total	14,900	37,000

Table 5 Travel time savings (car) by cycle highways. Source: Goudappel Coffeng

	With cycle highways	With cycle highways & 50% electric bicycles
Saving in hours of travel time by car per year	3.8 million hours	9.4 million hours
Saving in € (value of time = €10/hr by car)	€40 million	€100 million
Catchment area (accessibility of city centre within 45 minutes)	550,000 inhabitants	800,000 inhabitants

Table 4: The estimated economic benefits of an additional 675 km of cycle highways, and the additional 675km of cycle highways combined with 50% e-bike usage in the Netherlands; original work done by Goudappel Coffeng (2011)[67]

The 101-km Cycle Highway in Germany

In Germany, the Radschnellweg Ruhr's (RS1) - a 101km long cycle highway – effect on reducing vehicle traffic in the region has been assessed.[68] The number of bike trips relocated from the car due to the RS1 is summarized in the table below, based on two variable outcomes; the first outcome is based on the bike modal share rising from 10% to 14% and the second, rising to 20% (Table 5). The number of car trips replaced by bike trips daily due to the construction of the RS1 in the region is estimated to be 53,460.[68]

	Number of trips	**Passenger kilometres**
Bike modal share increasing to 14%	22,483	117,719
Bike modal share increasing to 20%	52,460	401,112

Table 5: The estimated number of daily car trips replaced by bike trips under two different scenarios: the first representing bike modal share increasing from 10% to 14%, and the second, increasing to 20%[68]

The benefits of improved cycle infrastructure are not limited to mobility but expand to realms including the economy, population health and health care costs, and the environment and climate.[67] The economic benefits of the Radschnellweg Ruhr have also been assessed in a cost-benefit analysis. The benefits encompass and are determined from indicators measuring pollutant emission reductions, improved road safety due to reduced vehicle trips, reduction in healthcare costs, and reduced consumption of resources.[68] The total of the benefits, maintenance costs, and initial construction costs show a clear net benefit to the construction of the RS1 (Table 6).[68]

	Bike modal share increasing to 14%	**Bike modal share increasing to 20%**
Benefit contribution per year	€14.8 million	€33.1 million
Maintenance costs per year	€3.3 million	€3.3 million
Initial construction cost	€6.2 million	€6.2 million
Benefit cost ratio	1.86	4.8

Table 6: Cost-benefit analysis for the Radschnellweg Ruhr (RS1) including benefits, maintenance costs per year, the initial construction cost, and the benefit: cost ratio for two increases in bike modal share scenarios, 14% and 20%[68]

Cycle Highway Network in the Capital Region of Denmark

Recent research conducted in Copenhagen looked at the cost-benefit of their proposed future cycle highway network.[56] They highlight that two fundamental changes can potentially shift the level of welfare benefits of bike infrastructure: 1) the recent popularity of e-bikes and 2) better bicycle infrastructure.[56] Their Cost-Benefit Analysis (CBA) included direct user benefits (e.g. travel time), external costs (e.g. congestion, health, safety), construction/maintenance costs, and effects on tax revenue.[56] They investigated the potential benefits of the proposed future network, including a significant expansion totalling 749km, and compared it to the current network of 162km.[56]

The CBA is conducted on the network in three development stages - each compared to the baseline of today's infrastructure - and found the bicycle infrastructure strongly beneficial in each stage.[56] The most beneficial scenario included e-bike share being compared to today and with health care costs complying with the most recent literature; this case showed an internal rate of return on investment of 23%.[56] The least beneficial scenario still saw a rate of return of 6% comparatively and assumed rising e-bikes and health benefits in line with previous valuation practices.[56] The single most important factor contributing to the calculated benefits were external health benefits, defined as societal benefits measured by the effect of healthier people who live and work longer, largely due to saved expenses of the health care system.[56] Additionally, the calculated rate of return on investments is very good when compared to other transportation infrastructure investments; public transportation and motorways return between 3 and 10%.[56]

The researchers conclude that when judging all effects combined with potential limitations, the proposed bike highway network expansion has a high probability of being beneficial to society.[56] It was also concluded that the internal rate of return is likely better than conventional projects for cars and public transportation.[56] The standout of health benefits being the single most important factor highlights that bike infrastructure investments should be tackled by local authorities as well as warrant additional interest from higher levels of government.[56]

Photo credit: Cycle Superhighways, Capital Region of Denmark

Cycle Highways Can Stimulate Tourism

Bicycle tourism is a broad term referring to a spectrum of cycling activities, where cycling is a fundamental component and primary mode of transport for a trip that is away from someone's home.[69] Generally, there is agreement in the literature, which considers a tourist, or bike tourist, to be away from their home for more than 24 hours.[70] Cycle tourism, as an emerging phenomenon, has been recognized and researched notably across Europe, along with countries such as New Zealand, Australia, and Taiwan. However, comparatively, North America has been slow to identify cycle tourism, allowing it to remain on the periphery, meaning a lack of investigation and leaving its economic potential largely unrealized.[71]

Realizing the Potential

The use of bicycles for leisure, recreation and tourism is undergoing a worldwide resurgence.[70,72] This phenomenon has been contributed to by its recreational value and perceived sustainability.[73] For some time now, this potential has been realized and capitalized on throughout much of Europe. Already in the late '90s, when cycle tourism accounted for 2-4% of holidays in Europe, projections were being made of growth to 9-12% by 2009.[74] For some time, cycle tourism has been integrated into development and transport policies, which has contributed to the development of regional, national, and pan-European routes.[75] An example of the large-scale and coordinated planning efforts is EuroVelo, a network of international cycle routes across Europe coordinated by the European Cyclists Federation.[76] Comprised of 17 long-distance routes, they see 5.3 million visitors annually with an average increase of 20% every year.[76]

Although bicycle tourism is relatively established in parts of Europe, it has been noted that North America has mostly lagged behind, being slow to identify and realize the potential cycle tourism has.[71] However, within the United States of America, recent interest has started to develop in the area cycle tourism, such as in Oregon[77], Arizona[78], and Wisconsin[79]. In addition, Taiwan has recently realized the potential of cycling tourism – one of the few nations in Asia doing so – and has dedicated resources toward developing cycle facilities and routes to boost its image as a cycle tourism destination.[73] The Taiwan Sports Affairs Council launched the project "the Planning and Establishment of Bikeway System in Taiwan" (NT$4 billion) to ensure people cycling would have access to a safe, comfortable, and fun bikeway network around Taiwan.[80] It has been highlighted that the provision of designated cycle routes, trails, and paths, is a widespread strategy to attract cycle tourists.[75,81,82]

Economic Benefits

Cycle tourism has been deemed an important and growing tourism market with the potential to provide a wide range of social, environmental, and economic benefits to a region[75]. However, much of the research has focused on the economic benefits to a region. A meta-analysis of bicycle tourism worldwide found that the average spend, per person, per day of overnight was £43.33, non-overnight £7.95, and all tourism and leisure cyclists £13.38.[81] The same meta-analysis also concluded that the ratio of residents to tourists was almost half-half (54:46), however, the economic return of cycle infrastructure was largely contributed by cycle tourists, who represented 77% of the value of local cycling provision.[81] The established economic return of investing in cycle infrastructure is contributed to by its perceived value with respect to cycle-associated tourism and the associated monetary spending of travellers.[28] The positive economic impacts of cycle tourism have garnered the attention of both local and regional policy makers, planners, and anyone else seeking to capitalize on further cycling provision in an area, along with those seeking to develop infrastructure for local and regional benefit.[81]

Examples from Abroad

The benefits of increased cycle tourism, often quantified economically, have been assessed in various regions around the world. Cycle tourism within Europe has been assessed to be worth €44 billion, contributing over 2.3 billion cycle tourism trips annually.[74] Within the UK alone, cycle tourism creates a total spend of £520 million and overnight trips are calculated to have an average spend of £46.75 per day.[65] A summary of the scale and value of bike tourism in different places is summarized in the table below (Table 7).

Country	Numbers	Value
France	-15% of domestic population	-Unknown
Fyn, Bornholm, Denmark	-9% of all foreign tourists -53,000 cycle tourists -477,000 bednights	-3.5% of total tourism turnover
United Kingdom	-2% of all leisure/day trips -1% of all holiday trips	-Leisure day trips (£293 million) -Domestic holidays (£180 million) -Overseas holidays (£60 million)
Ireland	-9% of all overseas tourists	-£538 per person
South Island, New Zealand	-1.6% of domestic holiday-makers -3% of overseas tourists	-$64 a day per person -$3021 per person per trip -$75 million to economy -1472 full time jobs

Table 7: The estimated scale and value of bike tourism in various countries, including France, Denmark, the United Kingdom, Ireland, and New Zealand[75]

As we geographically leave Europe, these findings are supported elsewhere, including New Zealand (Table 7). Research in New Zealand found that cycle tourists generated a lower daily spend when compared to the average of all international visitors ($64 versus $152). However, they had a higher total trip spend ($3,021 versus $2,776), largely due to longer stays.[83] Bicycle tourism on the South Island was associated with a direct expenditure of $76 million, a total economic output of 160 million and an estimated 1,472 jobs per annum.[83] At the time, this was considered comparable with the cruise ship market.[75] In the Wisconsin, USA, recreation and tourism contribute $924 million to the state's economy annually.[79] They note that more than $535 million is attributable to bicyclists from other states and highlight the potential there is by increasing non-resident cycling.[79] Comparatively, in North Carolina, a one-time investment of $6.7 million in infrastructure generates a nine-to-one return annually ($60 million).[84] It is highlighted that the demographics attracted by cycling are often affluent, further contributing to their ability to spend money.[84,85]

Canada and British Columbia: Current Levels and Potential

The demographics comprising cycle tourists have been investigated. A survey conducted in Montana, the United States, on touring cycling looked at the residency location of respondents; among international respondents, Canadians represented the largest group, followed by the Netherlands and the United Kingdom.[71] Research conducted in New Zealand found that Canadians were the 5th largest international group and comprised 5.9% of all cycle tourists; they follow behind Germany (22.7%), the UK (17%), the US (10%), and Holland (7.2%).[83] This suggests that Canadians represent a significant proportion of cycle tourists, especially when considering the distance from and population size of Canada.

The benefits of cycle tourism have been identified and capitalized upon in numerous regions. Within Canada, some measurable impacts of bike tourism have been found, although there is largely an absence of research into the topic. In Québec, cycle tourism has been investigated and has been gaining popularity since the 1990's - 10 % of the population can be considered a touring cyclist.[85] People cycling contribute notably to the economy, spending $166 million province-wide in 2000, supporting 2,800 jobs, and generating $17.2 million in tax revenue for Québec and $13.6 million nationally.[58] Quebec has also invested in developing a bike network, La Route Verte, of approximately 4345km to draw tourists and promote cycling. By 2000, with the route only partly finished, people cycling along it spent $95.4 million (along with 2,000 jobs and $15.1 million in tax revenue for Québec and $11.9 million for the Government of Canada).[58] In Québec, bicycle tourists spent $83 per day, more than other tourists' average of $66 (2005).[85]

Meanwhile, in Ontario, cycle tourists spend a total of $428 million and comprise 1.8% of total visitor spending.[86] Cycle tourism has also been included in Ontario's Cycling Strategy (2013)[87] and Cycling Tourism Plan (2017)[86]. Cycle tourists in Ontario are largely within-province residents (88%). However, the majority of money is spent by overseas visitors; overseas visitors comprise 3.4% of total visitors but contribute 21% of the total spending.[86] It is also highlighted that in Ontario, cycle tourists spend an average of $255 per trip compared to the average of all visitors being $171 per trip, facilitated by the fact that cycle tourists stay longer than regular visitors. [86]

In order to support the growth of cycle tourism in Ontario, building and maintaining infrastructure is key. In 2013 the goal of identifying a province-wide cycling network and linking it to prioritizing future highway investments was identified[87] - and in 2015, the Ministry of Transportation has agreed to invest $25 million over three years in order to help realize this. [86] Growth in cycle tourism is further supported by The Ontario Trails Action Plan, through the development of a provincial cycle tourism route, as well as Ontario's Tourism Action Plan, which notes making investments in response to the shifting needs of the provinces tourism sector and includes investment in cycle tourism.[88,89]

Within British Columbia, we also have the potential and opportunity to better develop our cycle infrastructure

better and cycle tourism industry. The Provincial Government shows interest in promoting cycle tourism[90]; however, there is a lack of direction and cohesive vision for the province. The BC Cycling Coalition urges improved infrastructure in order to facilitate cycle tourism, highlighting popular routes, to foster associated economic benefits.[91] Thus far, there has been some research on the benefits of mountain bike tourism in BC and has identified notable economic benefits.[92,93] For example, $38 million is realized from mountain bike tourism in the Sea-to-Sky corridor alone (2006).[93] However, in order to realize the full potential of cycle tourism, infrastructure investment is required. This would facilitate attracting a wider demographics of bike tourists. Within B.C., cycle tourism is largely under-researched and economic benefits are left largely unrealized.

Bike Tourism, Infrastructure, and Cycle Highways

The growth of bicycle tourism in areas has been linked to the construction of and investment in high-quality bicycle infrastructure[69,94,95] and cycle highways, originally built to attract commuters, have been shown to create additional benefits for recreation, sport, and tourism[28]. Bicycle tourism has been developing in large cities, as opposed to the suburbs and countryside, due to a greater infrastructure provision.[69] Route and trail development have been found to stimulate demand for cycle trips and holidays in some European countries, including the UK, France, and Denmark.[75] The most important factors determining the appeal of a bike tourism location are comfortable climate, segregated bicycle facilities, and road surface/pavement.[73] Poor infrastructure negatively impacts cycle tourism rates; it has been highlighted that cycle touring routes need to be safe, direct, comfortable, and cohesive.[69] Interestingly, the aforementioned characteristics largely mimic what is delivered by not just high-quality bike infrastructure but also cycle highways. This high standard of infrastructure and its link to bike tourism is shown directly by the infrastructure contained within the EuroVelo network (Figure 18), providing a network that is both used by cycle commuters and travellers alike across the continent.

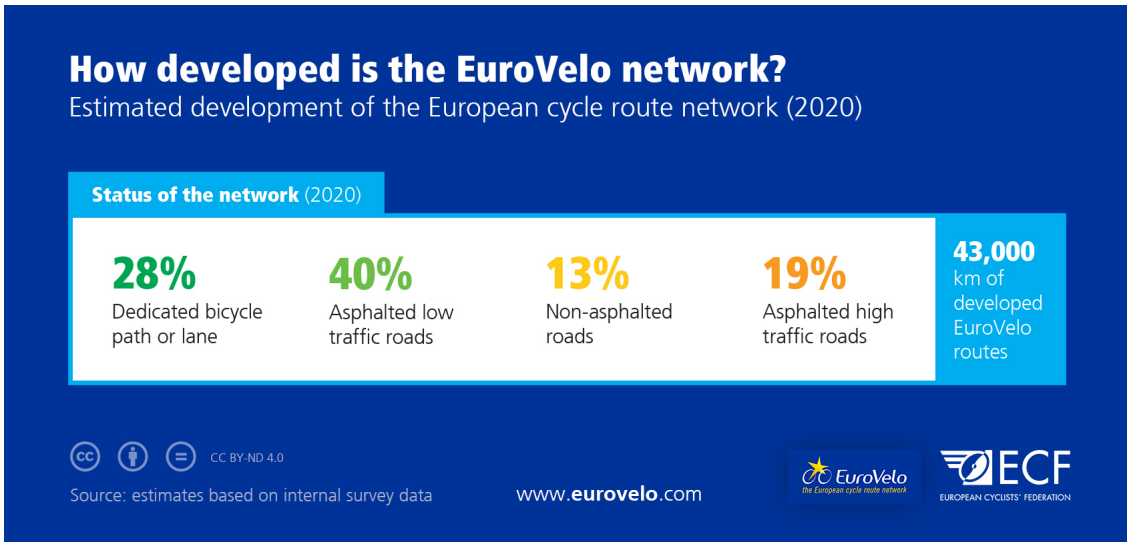


Figure 18: The estimated development of the EuroVelo network across Europe, including the percentages of routes within the 43,000km network that are on dedicated bicycle paths or lanes, asphalted low traffic roads, non-asphalted roads, and asphalted high traffic roads[76]

The overlap of the requirements to generate cycle tourism and create a functioning long-distance cycle network for commuters is advantageous and creates an interesting opportunity. However, as demonstrated by European nations, there needs to be integration in policy and planning, and government plays a notable role in the success of cycle tourism, ranging from infrastructure investment, policy, and awareness.[69] Research in Taiwan, where the potential of cycle tourism is being realized, notes the importance of a guiding framework to ensure there are clear bicycling policies, road safety regulations, and bicycle infrastructure plans and standards in infrastructure projects.[73] Due to the overlapping factors that contribute to developing cycle tourism and those provided by cycle highways and facilitating commuter cycling, it is suggested that they are taken together into consideration in order to develop both further.

The Growth of E-bikes and Micro Mobility: Added Value to Cycle Highways

Micro mobility generally refers to small and lightweight vehicles that operate at lower speeds than combustion engine vehicle traffic. Micro mobility includes non-motorized bikes, skateboards, and rollerblades, as well as electric bikes (e-bikes), and e-scooters, to name a few (Figure 19). For the following sections, e-versions of micro mobility will largely be considered, and e-bikes are considered to be pedal assist bikes that only supply an assist while the user is pedalling,

BICYCLE-STYLE E-BIKE

E-SCOOTER

The e-bike market is valued at $24 billion

Figure 19: Common styles of e-mobility, the bicycle-style e-bike, and the e-scooter [96]

E-bike and Micro-Mobility Trends: Worldwide and in Canada

E-bikes are quickly growing in popularity worldwide, shown by quickly increasing usage and sales. In 2017 the global electric bike market was estimated to be $16.34 billion[97] and was valued at $23.89 billion in 2020.[98] In China, sales rose from 300,000 in 2000 to 30 million in 2021[99]; in Holland, a 30% increase in sales was seen in 2015 alone[100] and in 2018, e-bike sales surpassed that of conventional bikes for the first time[101]. The automotive industry is also aware and aiming to capitalize on the market growth with GM releasing its first electric bike in 2018.[102] This global e-bike market growth has been attributed to government support along with shifts in consumer behaviour, driven by perceptions of eco-friendliness, being an efficient commuting solution, increasing fuel costs, and growing interest in cycling as a fitness and recreational activity.[97]

Within North America, the market is largely driven by Canadian and American (U.S.) demand and has been estimated to grow 11.01% annually between 2021 and 2028.103 Canada ranks 6th globally in the total value of electric bicycle imports (26.8 million USD) and has imported 2.7% of Taiwan's global e-bike exports in 2020 (Figure 20). This is very notable, especially when considering population size: when the total import value of Canada is compared to that of the U.S., ranking second globally, we see that Canadians import comparatively more e-bikes per capita than our neighbours (.71 and .66USD per capita, respectively). The Canadian market is largely fueled by demand from retired individuals and a growing interest in recreational activity, along with a favourable regulatory frameworks and infrastructure developments.[103]

The Richards Street Bikeway in Vancouver, B.C.
Photo credit: City of Vancouver

Value of electric bicycle exports from Taiwan in 2020, by importing country

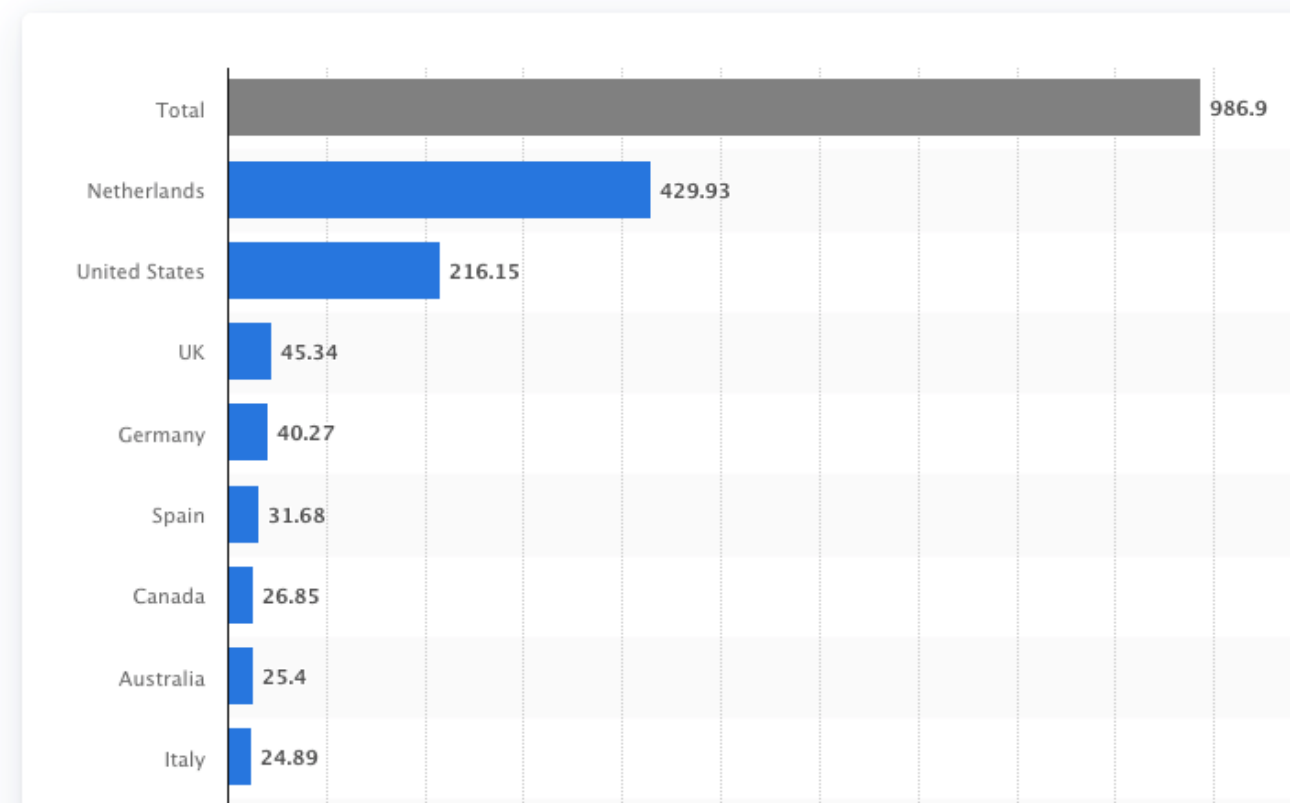


Figure 20: Value of electric bicycle exports from Taiwan in 2020, by importing country (in million USD) [104]

Secondary to e-bikes, more people are buying and using e-scooters worldwide. The e-scooter market is currently worth 20.9 billion USD (2020) and is forecasted to grow at a compounding rate annually over the next decade.[105,106] This contrasts the tepid growth between 2016 and 2020.[107] Drivers of the e-scooter market can be considered comparable to e-bikes: factors such as increasing climate change awareness, prices of petroleum products, environmental regulations, government incentive and subsidy programs, technological advancements in batteries, and e-scooter sharing services.[105,108] Many regions across Canada have seen a rapid uptake of micro mobility, including e-bikes and e-scooters.[96]

The growth of e-bikes and micro mobility is further contributed by the increasing number of share companies appearing globally, such as Lime, Jump and Bird, and operating in cities in Australia and New Zealand, South America, Asia, and throughout the U.S. and Europe. Revenue from global e-scooter share programs is projected to double over the next four years and e-bike share programs to increase by 50% (Figure 21).

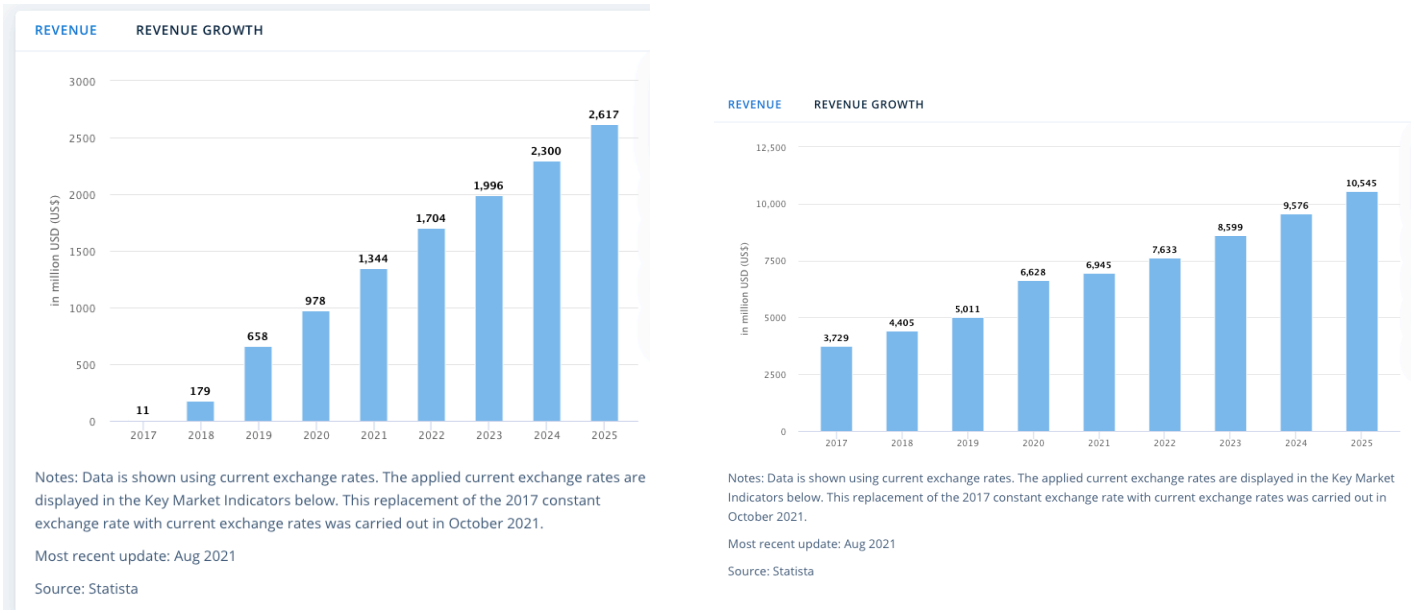


Figure 21: Global revenue from e-scooter share programs worldwide (left) and global revenue from e-bike share programs worldwide (right)[109]

Although Canada has lagged behind other parts of the world in adopting micro mobility sharing, largely due to legislation grey areas, things are changing: Alberta and Quebec are amending legislation and Ontario and British Columbia are in the process of doing the same.[110] Due to this, within Canada, we are seeing various pilot programs for both e-bike and e-scooter sharing, including Toronto, Edmonton, Victoria, Montreal, Waterloo, Calgary, and Kelowna. Calgary's two-year e-scooter pilot program was closely followed by a unanimous city vote for companies to continue operating.[111] Lime, a micro mobility company operating in 130 cities around the world, has stated that Calgary holds the highest number of rides per device globally and is leading the micro-mobility movement in Canada.[111] This shows Canadians shift towards the adoption of e-bikes and scooters in a relatively short time period and further supports growth within the micro mobility sector.

Growth of Micro Mobility in Metro Vancouver

In line with the aforementioned trends, e-bikes are growing in popularity within Metro Vancouver as well.[112] This is supported by the Provincial government, providing rebates for e-bikes to individuals ($750,000 over a two-year period), and conducting a pilot program for cargo e-bikes for businesses.[113] They are also growing in usage for business purposes, including Securiguard using e-bikes in their patrol.[114] Although the exact modal share within Vancouver is unknown, it is clear that it is growing - in 2016 it was reported that "Local e-bike firms are experiencing a sharp uptick in sales in the past two years, ranging from 100- to 500-per-cent growth."[115]

Although in the early stages, within Metro Vancouver, we see the potential of micro mobility supported by the implementation of e-mobility share pilot programs. A provincial-level initiative to assess e-mobility, namely e-scooters, as a safe mode of transport started on April 5th, 2021 and, within Metro Vancouver, includes: the City of North Vancouver, City of Richmond, City of Vancouver, District of North Vancouver, and District of West Vancouver, and, in the province, the City of Kelowna, City of Nanaimo, City of Vernon.[116]

North Vancouver saw Canada's first electric bike share program in 2013[114] and is currently is conducting a two-year e-bike share pilot program with Lime, closely joined by the City of West Vancouver, since July 26, 2021.[117] Since its launch, there has been an average of 200 trips per day (median 1.6km in length) totally over 25,000km (Figure 22).[118] Lime already operates in Calgary and Edmonton and runs pilot programs in Ottawa and Victoria. Most recently, Richmond has approved a contract for a pilot program with Lime.[119]

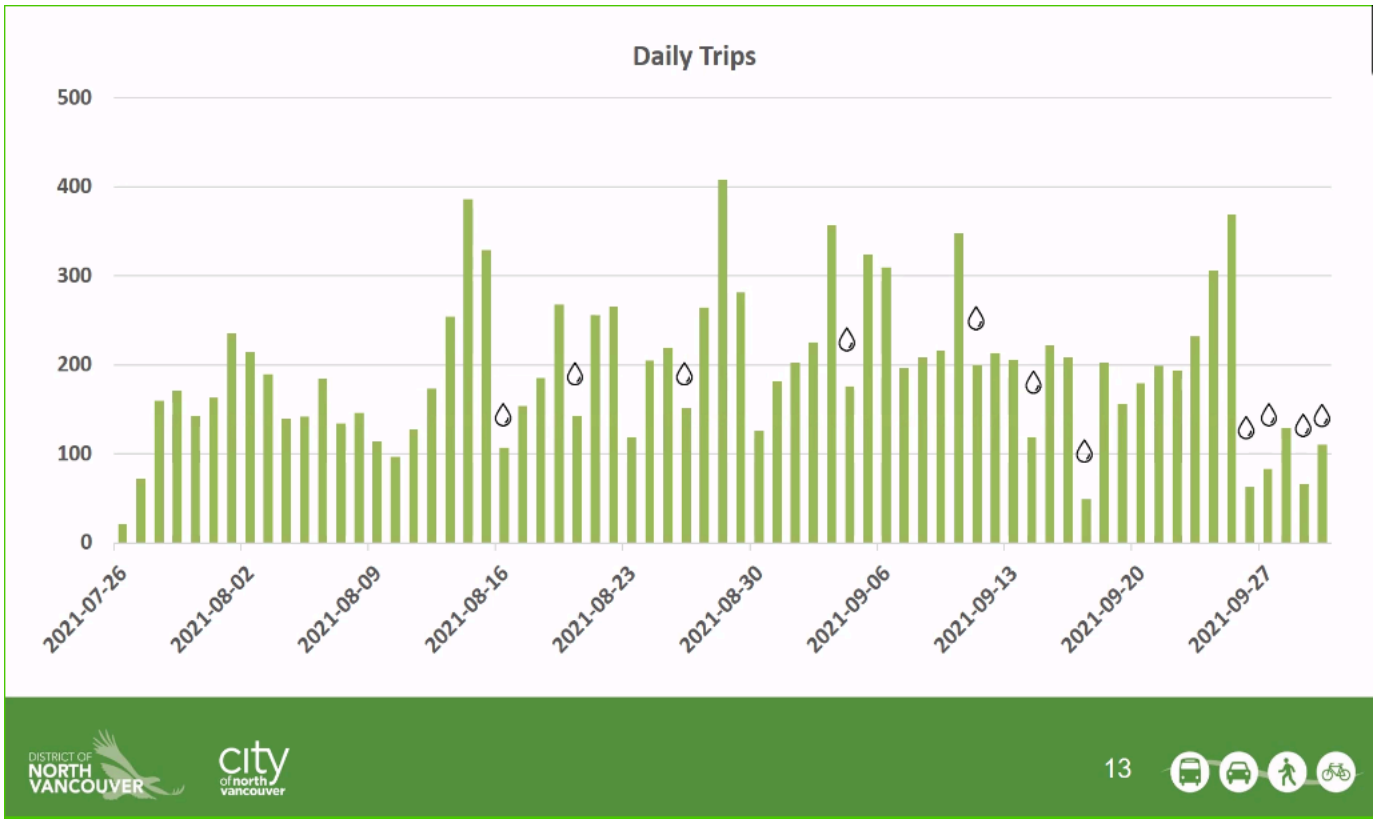


Figure 22: Daily ridership since the launch of Lime's e-bike pilot program on the North shore; raindrops denote rainy days[118]

Within Metro Vancouver, we see additional support for e-bikes in various jurisdictions through guidelines and regulations, including the City of Vancouver's Active Transportation Plan 2014 regarding electrical outlets in off-street bike parking, New Westminster outlining electrical out access in bike storage facilities, North Vancouver requiring charging facilities and bicycle storage in new developments, and West Vancouver planning to implement education and awareness for e-bikes.[114]

Micro Mobility Delivery Services and Cargo Bikes: Worldwide and in Metro Vancouver

Micro mobility is also being used at the business and corporate level in the form of cargo bikes; these versions of e-bikes are built to carry large amounts of cargo. Cargo bikes serve to increase the efficiency of deliveries within the urban space. The application of cargo bikes is especially relevant to 'last mile' delivery in areas with high population densities, as this portion of the supply chain often faces delays.[120] Cargo bikes have been shown to increase delivery efficiency, be cheaper to run, reduce traffic disturbance, along with reducing the environmental impact of deliveries within the urban environment.[121–124]

Around the world, cargo bikes have already changed urban logistics and show an enormous potential, namely the ability to optimize logistics in densely populated areas with dense delivery points.[124] This is in part a response to retail e-commerce having grown and projected to keep growing, both worldwide and in Canada, contributing to increasing numbers of deliveries.[125] Alongside, food delivery services have also been growing worldwide[126], and associated companies have already realized the benefits of employing bikes for delivery[124]. Within the US, companies like UPS, DHL, and FedEx have been using cargo bikes already for almost a decade.[124]

Various studies conducted have investigated the efficiency of cargo bikes and compared them to vehicle deliveries. A study conducted in England found that freight cycles performed better compared to vans within cities, making deliveries an average of 1.61 times faster.[124] Regarding economics, it was found that swapping a conventional delivery fleet for bicycles paid for itself after 15 months and was profitable with a high rate of return.[120] The cost of mobility (parcel/km) of cargo bikes has been found to be almost half that of vehicular delivery, and speed and delivery times improved by 69% in high traffic volumes.[127]

This comes along with a notable potential for environmental impact reduction within the delivery industry, as cargo bikes have a much smaller environmental impact than vehicles. For example, if cargo delivery were to replace 10% of van-km currently driven in London, 133.3million kg CO_2 would be saved.[124] In Europe, the potential shift to cargo bikes has been estimated to be 51% of all within city motorized freight trips.[122] When scaling up the current potential of cargo bikes, compounding with the estimated reduction in environmental effects, a reduction of environmental impacts of the delivery industry becomes large.

In Canada, we already see the appearance of cargo bikes. FedEx chose Toronto to pilot their cargo bikes and is looking to expand to other cities in Canada.[128] In addition, Montreal's cargo bike pilot, Colibri, makes more than 5,000 deliveries per day and is more profitable and efficient than trucks.[129] Deliveries per hour were found to be 30-40% more efficient than trucks in terms of deliveries per hour.[128]

Vancouver closely follows behind Toronto and Montreal, with a recent pledge to create an e-bike cargo delivery hub[129]; here we already see numerous companies including Eeco, Uber Eats, Door Dash, employing bikes, and Shift, employing cargo bikes for their deliveries. The provincial government also offers a rebate of $1,700 for businesses for the purchase of a cargo bike and can purchase up to 5 through the program.[113] The Vancouver-led, province-funded cargo delivery hub project will run for 14 months starting June 2021.[129] This pilot project will be followed by an evaluation in the spring of 2022, focusing on quantifying the productivity, cost, incidents, and greenhouse gas emissions reductions.[129] Rob Fleming (MoTI), referring to the intentions of the project, can be quoted as saying, "With COVID-19, there has been a surge in online shopping, same-day shipping and home delivery, increasing the number of delivery trucks on B.C.'s roads. This project will support efficient last-mile delivery that does not add congestion, noise or air pollution to Vancouver's busy downtown core".[129]

However, it has been highlighted that currently, there is a lack of adequate infrastructure, limiting the potential of cargo bikes; for example, cargo bikes require infrastructure that accommodates their width. In Vancouver, for example, 'All Ages and Abilities' routes meet these requirements. Mike Zipf highlights that Vancouver is taking width into account when

constructing their new bike routes to help accommodate the potential future usage of cargo bikes.[130] However, Sandra Allen, from Shift Delivery, also says that obstructions of bike lanes are common, happening on average twice per day and impeding the efficiency of cargo bikes to maneuver throughout the city.[130] In Copenhagen, we see the potential of cargo bikes being realized, occurring along with their developed network of cycle highways. It is clear that high quality, networked, and accommodating infrastructure is crucial to help realize the potential of e-bikes and needs to be given greater consideration in city and transport planning.[131]

Shift Delivery trike at HUB Cycling's 2018 Bike the Night event

E-Mobility Options Increase Micro Mobility Use

E-mobility options contribute to growing micro mobility usage, past conventional micro mobility levels, by making longer distances feasible and making micro mobility accessible to a greater portion of the population.

In the Netherlands, e-mobility makes travelling larger distances more accessible, and it has been found that e-bikes increase how often people ride.[132] Wim Bot, from the Dutch Cyclist's Union, highlights that e-bikes make reaching distances of 15km very reasonable; city transportation and planning models assume the reach of a conventional bike to be 7.5km; however, this is doubled to 15km for the e-bike.[133] As it so happens, conveniently Dutch cities tend to be 10-15, up to 20km apart and are the best distances to justify cycle highways.[133]

When looking at Vancouver, these distances are also extremely relevant. For example, the following locations are shown with distances as-the-crow-flies (ACF) and the shortest suggested vehicle routes as suggested by google maps (car):

- Richmond city centre (Brighouse) to downtown Vancouver Art Gallery (VAG) - 12.9km (ACF) – 15.2km (car)
- Downtown Vancouver (VAG) to Burnaby (Metrotown) – 10.2km (ACF) – 12km (car)
- Burnaby (Metrotown) to New West (Douglas college) – 7.4km (ACF) – 9.1km (car)

These distances show that the potential for e-mobility to address regional travel needs is high.

It is not just that it is easier to bike farther with the support of e-mobility, but it has been shown that users actually do travel farther distances when using them in the place of conventional bikes.[134–136] A recent study found that individuals who purchased an e-bike increased from 2.1 to 9.2km travelled by bike per day.[136]

E-mobility options also make micro mobility accessible to a larger segment of the population, whom otherwise may not employ more conventional micro mobility options (e.g. pedal-bike).[132] E-mobility helps overcome barriers to micro mobility by being less strenuous, going places more quickly (without being sweaty), carrying more cargo, and increasing perceptions of safety.[132] Notably, older individuals and those with physical limitations state that e-bikes allow them to ride if unable to ride a standard bike.[132] E-mobility has been shown to provide accessibility in Portland, where 74% of e-scooter users reported having not used the (conventional) bike share in place since 2016.

As e-mobility makes longer distances accessible and appeals to a greater segment of the population than the conventional bike, we see a modal shift from other forms of transportation.[132] **Previous research has shown that e-bikes can replace the conventional bike, bus, and even up to 76% of car trips.[134,135]** Additionally, car owners have been found to be more willing to use an e-bike than a conventional bike and public transport.[134] In Portland, the modal shift was most notably seen away from walking, single-occupancy vehicles, and ride-hailing; it is estimated that e-scooters replaced 301,856 vehicle miles during the 4-month pilot.[137] During the e-scooter pilot in Calgary, it was reported that 30% of riders had replaced a car trip with a scooter trip.[110]

E-Mobility and Cycle Highways

When looking at the trends and considering the context of Metro Vancouver, a few things seem quite clear: more people are buying into and using micro mobility options, along with both provincial and municipal level interest in these modes of transportation. The rapid emergence of micro mobility warrants their incorporation into our transportation network.[96]

WSP highlights that micro mobility addresses “some, if not all, of our shifting mobility needs” and can help close gaps in our current transportation networks.[96] Shifting transportation needs have been deemed the ‘missing middle’ and refer to trip types, technology options, network connection, and demographics currently forgotten when planning transportation.96 An example of a ‘missing middle’ is first-and-last-mile trips. By better including these transportation avenues via micro mobility, it is argued that many of these gaps could be filled.[96]

The availability of e-bikes, and generally micro mobility, friendly infrastructure is a key motivator affecting its adoption.[96] This includes separated and comfortable cycle lanes, maintained at a high quality, and that are accessible by broad demographics at a networked level.[96] When surveyed, people tend to support the use of e-bikes and e-scooters on bike lanes, contrasting less support for being ridden on roadways or sidewalks.[96,137] WSP urges that micro mobility is considered in the planning and functional design of all future cycling routes.[96]

Overall when we look at cycle highways and e-mobility together, we see a positively reinforcing effect. Firstly, increased availability of high-quality infrastructure, such as cycle highways, can increase micro mobility usage. A survey conducted in the Netherlands found that 20% of users bought an e-bike because of the Rijnwaalpad, one of the early cycle highways implemented in the country.[138] Secondly, increased availability of micro mobility and e-mobility options, in addition to conventional bikes, makes micro mobility more appealing and engages wider user demographics; this means cycle highways become accessible to more people. Sjors van Duren, working on cycle highways in the Netherlands, can be quoted as saying, “Even without the e-bike, the concept of the cycle superhighway can be a game-changer. But with the e-bike it makes it even stronger.”[138]

To dive deeper into the case for transportation equity see our companion report: Equity Analysis of Metro Vancouver's cycling network.

The Potential for Cycle Highways to Address Transportation Inequity

Equity in transportation means that the impacts, benefits and costs are considered fair and appropriate.[139] The impacts of transportation planning decisions can be both significant and diverse. These include effects on individuals' economic and social opportunities, external costs including congestion and collision risk, land value, local economic activities, including employment and economic development, and household expenditures.[139] In addition, high levels of public resources are also used, such as tax funding and road right-of-way's; these disproportionately favour some users over others.[139]

In terms of equity, "bicycles are the cheapest and most accessible form of mobility"[140]. However, oftentimes the supporting infrastructure for employing a bike as transport is poor or absent. Although the bike itself is seen as equitable, it cannot operate within the urban space in an equitable way without the infrastructure that supports equitable access. NACTO has highlighted that poor or absent bike infrastructure disproportionately impacts low-income communities and communities of colour. [141] In Vancouver, transportation inequality is displayed through certain demographics being over-represented as transit users compared to the general population[142] and certain minorities having less access to bike infrastructure when compared to the regional average[143].

It is being increasingly highlighted that there needs to be greater consideration of equity when we design our transportation infrastructure and systems.[96,141] Numerous studies have found that there is an inequitable distribution of transportation infrastructure around our urban areas. For example, less transportation infrastructure accessibility correlated with areas with poorer socio-economic indicators and minority populations.[143,144] As mobility has been tied with economic opportunity, health, and quality of life, inequitable transportation means an inequitable distribution of its consequences and, with shifting mobility needs, our most vulnerable populations need to be taken into greater consderation.[96,139]

It is becoming increasingly clear that equity considerations need to be made when designing our transportation infrastructure, and specifically bike infrastructure, if we want to realize an equitable mobility network. Other regions within Canada have already begun doing so. However, across Metro Vancouver, we currently lack an overarching equity analysis relevant to our cycling facilities and integrated within our planning decision. For this reason, we have decided to include an equity component in our GIS analysis.

Case Studies on the Early Developmental Process

Photo credit: Cycle Superhighways, Capital Region of Denmark

Case Studies on the Early Developmental Process

Explore each case study in more detail including early development, key stakeholders, funding and the route selection process in the Supplemental Background.

Photo credit: Cycle Superhighways, Capital Region of Denmark

The following section takes a look into the early developmental stages of cycle highways in Europe, including the Capital Region of Denmark, the Province of Gelderland, Netherlands, and London, England and trails/greenways in North America, Minneapolis, United States of America and in the Capital Regional District, Canada. Each case is concluded with takeaways, summarized at the end of this section.

Cycle Highways in Europe

Cycle Highways are becoming more and more commonplace in Europe, namely in the northwestern region. The following section outlines the development of three successful examples of cycle highways.

Capital Region of Denmark, Denmark

There exists an interesting agreement between municipalities in the Capital Region of Denmark: The Cycle Superhighways Collaboration. This was initiated by the Copenhagen Municipality in efforts to increase bike modal share and target longer commuter journeys by people cycling. Early work established a heat map of the region, highlighting important areas to connect. The Cycle Superhighway Collaboration now includes 30 municipalities with a shared vision of a 'cycle superhighway' network that covers the entire capital region.[145] Projects between municipalities have been quite successful and are largely attributed to an office in Copenhagen working full time on the project, without which the project would not have continued and ended up as successful.[146]

Early cycle highway routes saw huge increases in the number of people cycling – at least 60%. A number of the newcomers used to drive – as high as 28% on one route. The average trip link was at least 7.5km.

Copenhagen was the city in the region that motivated and initiated movement toward improving cycle infrastructure in the region. Around 2005, Copenhagen

set an ambitious goal of increasing the modal share of bikes to 50% for trips to work and educational institutions.[146] They set the early groundwork to get the Cycle Superhighways Collaboration started.

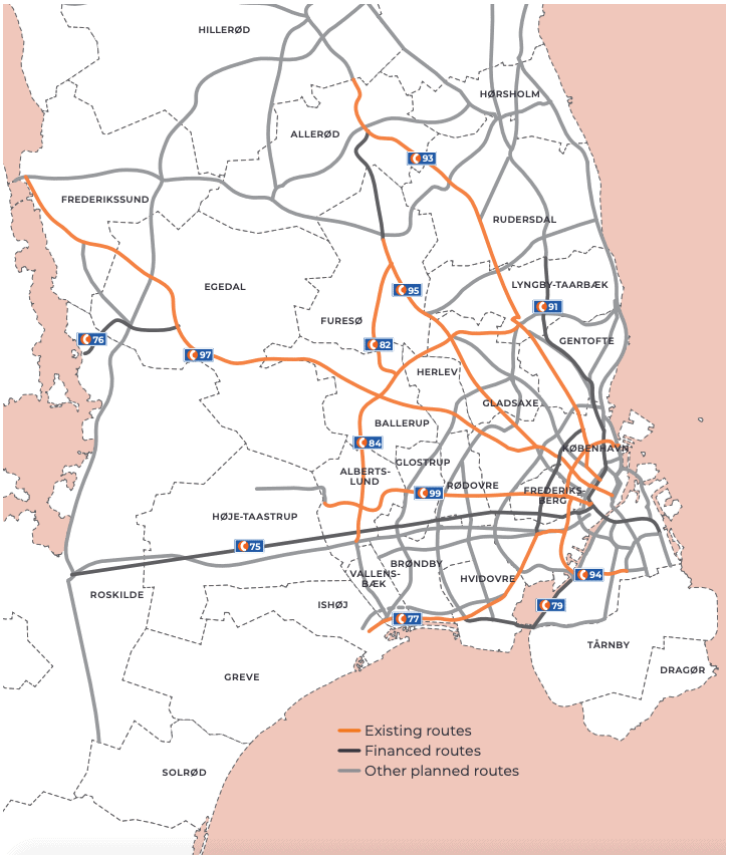
Initially, 16 municipal regions joined together to create the Cycle Superhighway Collaboration in 2011. This has now grown to 30 member municipalities. The Collaboration includes a steering group, project group, operations group, and the Office of Cycle Superhighways.

The Capital Regional of Denmark and the State (Federal) Government are both involved in that they provide significant funding for the Office of Cycle Superhighways and related on the ground infrastructure projects.

After the 16 municipalities initially came together in 2009, the Capital Region granted €54,000 towards the project, and the state committed €134 million for the development of cycling infrastructure.[147] By 2010, the Capital Region had committed an annual €400,000 to the development of the Cycle Superhighway Collaboration, formed in 2011.[147] The Cycle Superhighways Collaboration is in total funded 70% by the Capital Region and the remaining 30% is split by the municipalities.[148]

Municipalities can apply for funding for about half of the project costs. Initial route planning for the region was done by the City of Copenhagen using a heat map to depict activities within 2km (residences, workplaces, education). Route planning is done by public sector organizations using trip diaries, traffic flows, satellite images and assessment rides. A number of routes focus on expanding and improving pre-existing routes and upgrading them into cycle highways.

The Cycle Superhighways Collaboration together have now developed and planned a network of 26 routes to connect suburban areas to the city (Figure 25). The planned total distance of the network aims to reach 746km by 2045 (Figure 25).



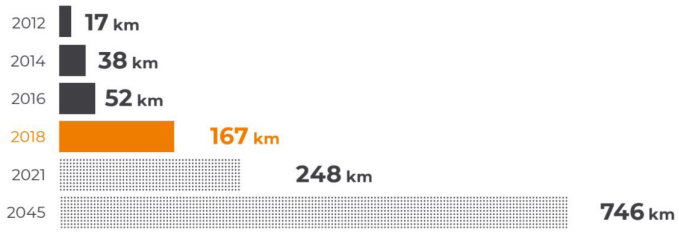


Figure 25: The 26 routes, existing (orange), financed (black), and planned routes (grey), in the cycle superhighways network in the Capital Region (left)[149]; the planned increase in total distance of the cycle superhighways network in the Capital Region until 2045[145]

Benefits

Wider benefits of the cycle superhighways have been estimated and include [150]:

- Social benefits: Every year, 720,000 fewer car journeys and 55,000 fewer hours spent in traffic. Cycling as transportation is a time-efficient way to exercise.
- Health benefits: An additional 6 million cycle journeys annually. Approximately 40,000 fewer sick days per year, significant public cost savings, and extra tax revenue.
- Economic benefits: Vehicle congestion is reduced. Deliver $860 million surplus.
- Environmental benefits: 45 routes will lead to an annual reduction of 1,500 tons of CO2 emissions and avoid 2,500kg of NOx per year.

Case Takeaways

1. Propose a network across the region with clear motivations and research backing
2. Create a central body to facilitate cooperation between municipalities
3. Look for political and financial support from the regional and national governments
4. Make clear what upgrades are required to transform a current cycle route into a cycle highway

Gelderland, Netherlands

Considering the history of cycling in the Netherlands, the concept of snelfietsroutes (directly translated to fast bike routes) is quite new. The idea only really began to gain traction in 2006, when it was posed as a means of combatting traffic jams.[151] The association of cycle highways with traffic reduction meant that there were significant monetary contributions made from higher levels of government towards their development.[152]

The province of Gelderland, containing 20 different municipalities, has taken a leading role and is considered to be the best model in the country when it comes to the development of cycle highways.[133] It must be noted, however, that fast bike routes are cropping up all over the Netherlands due to their presence on the national agenda; Gelderland is one of the six regions taking the first steps towards developing 675km of snelfietsroutes across the country.[153] That being said, the province of Gelderland is known to apply 'big picture' thinking, and levels of funding, planning, and cooperation that is not usually seen on cycling projects in the Netherlands.[138] Currently, Gelderland, is in the process of developing a network of 12 snelfietsroutes and is investigating and making plans for seven more.[154]

The first route constructed in Gelderland, the Rijnwaalpad between Arnhem and Nijmegen, can be considered the best example of a cycle highway in the Netherlands. It contains fewer compromises that decrease route quality than those found in other regions.[133]

Rijnwallpad: Facts and figures:

- People cycling ride 16km in under 45 minutes, without having to stop once[138]
- The busiest section of the route sees more than 6,000 people cycling per day[138]
- One-third of users are new to cycling[138]
- 20% of users bought an e-bike because of the Rijnwaalpad[138]
- The project has received international plaudits as a model to be replicated elsewhere[138]

Development of the cycle highways (or fast routes) was a collaborative effort. Parties included the central government, province, regional authorities, adjacent municipalities, special interest groups, and collaboration on bridges and tunnels from rail groups and higher levels of government.[155]

The Dutch Cyclists' Union was initially a project leader, helping with collaborative talks. Using a government grant, the Union researched cycle highways as a way to combat congestions. They started a campaign considering five routes that often had traffic jams.[151]

Route planning for new cycle highways is a collaboration between local governments and the Cyclists' Union considering the origin and destination of vehicle trips, workplaces and future development.[133] The theme of congestion alleviation has played a significant role in funding and planning for cycle highway routes.

Regions considered for cycle highways have high population centres. Many of the cycle highways were upgraded from existing bike routes.[156]

Case Takeaways

1. Develop a vision of usefulness and necessity and put route(s), with research backing, on a map
2. Set up a working group with municipal and regional representatives and fill a leadership position
3. Get on the national agenda to acquire funding from higher levels of government[133]; use modelling to secure financial partners
4. Focus on upgrading pre-existing bike routes into cycle highways

London, England

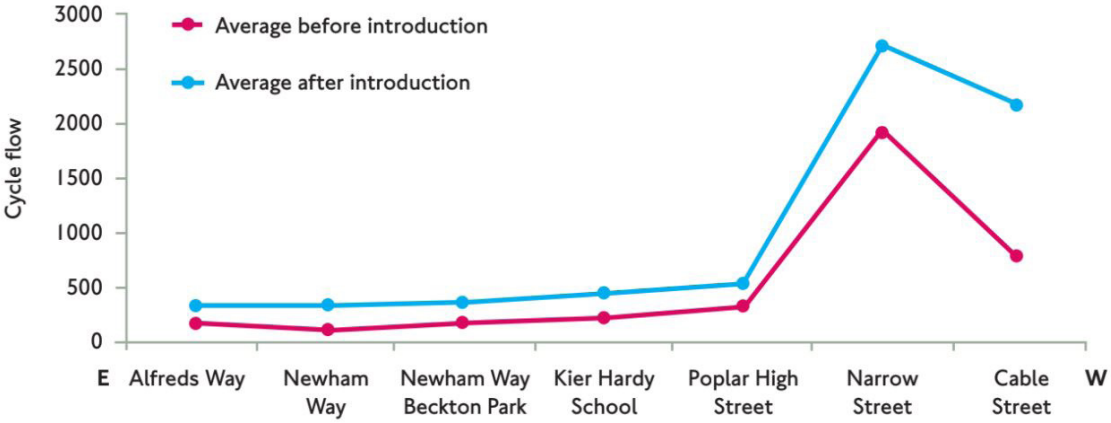
The first cycle highways in London included 12 cycle routes, named 'Barclays Cycle Superhighways,' radially extending from inner London.[157] They aimed to make it safer and easier to commute by providing continuous and direct cycle routes.[157] These routes were proposed by Mayor Ken Livingstone, partially funded by Barclays Bank, and introduced under Boris Johnson. These early stages of Cycle Superhighways in London were considered the 'era of blue paint' and focussed on improving readability and low-cost carriageway solutions.[158] It has been noted that the cycle highway projects in London differ from that of the Netherlands and Belgium, which have capitalized on cycling traditions and existing infrastructure, and largely pass through rural areas. In London, the challenge is how to retrofit the urban space that was not originally planned for bicycles.[158]

The first cycle superhighways - pilot routes – aimed to show how cycling could be just as good or even better than the tube. This original set of cycle routes kicked off 'London's Cycle Revolution' and developed largely under Boris Johnson's government. Transport for London has made notable contributions towards the cycle highway projects, including monetarily and through facilitating discussion between different stakeholders and governments.[159] Now, current design standards make the routes look somewhat dated: between 2012 and 2015, the 2nd generation of cycle superhighways began and was designed to be physically separated from traffic, requiring complete street redesign.[158] As Transport for London has jurisdiction only over major arterial roads, London's cycle superhighway infrastructure is built on heavy traffic corridors.[28]

The pilot routes, CS3 and CS7, opened in London in 2010:

Facts and Figures:

- 84% of CS3 users felt safe during their journey[62]
- Since the introduction of the CS3, cycling has increased by 83% and on the CS7, by 46% (Figure 26)[160]
- Found notable increases in people cycling along CS3 and CS7 and consistent with other routes (Figure 27)



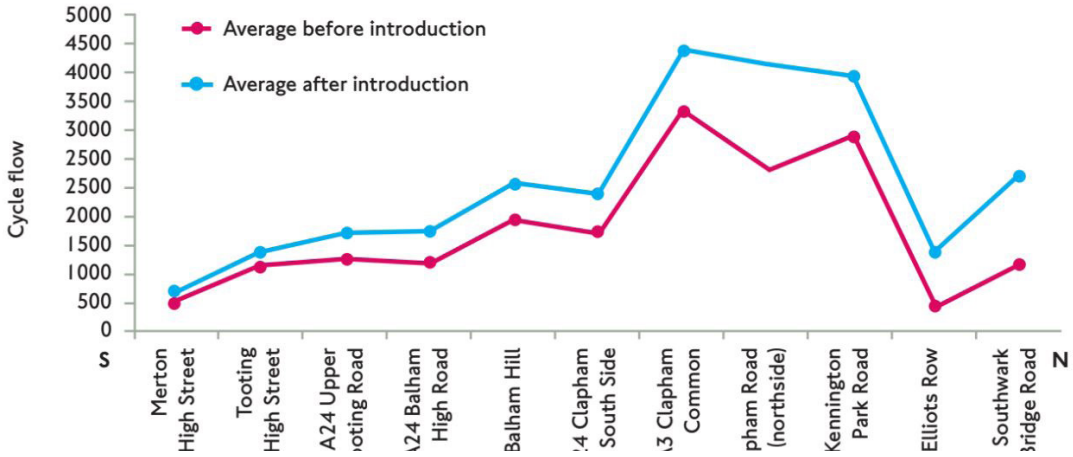


Figure 26: Average two-way cycle counts (7:00-19:00) on the CS3 (above) and CS7 (left) before and after the introduction of cycle superhighways[160]

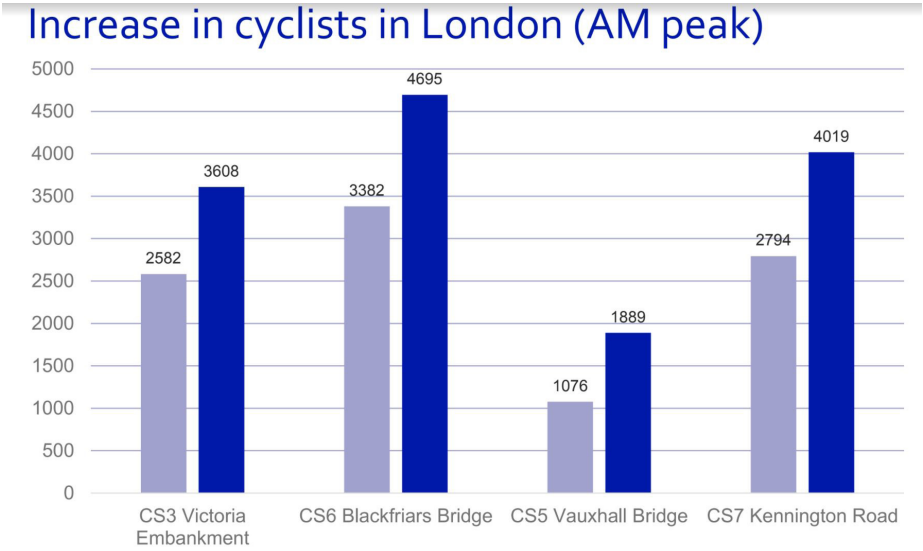


Figure 27: Increase in people cycling travelling at the AM peak hour along four different cycle highways, including the first two constructed (CS3 and CS7)[161]

Plans for 'cycle highways' in London were first announced by Mayor Ken Livingstone in 2008.[162] He set the target of a 400% increase in cycling by 2025 and proposed £400 million for the construction of 12 'cycle superhighways.'[163]

A number of groups were involved in the development of cycle highways. London mayors Livingstone and Johnson provided political leadership[164], Transport for London led the coordination, implementation and engagement[159], and Barclays Bank provided partial funding.[165] The London Cycling Campaign, a charity that pushes for improved cycling conditions, supported the routes and provides feedback.[166] Another cycling charity, Sustrans, is involved with the National Cycling Network and provides guidelines and suggestions on cycling infrastructure and design.[167]

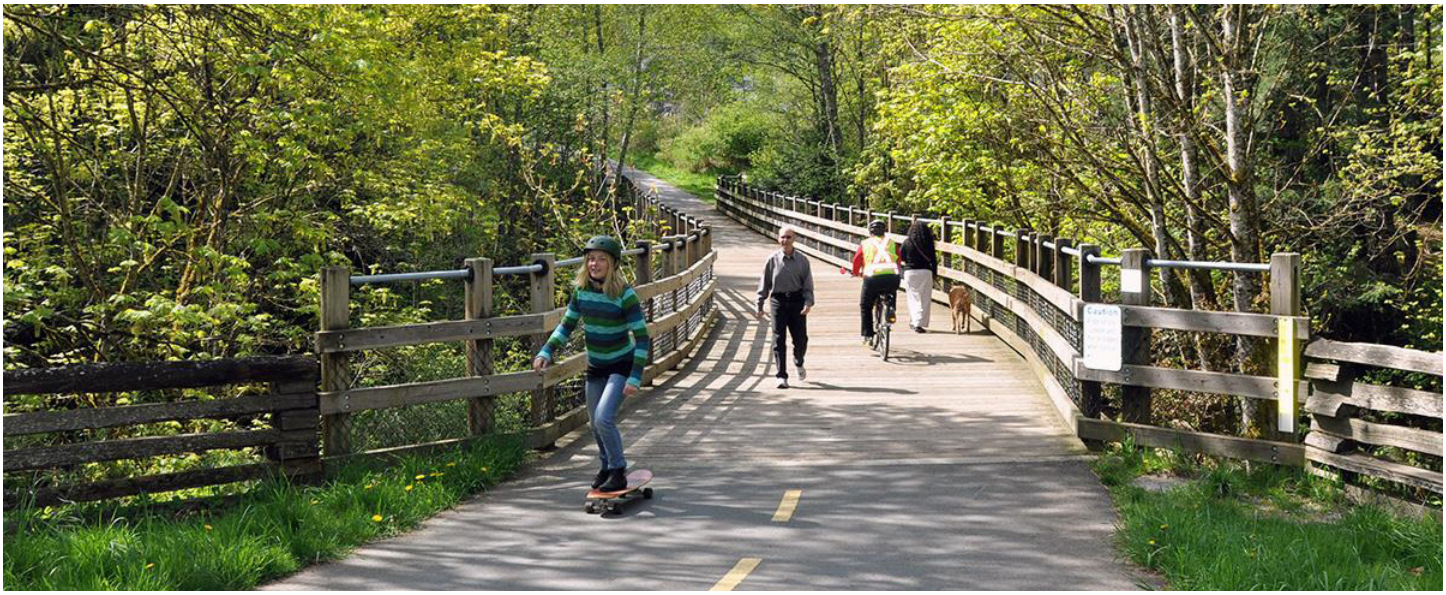
The first cycle highways were comparatively low cost and involved minor street changes to better accommodate people cycling.[161] Social media pressure from supporters of the early routes helped bring cycle highways more attention through the mainstream media.

Funding for the routes largely came from government grants and Transport for London.[168] Boroughs and businesses along the route were provided additional funding for bike parking, cycle training and maintenance sessions.[169] Barclays Bank provided £25m over 5-years.[165] This kind of funding - brand urbanism, is a relatively new strategy and can be both a win for governments to create ambitious projects and an opportunity for the brand to show its involvement and responsibility to a city.[170]

The 12 original radial routes expanding out from central London were selected to provide geographical coverage, upgrade existing routes, and with future commuter potential.[157]

Case Takeaways

1. Use evidence-led analysis to map out routes/the network (Strategic Cycling Analysis[171])[168]
2. Have a neutral and invested authority identify and engage stakeholders and create a platform for discussion and collaboration; develop shared frameworks and agreements
3. Get creative with sources of funding
4. Capitalize on pre-existing infrastructure and what routes people are already cycling along
5. Use high profile events to gain momentum (see supplemental background for more details)



The Galloping Goose Trail in Victoria, B.C., Canada
Photo credit: Capital Regional District

Greenways and Trails in North America

Within North America, there are no constructed bike infrastructures that have taken the name of 'cycle highway.' The examples coming closest to a 'cycle highway,' or rather possessing a greater number of commonalities to how cycle highways have been defined, are often named 'greenways' and 'trails.' An important distinction is that 'greenways/trails' are often multi-use routes considering a variety of users. For example, The Capital Regional District Trails in British Columbia make sure to adequately consider and address the needs of people cycling, pedestrians, skateboarders, inline-skaters, mobility-challenged individuals, etc.[172] In comparison, 'cycle highways' prioritize the needs of people cycling.

Minneapolis, United States of America

The Midtown Greenway was developed out of an old grade-separated rail line running through the city. A rail-to-trail conversion came about when the potential value of an active transportation corridor was realized for the route. What began as a group of volunteers developed into the Midtown Greenway Coalition. This happened alongside the route being purchased by the Hennepin County Regional Railroad Authority for its potential use as a transit corridor. A group dedicated to focussing on collaboration between various stakeholders was also developed: the Midtown Community Works Partnership. The development of a collective vision of the Midtown Greenway included numerous related projects and benefits such as housing, placemaking, and the revitalization of proximal areas, which contributed to its success.[173,174]

The Midtown Greenway is the heaviest used bikeway in the state and includes separated spaces for both bikes and pedestrians.

Facts and figures:

- Hosts up to 5,460 people cycling daily[175]
- Bike traffic on the Greenway increased 261% between 2003 and 2011[176]
- The City of Minneapolis experienced a 76 percent increase in cycling between 2007 and 2013[175]
- The Greenway is plowed in the winter, lit at night, and open 24/7

Benefits

- Has sparked numerous projects along the greenway, which include residential, office, retail, hotel space, along with bike storage and repair facilites[175]
- Increased property value (up 90%) along trail corridors[175]
- "The Midtown Greenway has helped spark more than $750 million worth of new housing developments along its edges. It has truly helped to revitalize south Minneapolis, as well as helping to spark the biking renaissance in Minneapolis." – Soren Jensen, Greenway Coalition Executive Director[175]
- There was a 36% reduction in bicycle crashes after the Midtown greenway opened[177]

Case Takeaways

1. Create a shared vision for the project to act as a guide for decisions, policy, and construction
2. Create a dedicated group willing to work hard to get people on board with the vision and collaboration with representatives of various interest groups
3. Engage politicians, the community, corporate and powerful people, and minorities; collaborate with the transportation authority and apply for national-level funding
4. Seize the opportunity and realize the potential of converting abandoned rail infrastructure

Capital Regional District, Canada

The first long-distance multi-use trails accommodating cycling in Capital Regional District (CRD) were the Galloping Goose and Lochside Regional Trails. Both are considered 'rail to trail' conversions, as they make use of the old rail right of ways from the Canadian Northern Pacific Railway routes as they pass through the region. These trails are considered the backbone of a 475km CRD cycling network.[178] They have come about from strong advocacy from individuals, various councillors, and groups including the Provincial Capital Commission. They all helped garner support, decided on trail developments and projects via meetings, and agreed that the CRD has the rights to manage and operate the land the trails reside on.

The Galloping Goose and Lochside Trails are popular, and a high proportion of the region's daily bike trips travel on these paths.[178] The Galloping Goose and Lochside Trails are also partly responsible for Victoria's comparatively high bike mode share of 6.6% (work trips) in Canada.[178,179] The Galloping Goose provides a direct link between the urban core and the fast-growing suburbs to the west,[178] while the Lochside Trail provides a direct link between the urban core and the ferry terminal to the mainland. Victoria's mode share of 6.6% is four times the Canadian average for metropolitan areas (1.6%) and almost triple that of the next highest metropolitan area, Ottawa - Gatineau, with a 2.4% mode share.[179]

The Galloping Goose opened in 1987, and Lochside Regional Trail opened in 2001:

Facts and figures:

- Popular for commuting and recreation
- Runs along a former railway line
- The Lochside and Galloping Goose average 3.8 million visits per year, according to the CRD (2021)[180]

"Victoria is becoming a greenway capital. It is impossible to underestimate the economic and lifestyle benefits of having a continuous greenway linking the Western Communities with Victoria and the Saanich Peninsula."

- Andrew Petter, Provincial Minister

Case Takeaways

1. Work on multiple smaller projects within the greater project, incrementally building, garnering support, and acquiring funding as you go.[181]
2. Connect invested individuals at the political level to work together and push the vision[181]
3. Work on developing personal relationships, creating piecewise connections, within the city, regional, and provincial levels for support across the political landscape; political signals and '50c' dollars get the attention of municipalities[181]
4. It is an advantage to convert a pre-existing corridor; focus on establishing continuity

Photo credit: Cycle Superhighways, Capital Region of Denmark

Summary of Cases and Recommendations

The learnings from the five cases: Capital Region, Denmark (DK), Gelderland, the Netherlands (NL), London, United Kingdom (GB), Minneapolis, the United States of America (US) and the Capital Regional District, Canada (CA) outlined in the previous section are summarized here. Takeaways from each case, listed at the end of the respective case, have been compiled together and grouped into four main overarching themes: project vision and network plan, cooperation and collaboration, political and economic support, and infrastructure development. This is followed by an interesting note on hosting a notable bike event, the Tour de France, in relation to its impact on cycle highway progress. Within each topic, with reference to what was learned from the case studies, conclusions are drawn in an effort to provide guidance and help Metro Vancouver prioritize the next steps towards the realization of cycle highways in the region.

Project Vision and Network Plan

DK Propose a network across the region with clear motivations and research backing
NL Develop a vision of usefulness and necessity and put route(s), with research backing, on a map
GB Use evidence-led analysis to map out routes/the network
US Create a shared vision for the project to act as a guide for decisions, policy, and construction
CA Work on multiple smaller projects within the greater project, incrementally building, garnering support, and acquiring funding as you go.

Consistent in the cases investigated is the development of a vision and goal of the project, and the European cases showed consistency in the developing routes/network plans that we backed with research. Although the visions and goals of projects varied, they were important in garnering support and ensuring the project received widespread backing. Generally, cycle highway projects in Denmark, the Netherlands, and London focus on people cycling for commuting. In Denmark, a goal of creating a higher bike modal share in transportation and reducing car traffic motivated the development of long-distance routes connecting Copenhagen with the suburbs.[146] Research is conducted by universities, such as to acquire trip data and estimate traffic flows.[146] This was echoed in the Netherlands, where cycle highways were not

taken seriously until they were backed by the national government with an objective to reduce highway congestion.[182] In Minneapolis, it was highlighted that creating a shared vision was important for the development of their Greenway, as this meant there was something to guide decisions, policy, and construction. Comparatively, in Victoria, even though a vision for the project existed since 1988, the project was broken into multiple smaller projects, incrementally building towards the vision. This meant that support was garnered, and additional funding was acquired as they progressed, as opposed to being laid out from the start.

Having a clear network or route proposal with research and numbers to back it up makes a strong case for why it should be contracted and can be useful to convince stakeholders to get involved. Before any collaborations occurred, the city of Copenhagen contracted out a project to develop a network of cycle highways largely based on a heat map of activity nodes across the Capital Region of Denmark. In the Netherlands, after the proposal of a network, it is assessed on how it impacts congestion, potential ridership is calculated, and a cost-benefit analysis is conducted.[138,183] Many considerations are taken into account to inform where the route is constructed and how the network interlinks across London, and their new cycle highways take a rigorous data-informed and evidence-led approach when planning their routes (see Strategic Cycling Analysis[171]). This contrasts with the implementation of the first generation of cycle highways, however, which were largely pushed through due to political steer from both Mayor Johnson and Livingstone.[168] Neither Minneapolis nor Victoria had a notable route or network planning component as they were rails-to-trails conversions bound by the pre-existing infrastructure lines.

To propose a credible project and garner support, it is proposed to:

- Create a Shared Vision to Guide the Project
- Conduct an Evidence-Led Analysis to Inform the Design of a Network

Cooperation and Collaboration

DK Create a central body to facilitate cooperation between municipalities
NL Set up a working group with municipal and regional representatives and fill a leadership position
GB Have a neutral and invested authority identify and engage stakeholders and create a platform for discussion and collaboration; develop shared frameworks and agreements
US Create a dedicated group willing to work hard to get people on board with the vision and a collaboration with representatives of various interest groups.
CA Connect invested individuals at the political level to work together and push the vision

Regarding cooperation and collaboration, we see two themes within the cases investigated: 1) the establishment of a central group to engage and host discussions between various stakeholders and 2) the connection between passionate and invested individuals, which grows momentum for the project. Copenhagen is an excellent example of this and where the Cycle Superhighways Collaboration was established. It was started by the Copenhagen Municipality, who realized routes transcending municipal boundaries would need to be collaborated upon. Now it is comprised of 30 municipalities, which convene on the continued development of cycle highway networks across the region. In Gelderland, the Netherlands, Fietsersbond acted as a project leader and coordinated collaboration talks. Wim Bot highlights that setting up a working group with municipal and regional representatives was of utmost importance.[133] In London, TfL identifies and engages with stakeholders. As they are considered to create a neutral ground for discussion, as well as being invested in the development of transportation in the region, cities are quite receptive and open to conversations with them.[159] In Minneapolis, the comparative group was the Midtown Community Works Partnership, a public-private partnership that included executives of

corporations, non-profits, the Mayor, elected officials, and council members and helped unify policy and guide development.[173]

The presence of a dedicated group is also a recurring theme in the cycle highways projects. In the Netherlands, this takes the form of Fietsersbond, who lobby the government for better cycling infrastructure and now receive national funding for the investigation and development of cycle highways. In Minneapolis, a group was created around the greenway project by a few individuals invested in the idea. Tim Springer highlights that this group, the Midtown Greenway Coalition, was key in the realization of the project.[184]

In the Capital Regional District, a passionate group of individuals was positioned throughout government and made connections with other invested individuals and working together, pushed the vision at the political level.

To grow momentum for the project and foster cooperation and collaboration, it is proposed to:

- Connect with Interested and Invested Individuals
- Establish a Cycle Highways Focussed Group to Engage and Host Discussions Between Stakeholders

Political and Economic Support

DK Look for political and financial support from the regional and national governments
NL Get on the national agenda to acquire funding from higher levels of government; use modelling to secure financial partners
GB Get creative with sources of funding
US Engage politicians, the community, corporate and powerful people, and minorities; collaborate with the transportation authority and apply for national-level funding
CA Work on developing personal relationships, creating piecewise connections, within the city, regional, and provincial level for support across the political landscape; political signals and '50c' dollars get the attention of municipalities

Cycle highway projects are often on local roads and considered within the jurisdiction of municipalities; however, projects often address regional issues, such as air pollution and traffic congestion. This can complicate funding. However, getting multiple levels of government on board with the project can lead to funding opportunities. In Denmark, in the early stages of the municipal partnership, the Capital Region granted €54,000 towards the project and two years following, they committed to providing €400,000 annually to the Cycle Superhighways Collaboration. In total, the Collaboration is funded 70% by the Capital Region and the remaining 30% by the municipalities.[148] In the Netherlands, getting on the national agenda and project visibility led to funding for cycle highways; the national right-wing pro-car party supports cycle highway developments.[133] Modelling the benefits of cycle highways has also contributed to securing support from financial partners.[138]

However, to date funding has been incidental and long-term funding is required to ensure security in planning, contrasting how funding is allocated in Denmark.

In London, the first generation of cycle highways capitalized on a novel funding source: Barclays Bank. Brand urbanism, asking large corporations to make notable investments towards developing urban shared spaces, can be a strategic way to acquire additional funding. Comparatively, in Minneapolis, various individuals were engaged, including political individuals and corporate and powerful people, to gain support. Similar to the Danish and Dutch cases; however, much of the funding for the Greenway came from various levels of government.[185] The trails in the Capital Regional District gained much of their support across the political landscape through a personal relationship between interested politicians. Upper levels of government displaying project support subsequently motivated local governments to invest in them. Local action was also catalyzed by higher levels of government offering to fund approximately 50% of the project's cost, making it more feasible for local governments to budget it into their finances.

To contribute to making projects feasible at the municipal scale, it is proposed to:

- Secure Funding from Higher Levels of Government

Infrastructure Development

DK Make clear what upgrades are required to transform a current cycle route into a cycle highway
NL Focus on upgrading pre-existing bike routes into cycle highways
GB Capitalize on pre-existing infrastructure and what routes people are already cycling along
US Seize the opportunity and realize the potential of converting abandoned rail infrastructure
CA It is an advantage to convert a pre-existing corridor; focus on establishing continuity

In both the cycle highways developments in Europe and the Greenways in North America, we see previously existing infrastructure being capitalized on and upgraded. This means that projects do not have to be realized from scratch, requiring less planning, cutting down costs, and capitalizing on pre-existing cycling. In Denmark, before the concept of cycle highways became commonplace, there already existed a culture of biking and some internationally recognized bike infrastructure designs. In Denmark, it is made clear what upgrades are required in order to make a cycling route into a cycle highway.[146] To do this, the Office of Cycle Superhighways provides an excel spreadsheet and data collection instructions to municipalities; they are clearly shown whether the route meets the base standard of a cycle highway and, if not, what areas need improvement.[146] A process of upgrading pre-existing bike routes to a cycle highway is also done in the Netherlands and London.

Comparatively, in North America, both the Greenway in Minneapolis and the Trails in the Capital Regional District were rails-to-trails conversions. In Minneapolis, this was an abandoned grade-separated rail corridor running through the centre of the city and already had numerous advantages, such as grade separation, proximity to activity nodes, a recreation facility, and the ability to be a good transportation corridor. This was similarly done in Victoria, but the old train corridors, residing largely outside of the urban cores, were seen to have recreation potential largely. Much of the work done on these trails, due to changes in land rights and ownership which occurred in a piecewise fashion, was directed at establishing continuity.

In order to make investments the most effective per dollar spent, it is proposed to:

- Capitalize on Upgrading Pre-Existing (Bike) Infrastructure

Photo credit: Cycle Superhighways, Capital Region of Denmark

An International Bike Event: The Tour de France

The Tour de France was hosted by London (UK) in 2007 and Utrecht (Netherlands) in 2015, which has left lasting impacts on cycling in both regions.

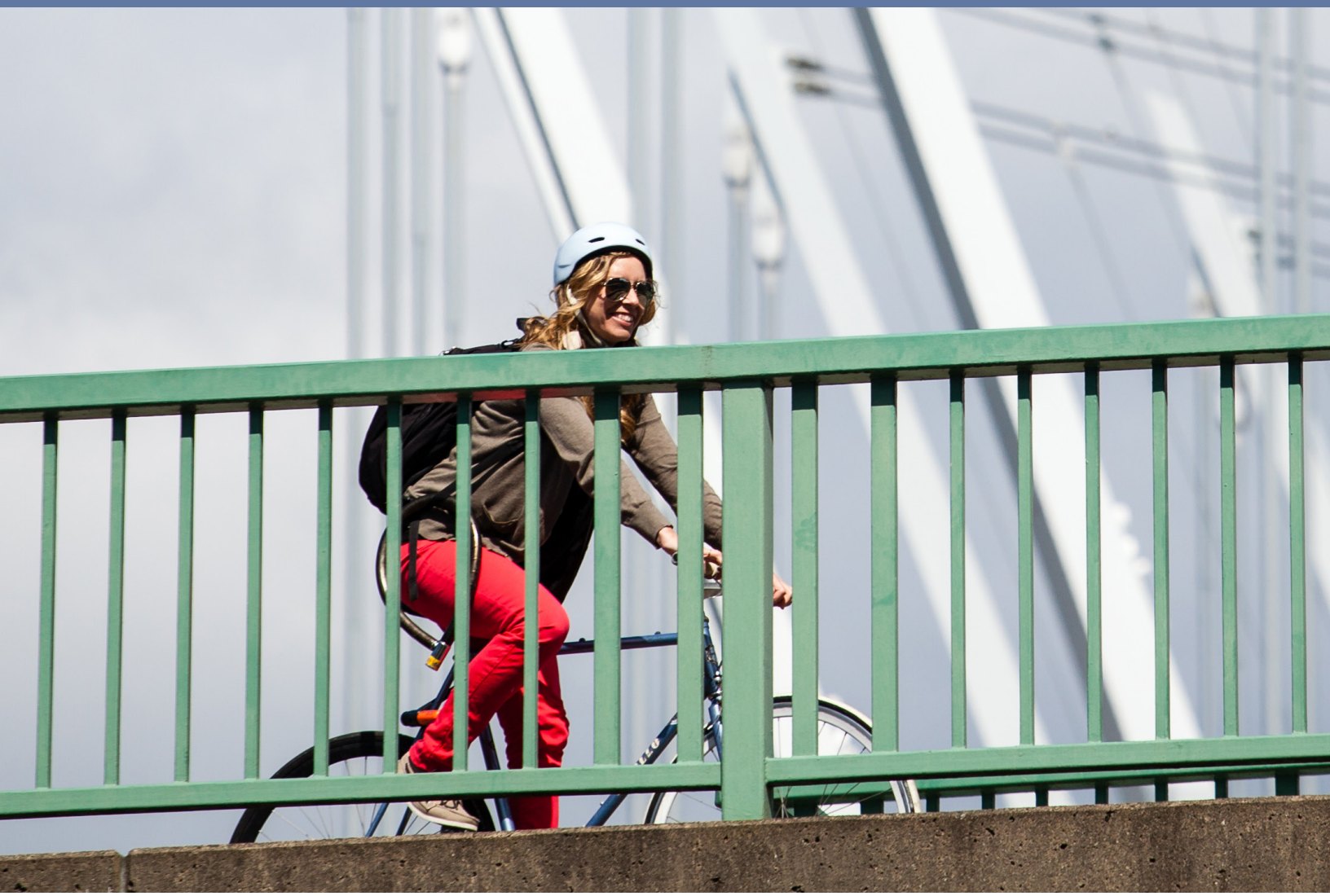
In London, Mayor Ken Livingstone, who began the idea of cycle highways in London, put a bid in to host the Tour de France in 2007. It's argued that hosting the Tour de France was not done as an isolated action but rather within a broader strategy to develop cycling in London.[162] Mayor Ken Livingstone can be quoted as saying:

'The Tour will be great for London, showcasing the UK capital to the world, bringing huge amounts of visitors to London, and encouraging more Londoners to take to two wheels. Cycling is increasing here more than any other city in Europe, with a 72 percent increase in the last five years. We want to use the excitement of the Grand Depart to help us persuade even more people to cycle, not just as a sport but as an everyday and non-polluting way of getting around the city.' [162]

In addition, TfL, the host organizer, had stated objectives for the event: 1) promote cycling in the capital, 2) market London on a World Stage and encourage tourism, 3) demonstrate London can bid for and win major sporting events. [162] During the event, media coverage promoted TfL's future commitment to cycle provision, with a focus on environmental and health benefits.[162] It has been highlighted that post-London hosting the Tour de France Grand Depart, there was a swath of cycle-related activity, including most notably Mayor Johnson publishing a Cycling Revolution policy document, a key part being that TfL would create cycle superhighways and a cycle hire scheme.

Comparatively, in the Netherlands, the intention of hosting the Tour de France Grand Depart may not have been so deeply integrated with helping precipitate a cycling culture but has improved Utrecht's image as a cycling city as well.[186] In part due to having been known for its cycling culture, the Netherlands has also hosted the Tour de France Grand Depart multiple times prior to 2015 (1954 Amsterdam, 1973 Scheveningen, 1978 Leiden, 1996 's-Hertogenbosch, and 2010 Rotterdam). In Utrecht, however, people did seize the opportunity of hosting a global event to promote cycling. Due to the event, interest in cycling and cycle touring has increased.[186] In addition, the Tour de Force, a national cycling initiative, was formed in 2015, the same year the Tour de France was hosted. However, the Tour de Force was initiated by the city of Zwolle after they won a cycling competition; as the initiative was formed at the same time as the Tour de France started in Utrecht, the global cycling event inspired its naming.[156] It is an initiative of local and central governments with a goal of keeping the Netherlands in a leading place in the field of cycling. Within their agenda, they prioritize cycle highways and advocate for their construction at the national level.

Regional Analysis for Possible Cycle Highway Routes in Metro Vancouver



Regional Analysis for Possible Cycle Highway Routes in Metro Vancouver

An analysis of potential cycle highway routes in the Metro Vancouver region was conducted using various data sets and employing GIS software. This aims to serve as a preliminary analysis to highlight possible routes for consideration to implement cycle highways as well as inform subsequent analyses. The analysis also contains an equity component, which subsequently informs the analysis proposing possible routes for consideration.

Equity Analysis

Background and Basis for Analysis

In order to investigate transportation equity across Metro Vancouver, two types of equity were investigated: social equity and spatial equity. The contributing factors of social equity, referring to socio-demographic factors, and spatial equity, distributional or effects of access, in transportation is in line with previous research.[80,139]

Social equity measures included income level, transit-dependent populations (youth and seniors), racial/ethnic minorities and Indigenous populations, and education level. Vehicle access, transit access and bike infrastructure access were part of the spatial equity elements.

For the full background and methods see the companion report: Equity Analysis of Metro Vancouver's Cycling Network

Preliminary Equity Results and Significance to Cycle Highway Route Analysis

Transportation equity is important to address in any transportation planning work. Our equity analysis shows that there are several areas across Metro Vancouver that score lower on transportation equity. This preliminary analysis suggests that the coverage of the 'comfortable for most' cycling facilities has greater representation in more advantaged areas. However, further analysis is required to form a more complete picture and make more concrete conclusions.

For the cycle highway route analysis, the transportation equity results inform destinations to consider when assessing favourable cycle highway routes (Figure 33). These areas included those that were less advantaged on the social equity measures and had poor transit, cycling or vehicle access (spatial equity). The goal is for this information to contribute to developing cycle highways that will make improvements and address concerns relevant to transportation equity, and help guide which regions may stand to benefit most from implementing cycle highways.

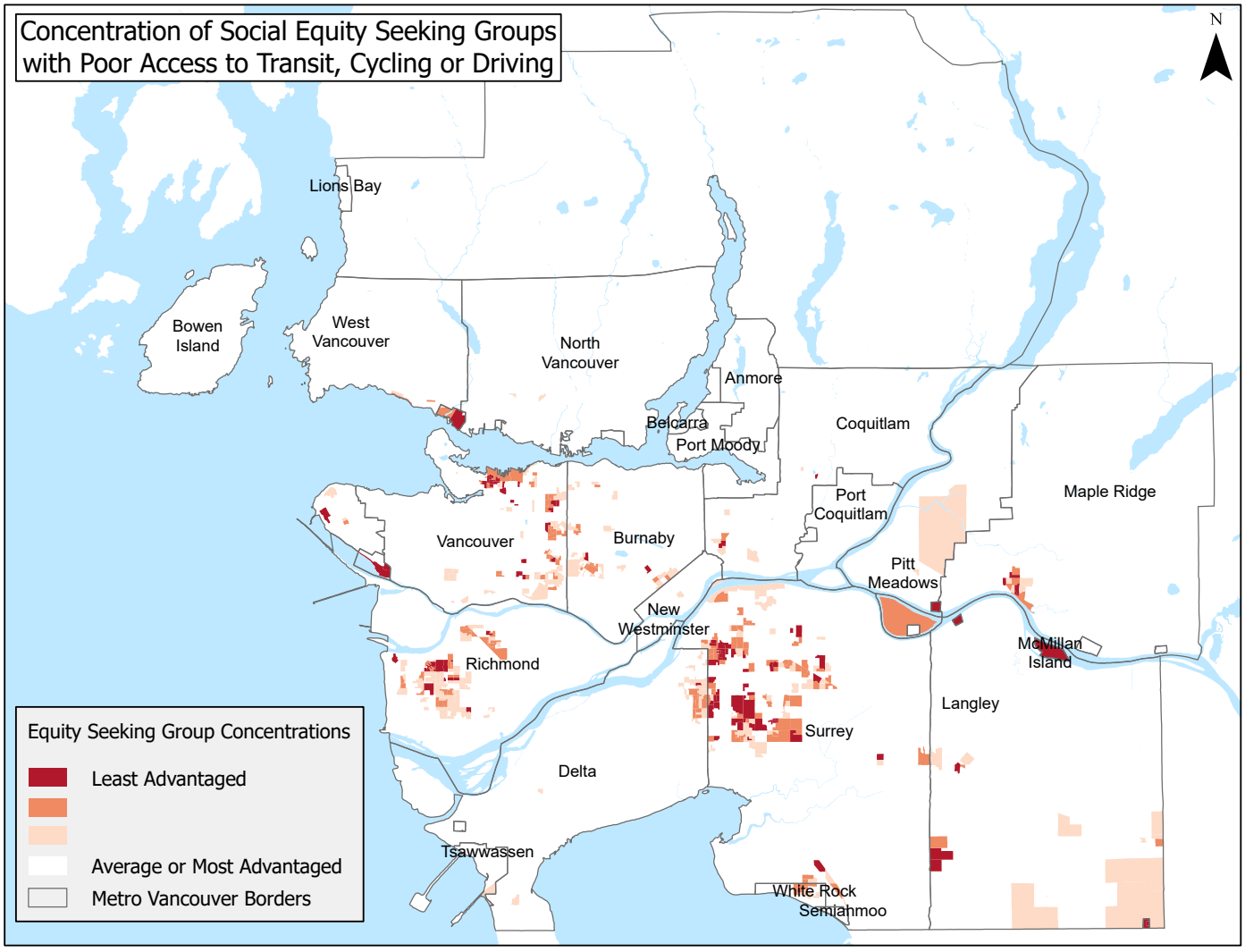


Figure 33: Areas with the highest concentration of equity-seeking groups, denoted in shades of red, across Metro Vancouver

Route Analysis

Background and Basis for Analysis

A GIS analysis was conducted to investigate routes with good potential for the implementation of a cycle highway. In order to inform the GIS analysis, variables of interest were investigated. Variables were selected based on literature that outlined important traits of a cycle highway, especially those that were considered likely to have a notable and pre-determining impact on its future success and usage. We highlight that these criteria focus on the unchangeable or largely unmodifiable factors of the region, for example, topography, versus factors that can be addressed retroactively through design and development, such as paving or separation from traffic.

The criteria outlined below were chosen for the following reasons:

- They have been based on and follow various pre-existing guidelines for cycle highways
- They are considered, or have the potential, to play a notable early-stage role in the development of a cycle highway (i.e. favourable route selection) and are deemed worth considering at an early stage as they are difficult to remedy retroactively
- They are feasible and an application of the GIS software
- Data is accessible and able to be imported into the GIS software when not available through GIS

Explore the Supplemental background for more information on the Route Analysis including route criteria, data collection, scoring, and initial proposed routes

The six criteria chosen for the GIS analysis of candidate cycle highway routes in Metro Vancouver include:

1) Major Destinations

- The route travels through and connects major destinations, including:
  - *Residential areas*
    - Population density
  - *Employment areas, amenities/commercial areas, and education facilities*
    - Job density
    - Number of services/amenities (e.g. medical office, post office) served
    - Number of commercial areas served
    - Number of education facilities served
  - *Transportation*
    - Number of transportation hubs on route (e.g. SkyTrain station)
    - Number of connections to active transportation routes (e.g. other bike routes)
  - *Areas facing higher relative transportation inequity (from VI.A. Equity Analysis)*

2) Gradient

- The route travels across topography with limited or gradual elevations changes; avoid steep inclines
- Gradient percentage of less than 4% is recommended and a maximum of 6%
- Gradient severity can be calculated dependent on the distance

3) Intersections and Stops

- Route favours passage through areas that have fewer or no intersections or required stops
- If intersections are included, favour those with the possibility to become a bike-right-of-way

4) Directness

- The route travels as close as possible to the most direct path, or as the crow flies and detours are reduced and avoided
- Detour factor is less than 1.2 (Detour factor = Lch/Lo; Lch = length of CH, Lo = length 'as the crow flies')

5) Length

- The route is a minimum of 5km long

6) Road Type and Posted Speed Limit (only applies when route travels along a roadway)

- Route favours lower speed limits on roads
- Give preference for smaller, low traffic roads; avoid arterial roads
  - Within urban areas, aim for speed limits at or below 30km/h, especially when bike traffic is mixed with car traffic, i.e. no separated bike path
  - Bike routes along roads with separated bike lanes are suggested to have speed limits of 60km/h or below; speeds up to 80 km/h may be permitted provided there is adequate protection

Initial Route Selection

Some potential routes were selected, to begin the GIS analysis. Ideas for potential routes were drawn from previous work done by HUB Cycling on potential cycle highway routes, TransLink's Major Bikeway Network, and long-distance routes identified by HUB Cycling along the Ministry of Transportation and Infrastructure's highways.

These potential routes were then broken down into two groups. The first group includes existing bike 'routes.' The second group is denoted as 'corridors'; corridors may include existing bike routes but also may have an absence of bike facilities or poor-quality facilities.

The potential routes were further refined by the following criteria:

- High-quality routes (namely regarding the 'route' group)
- Good potential for ridership
  - Connected destinations such as town centres and were anchored by destinations on each end
- Included more municipalities than just Vancouver
- Connected at least two municipalities
- Included more suburban municipalities (namely regarding the 'corridor' group)
- Were included on TransLink's Major Bike Network

The four routes (and two proposed extensions) used in the analysis include:

1) BC Parkway

The BC Parkway connects Surrey, New Westminster, Burnaby and Vancouver and roughly follows the Expo Skytrain line. As there is no strong anchor where the BC Parkway ends in Vancouver, we included an extension via 10th Avenue Bikeway through the Broadway Corridor and ending at the Arbutus Greenway. This extension was analyzed in addition to the pre-existing BC Parkway route.

2) Central Valley Greenway

The Central Valley Greenway connects New Westminster, Burnaby, and Vancouver and roughly follows the Millennium Skytrain line. We connected the Central Valley Greenway to downtown via Quebec Street and the Dunsmuir viaduct; this extended Central Valley Greenway route and constituted the route analyzed below.

3) Union Adanac - Frances Union Bikeway (FUB)

This route includes the Union-Adanac Bikeway in Vancouver and the Francis-Union Bikeway in Burnaby. As the Burnaby end lacks a strong anchor, we connected it to the Burnaby campus of Simon Fraser University (SFU); this constituted one of the analyzed routes. We also analyzed an extension to the route: downtown Vancouver to the North Shore, ending at the Ambleside Town Centre. This extension was analyzed in addition to the pre-existing Union Adanac - Frances Union Bikeway route.

4) Vancouver to Steveston

This route is anchored by downtown Vancouver and Steveston Town Centre.

The six corridors used in the analysis include:

1) Downtown Vancouver to Tsawwassen Ferry Terminal

This route roughly parallels the Highway 99 and 17A corridors.

2) Coquitlam to Maple Ridge via Lougheed Highway

Following the Lougheed Highway, this corridor connects Lougheed Regional Centre to Pitt Meadows Town Centre and Maple Ridge Town Centre.

3) Tri-Cities via Barnet Highway to the North Shore

In the east, this corridor starts at the Coquitlam Regional Centre and runs through the Port Moody Town Centre. The corridor follows the Barnet Highway into Burnaby and then the Francis Union Bikeway to the Ironworker's Bridge. On the North Shore, the corridor roughly follows the Spirit Trail to Lonsdale Regional Centre before ending at Ambleside Town Centre.

4) Surrey Regional Centre to Langley Regional Centre

Linking Surrey, the Township of Langley and Langley City, this corridor is roughly parallel to the Fraser Highway.

5) Surrey Regional Centre to Maple Ridge Regional Centre

This corridor includes the Golden Ears Greenway - an existing route that has limited stopping for about 10 kilometres from Tynehead Park across the Golden Ears Bridge. Anchored in the west by Surrey Regional Centre, the corridor links Guildford Town Centre before ending at the Maple Ridge Regional Centre.

6) White Rock Town Centre to Richmond Regional Centre

Roughly following the Highway 99 corridor from White Rock to Richmond, this corridor connects the White Rock Town Centre and Richmond Regional Centre.

Analysis

We broke each route into smaller segments of approximately 1km. This allowed us to see the strengths and weaknesses of the whole route as well as subsections. Using GIS software, we analyzed each route and corridor based on the selected criteria. Results were exported to Excel and scored based on the scoring tool. Results of the analysis were integrated with results from the equity analysis. Lastly, once the selected corridors and routes were analyzed, we queried GIS for any other routes that fit the criteria and scored these with our scoring tool.

Scores of Proposed Routes and Corridors

The scores for each segment were added up to get a total score for each route or corridor. The total scores are shown, as well as their percentage of the possible maximum score in Table 9.

Name	Total Weighted Score	% of max score
Route 1 - BC Parkway + Extension	38.9	58.5%
Route 1 - BC Parkway	38.8	58.4%
Route 2 - Central Valley Greenway	37.1	55.7%
Route 3 - Adanac & FUB + Extension	35.0	52.6%
Corridor 3 - Tri-Cities to North Shore	33.0	49.7%
Route 3 - Adanac & FUB	32.3	48.5%
Route 4 - Vancouver to Steveston	30.1	45.3%
Corridor 2 - Coquitlam to Maple Ridge	27.7	41.6%
Corridor 6 - White Rock to Richmond	26.6	40.1%
Corridor 4 - Surrey to Langley	26.6	39.9%
Corridor 1 - Downtown to Tsawwassen	26.3	39.6%
Corridor 5 - Surrey to Maple Ridge	24.2	36.4%

Table 9: Total scores for each route and corridor, including proposed extensions

The scores of the ten routes (and two extensions) and corridors ranged from 36.4% to 58.5% of the maximum possible score. From these scores, we see that the routes and corridors fall into three rough categories. The top third in scoring (denoted in blue) includes four routes: the BC Parkway plus our proposed extension to the Arbutus Greenway, the pre-existing BC Parkway route, the Central Valley Greenway, and the Francis Union Bikeway plus our proposed extension from downtown Vancouver to the North Shore. Scoring in the middle (denoted in tones of green/yellow/orange) were the Tri-Cities via Barnet Highway to the North Shore corridor, Union Adanac and Francis Union Bikeway, and the Vancouver to Steveston route. The bottom third in scoring (denoted purple) were the remaining five corridors, Coquitlam to Maple Ridge via Lougheed Highway, White Rock Town Centre to Richmond Regional Centre, Surrey Regional Centre to Langley Regional Centre, Downtown Vancouver to Tsawwassen Ferry Terminal, and Surrey Regional Centre to Maple Ridge Regional Centre.

Existing routes that scored the highest were the BC Parkway and Central Valley Greenway. Both routes have limited hills, run through several denser populated areas, and link key destinations. In addition, large portions of both routes are off-street, thus not required to share a roadway with motor vehicles. Regional connections are met by the BC Parkway, linking four different municipalities, and Central Valley Greenway, connecting three. Also, our proposed extensions elevated the scores of each of the routes they were applied to.

Aside from the Tri-Cities to North Shore Corridor, the rest of the corridors did not score as high as the routes (and proposed extensions). This, for the most part, was due to the corridors residing in more suburban areas. These areas are less dense and contain fewer major destinations, which was a key component influencing the score. On the other hand, it must be highlighted that suburban areas stand to gain from high-quality cycling facilities that connect people to key destinations.

Integration of Equity Analysis Findings

The analysis aims to include and integrate equity considerations and draws from results of the previously outlined equity analysis. Each of the proposed routes and corridors connects to some of the disadvantaged areas. Of note is the BC Parkway. This route links more disadvantaged areas in North Surrey with some disadvantaged areas in Burnaby. The BC Parkway then runs through the north part of a disadvantaged area of notable size in south and east Vancouver.

GIS Query: Additional Possible Routes

Other possible routes beyond those initially identified were queried in GIS and scored. As Table 10 illustrates, several Vancouver routes scored well, including Ontario, Inverness, Off Broadway, Sunrise and Woodland. Surrey's Wildflower route also scored relatively well, as did Coquitlam's similarly named route. Although the additional routes expand to disadvantaged areas, they are overrepresented within the City of Vancouver and few cross municipal boundaries in a meaningful way.

Name	Total Weighted Score	% of max score
Route 1 - BC Parkway + Extension	38.9	58.5%
Route 1 - BC Parkway	38.8	58.4%
Ontario	37.6	56.5%
Route 2 - Central Valley Greenway	37.1	55.7%
Route 3 - Adanac & FUB + Extension	35.0	52.6%
Corridor 3 - Tri-Cities to North Shore	33.0	49.7%
Inverness	32.3	48.6%
Route 3 - Adanac & FUB	32.3	48.5%
Wildflower Sur	30.7	46.1%
7th	30.6	46.1%
Sunrise	30.5	45.9%
Woodland	30.3	45.5%
Route 4 - Vancouver to Steveston	30.1	45.3%
Serpentine	28.2	42.4%
Wildflower Coq	28.2	42.4%
Corridor 2 - Coquitlam to Maple Ridge	27.7	41.6%
38th	27.4	41.2%
Corridor 6 - White Rock to Richmond	26.6	40.1%
Corridor 4 - Surrey to Langley	26.6	39.9%
Corridor 1 - Downtown to Tsawwassen	26.3	39.6%
Cypress	26.3	39.5%
Ridgeway	25.5	38.4%
Corridor 5 - Surrey to Maple Ridge	24.2	36.4%
Langley	24.1	36.3%
Balaclava	23.8	35.8%
Fraser Trail	23.1	34.7%
Richmond Dyke	19.4	29.1%
Traboulay	18.2	27.4%

Table 10: Additional routes with potential for implementation of a cycle highway in Metro Vancouver, proposed via GIS query based on the predetermined criteria

Amalgamated Results

The map below (Figure 34) illustrates each of the investigated routes, corridors, and additionally proposed routes returned from the GIS query across the region. Each route has been segmented into pieces, approximately 1km in length, allowing better visualization of subsections. This map includes a visualization of the areas with the highest equity-seeking groups in the region (grey tones).

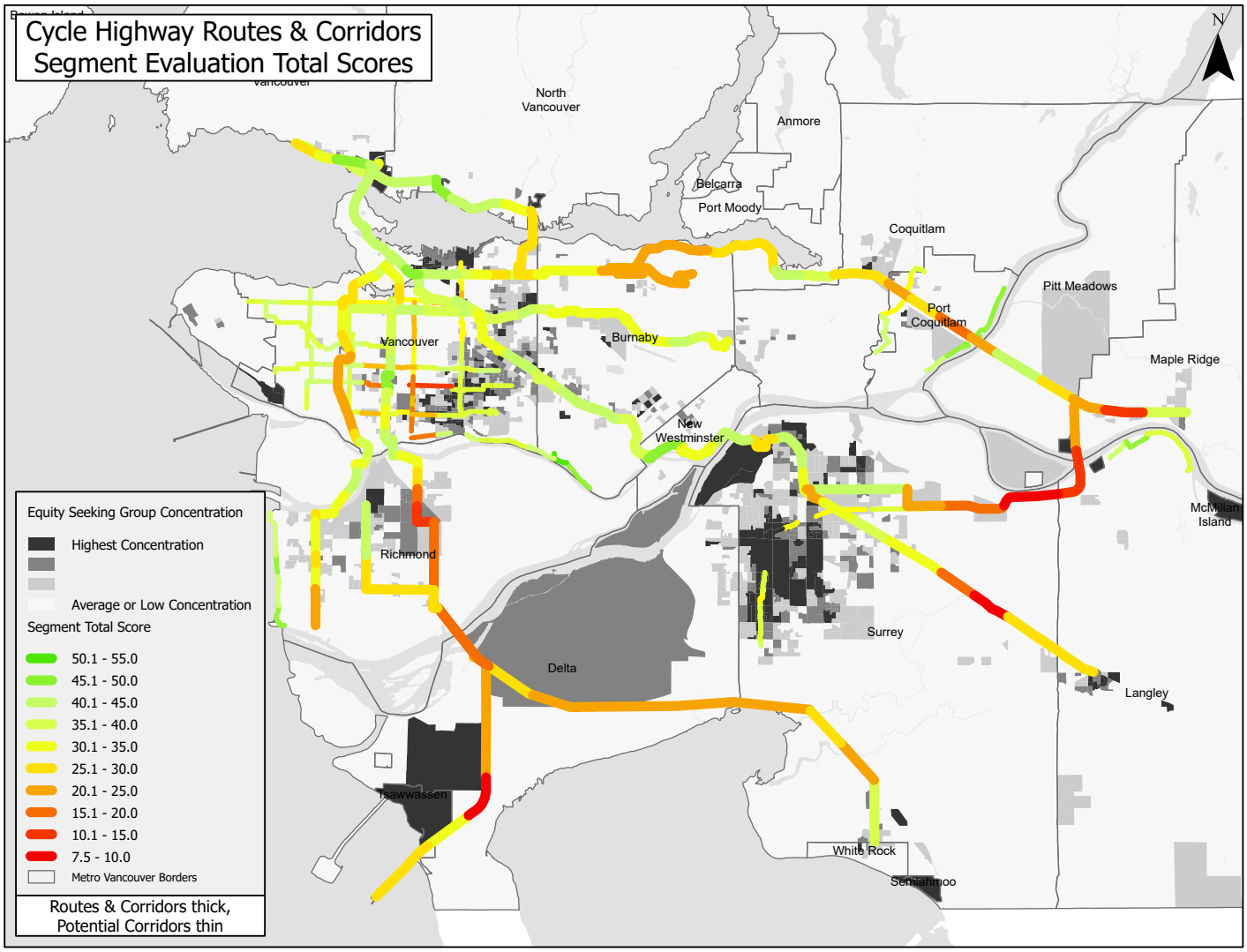


Figure 34: The relative scores of segments for each of the proposed routes, corridors, and GIS queried routes, overlaid on the concentration of equity-seeking groups across the Metro Vancouver

Cycling on Union Street in Vancouver, B.C.
Photo credit: Paul Krueger

GIS Analysis Conclusions: Recommendations and Future Work

Our analysis demonstrates that the following four routes and one corridor should be given preferential consideration for an upgrade to a cycle highway:

- **BC Parkway (plus extension to the Arbutus Greenway)**
- **BC Parkway**
- **Central Valley Greenway**
- **Adanac + Francis Union Bikeway (plus extension from downtown Vancouver to the North Shore)**
- **Tri-Cities to the North Shore**

Although the Ontario and Inverness bikeways scored similarly to these four, these included additional positive attributes. The four are not contained within any single municipality but link at least three municipalities together. This elevates their regional importance. Ontario and Inverness, while they scored well, are entirely contained within the City of Vancouver.

Also, the Central Valley Greenway and BC Parkway routes nearly mirror TransLink's 2018 Major Bikeway Network (MBN). The other two routes closely follow the updated MBN, are included in the Transport 2050 plan, and were recently adopted in 2022. The MBN is a conceptual framework of longer distance, regionally significant cycling routes. Cycle highways and the MBN share a number of concepts. The cycle highway concept could relatively easily be incorporated into the existing MBN. Municipalities seeking funding for bicycle projects through TransLink get additional consideration if the proposed project is part of the MBN. All four of these routes would be more likely to receive funding for upgrades as they are already included in the MBN (or upcoming updates).

Our ranking system proposes a data-informed analysis of the region and illustrates the relative favourability of several routes and corridors for upgrade to cycle highways. However, routes that scored relatively lower should still be given consideration as potential cycle highway routes, as they are still considered preferential routes within the region.

Limitations of the GIS analysis conducted include data availability and duration of the project. The data available and informing the equity analysis was managed in order to best align with our goals. There was an absence of data for the age 14-18 age group, who are still considered transit-dependent. Additionally, vehicle access was estimated by developing a

proxy based on average income and driver share percentages; groups with lower-than-average incomes and lower-than-average driver share percentages were predicted to have reduced vehicle access. However, this proxy is vulnerable to the impact of confounding variables. It would be valuable in future equity work and work pertaining to the development of cycle highways to obtain age data to be all-inclusive of those 18 and under, along with having data on car ownership across the region. Overall, more research is needed on how cycle highways can provide more mobility options for areas that are disadvantaged both on social and spatial measures.

The route analysis was more objective, measuring the physical features of the urban environment. However, pertaining to the criteria of 'major destinations,' care must be taken into defining this category. Locations included in our analysis were based on previous research and included residential, business/amenity/education, and transportation locations; major destinations also serve to approximate cycling potential. Recreation areas are also considered an important destination, and it is suggested that these areas, such as regional parks, be included in future analyses. Cycling potential can also be investigated further by access to data including trip data, such as start and end locations of daily commutes, providing information on traffic flows and trip lengths. The aforementioned considerations would contribute to a more robust analysis exploring cycling potential on proposed cycle highway routes; for the implementation of initial cycle highway routes, it is important to identify areas with the highest cycling potential.

In addition, further analysis can also be done on the existing dataset, such as identifying what percentage of potential cycle highways routes are already classified as comfortable for most; comfortable for most facilities require comparatively fewer upgrades to reach meet the high-standard set by cycle highways compared to routes with poor or absent cycle facilities. This is appealing as it saves construction costs and increases project feasibility.

It must be highlighted that this analysis is meant to serve as an initial exploration and preliminary analysis of the potential cycle highway routes in Metro Vancouver. A phased approach, where this analysis forms the basis and informs future analyses, is suggested. The underlying equity work is also a good start to regional understanding. Further work could delve deeper into both the social and spatial equity elements, adding additional data for a fuller and more nuanced analysis.

Future analyses on cycle highways are also recommended to integrate TransLink's MBN, or vice versa, as they have many overlapping characteristics. Considering this, more consideration should be given to how they intersect and complement each other. For example, it may be of interest to see what percentage of each potential route constitutes proposed MBN routes. Integrating findings of this cycle highways project with those of the MBN would likely prove beneficial to both and the overall outcome of long-distance high-quality cycle routes in the region.

Conclusions and Recommendations

Beach Ave. Bikeway in Vancouver, B.C.

Conclusions and Recommendations

Cycle highways have the potential to provide long distance, sustainable, healthy, affordable ways for Metro Vancouver residents to move around the region, to work, school, amenities and beyond. Their potential is augmented by the rapid growth in popularity and availability of e-bikes and electric assist mobility devices. Not only do cycle highways improve mobility options for those that choose to cycle, but they also they reduce motor vehicle congestion, improve air quality and reduce shared health care costs. Cycling is the fastest growing mode in the region already. With convenient, direct, intuitive cycle highways, research shows mode share would increase faster.

This report outlines the demand and benefits of cycle highways for the region of Metro Vancouver. This report also delivers:

- A two-part working definition for cycle highways with relevance to Metro Vancouver
- Recommendations for taking the next steps towards their development in the region
- Suggested routes for consideration to upgrade into cycle highways

Demand for Cycle Highways

Through investigating the challenges and goals, the current cycling conditions, and user preferences of cycle infrastructure in Metro Vancouver, it is concluded that there is a demand for the implementation of cycle highways.

Cycle highways have notable potential to address regional challenges, including vehicle congestion, climate change goals, and equity concerns. Metro Vancouver, projected to continue growing in population, is seeing increasing pressure on transportation networks and infrastructure. Cycle highways have been implemented in both Denmark and the Netherlands with the primary goal of reducing vehicle congestion. Additionally, transportation accounts for approximately 45% of the total greenhouse gas emissions of the Metro Vancouver region and reductions can be realized by inducing a modal shift from vehicle trips to biking. Additionally, equity issues throughout the region are intertwined with our transportation infrastructure, and there is a need for continued improvements. However, bikes, considered the cheapest and most accessible form of mobility, require supporting infrastructure to make them equitable and accessible. Cycle highways, with their long-distance connections designed for users of all abilities, can contribute to the realization of equitable mobility within the region. Implementation of cycle highways throughout the region is also in line with the Draft Regional Transportation Strategy 2050, outlining clear intentions of implementing an 850km network of 'traffic-protected bikeways' connecting urban centres that are comfortable for most users. Addressing the aforementioned regional challenges and increasing cycling and associated infrastructure is also echoed by the Metro 2050 Regional Context Statements and various initiatives and goals at the Provincial level, including CleanBC and the Active Transportation Guide.

There is also demand for cycle highways in terms of addressing user needs and accessibility issues, as well as discontinuity of the current network across the region. Both these factors are crucial to address, as they ensure wider demographics, and thus more individuals can employ bike infrastructure to meet their transportation needs. The long-distance and continuous connections of cycle highways elevate cycling as a transportation mode and make

it competitive with other modes of transportation, especially over longer distances; they have been found to increase bike ridership and contribute to increasing bike trip length. Additionally, the high-quality and cycling-focused nature of cycle highways make notable contributions to addressing user preferences, including favouring separated bike lanes and paths, route directness, increased safety, and smooth-riding surfaces. This is directly supported by research conducted within Metro Vancouver on cycle facility preferences. As there is notable incongruency between the most commonly used cycle routes in Metro Vancouver and those that are preferred – attributed to the absence and availability of other options - the implementation of cycle highways has the potential to fill the current gap between user needs and the currently available infrastructure.

Cycle Highway Working Definition

The concept of cycle highways is defined by their goals and design characteristics. Although still evolving, here a two-part working definition, consisting of clear objectives and design characteristics, is proposed for Metro Vancouver. This definition has been based on common themes found in regions that have implemented cycle highways, including Denmark, the Netherlands, and London, and through discussions with the Cycle Highway Working Group, including members of HUB Cycling and TransLink:

1. The objectives of cycle highways are to provide:

- The highest quality bike routes that protect and prioritize people cycling along the entire route
- Direct connections between major destinations and a backbone of the regional cycling network
- The ability to maintain consistent speeds and avoid frequent stops
- Safety and comfort for all ages and abilities, day and night, throughout the year
- Connections greater than 5km in length to facilitate long-distance and multimodal travel
- Readily identifiable and intuitive routes

2. Design characteristics of cycle highways include:

1. **Directness** – aim for the most direct route; reduce and avoid detours.
2. **Longer Lengths** – generally greater than 5km long.
3. **Connections Between Major Destinations** – may include residential, employment, amenities and commercial areas, and education facilities.
4. **Capacity for Speed** – structure and shape allow for higher speeds and speed maintenance.
5. **Mode-Separation and Path Types** – largely mode separated; interventions to limit conflict when not.
6. **Intersection Treatments and Minimal Stops** – minimize stops through intersection treatments.
7. **Consistent and Ample Widths** – allow for passing or riding alongside one another.
8. **Consistent and High-Quality Paving** – smooth and maintained.
9. **Lighting** – appropriate for riding in low-light conditions and at night.
10. **Minimizing and Alleviating Gradients** – avoid steep inclines and prioritize mild grades.
11. **Clear Signage and Branding** – ensures it is readily identifiable and intuitive to use.
12. **Regular Maintenance and Winter Service** – ensures reliability at all times of the year.
13. **Service Stations** – may include bike pumps, drinking water, and bike parking.

The working definition is proposed to be used as a jumping-off point in discussions with various stakeholders, including local, regional, and provincial level governments, TransLink, and HUB Cycling. Although the implementation of all design characteristics consistently may prove difficult, it is urged that the highest standards are aimed for whenever possible.

Benefits of Cycle Highways

Cycle highways impart notable benefits to both transportation and beyond transportation. Through increasing levels of cycling - health, environmental, and economic benefits are realized. Cycling has been repeatedly shown to promote general health, prevent disease, and improve mental and social well-being. This is realized by diverse segments of the population and e-bike users alike and further translates to reduced healthcare costs. A cost-benefit analysis conducted in Denmark found the single most important factor contributing to the positive monetary return on the cycle highway network expansion was the associated health benefits. Environmental benefits are largely realized due to the modal shift away from fossil fuel burning modes of transportation and have positive impacts on air quality and noise pollution. The UN Environment Program has highlighted that there is a staggering potential for reducing GHG emissions in the transport sector and requires a shift to environmentally efficient transport modes, such as cycling. Economic benefits include the stimulation of businesses proximal to the bike infrastructure and the cost-efficiency of implementation and maintenance of bike infrastructure relative to automotive infrastructure. Numerous cost-benefit analyses' have found positive returns on the implementation of cycle highways.

Economic benefits of high-quality cycle infrastructure such as cycle highways have also been found via fostering cycle tourism. This emerging phenomenon is occurring around the world, including in numerous countries throughout Europe. However, until recently, North America has been slow to identify the potential of cycle tourism. Canadians display an interest in cycle tourism and travel to destinations, such as the U.S. and New Zealand, as cycle tourists. Within Canada, Québec estimates that 10% of its population identifies as a cycle tourist and, to attract cycle tourism, has developed La Route Verte (4345km); along the route alone, people spend $95.4 million annually. Ontario has also followed suit. These benefits have the potential to be realized within British Columbia as well. The Provincial Government currently shows interest in cycle tourism, and some benefits of cycle tourism, via mountain biking, are already being realized. As aspects of routes favourable for bike touring and preferences of bike tourists overlap significantly with those addressed by cycle highway, creating an opportunity in tourism value via their implementation.

The benefits of implementing cycle highways are further supported by the significant increase in the use of e-bikes and micro mobility, both in Vancouver and across Canada, consistent with the trends seen worldwide. Shifts in consumer behaviour are attributed to their eco-friendliness, efficient commuting choice, rising fuel costs, increasing interest in fitness and recreation activity, and further compounded by the increasing number of companies offering share programs for e-bikes and e-scooters. Increasingly, cargo bikes are being viewed as efficient and cost-effective delivery solutions within the urban environment and have already been implemented successfully in parts of Europe. Within British Columbia, incentive programs for e-bikes and cargo bikes are offered by the Provincial Government, and pilot programs for shared e-mobility are popping up throughout Metro Vancouver. Recently, Vancouver has pledged to create an e-cargo-bike delivery hub, and within the region, we already see companies capitalizing on delivery bikes. Although the current infrastructure limits the potential of the cargo bike, these concerns would largely be addressed through the design and implementation of cycle highways. Increasing usage of e-bikes and e-mobility amongst the population adds value to cycle highways via increased accessibility and increasing trip lengths. By implementing cycle highways, e-bikes and micro mobility are effectively made more appealing as a transportation choice. Cycle highways and e-mobility can be considered to have a positively reinforcing relationship.

The Next Steps for Metro Vancouver

Investigation of three cases where cycle highways were successfully implemented within Europe (Denmark, the Netherlands, and England) and two cases of the successful implementation of greenways/ trails in North America (United States of America and Canada) has helped delineate priorities to begin the process of developing cycle highways in Metro Vancouver. Learnings pertain to four main categories: project vision and network plan, cooperation and collaboration, political and economic support, and infrastructure development. The main takeaways and recommendations for Metro Vancouver are outlined:

Create a Shared Vision to Guide the Project
Clearly outlining the visions and goals of the project are important to garnering support and receiving widespread backing. Visions and goals for the implementation of cycle highways have included increasing bike modal share in transportation, fostering greater commuter distances travelled by bike, and reducing vehicle traffic and highway congestion.

Conduct an Evidence-Led Analysis to Inform the Design of a Network
Proposing a network is stronger than individual routes. Ensuring that the proposed network and routes are backed by research shows informed decision-making and gives the project credibility; numbers, such as cost-benefit analysis, provide additional support. In Denmark, their network plan was based on a heat map of activity nodes, whereas in the Netherlands, proposed networks are assessed, estimating impacts on congestion, potential ridership, and cost-benefit analysis. In Denmark, universities conduct research (i.e. traffic flows) informing plans; something similar could be done in Metro Vancouver. The Strategic Cycling Analysis (London) clearly outlines an evidence-led approach to cycle highway route planning. This can be used to guide a similar analysis across Metro Vancouver.

Connect Interested and Invested Individuals
Connecting individuals who are interested in the creation of cycle highways helps grow momentum for the project and push the vision. People currently invested in the project should look towards getting more people on board. Individual connections may include advocacy groups, interested citizens, politicians, and government employees. HUB Cycling has started looking into this.

Establish a Group to Engage and Host Discussions Between Stakeholders
A group that hosts discussions and fosters collaboration between stakeholders is of utmost importance. This group contributes to establishing a working group comprised of stakeholders focused on the development of cycle highways across the region. Stakeholders may include municipal, regional, and provincial representatives, transportation authorities, and advocacy groups. It is of added benefit for this group to be neutral and have the focus of developing cycle highways in the region. In Denmark, a single municipality spearheaded a collaboration, now headed by an office focused on cycle highways and involving 30 municipalities. In the Netherlands, an advocacy group acted as a project leader, and in England, the regional transport authority successfully engages with stakeholders and hosts collaboration. Within Metro Vancouver, TransLink and HUB Cycling may be considered to work together to spearhead creating and hosting a collaboration between municipalities.

Secure Funding from Higher Levels of Government
Cycle highway projects address regional issues, such as air pollution and traffic congestion, and cross-jurisdiction boundaries. Addressing regional issues is of interest to higher levels of government, which can contribute notable funding. This can help overcome the barrier of the limitations of municipal budgets. In the Netherlands and Denmark, cycle highways are supported and funded at the national level. Within British Columbia, the Provincial Government has previously been involved with funding the development of the Galloping Goose and Lochside Regional Trails as well as showing project support, subsequently motivating investment from local governments. It is suggested that a regional cycle highways project in Metro Vancouver looks to the Provincial Government for

support and funding.

Capitalize on Upgrading Pre-Existing (Bike) Infrastructure

Investments are more effective, and planning costs can be reduced if routes do not need to be realized from scratch. Pre-existing bike routes with good bike ridership are good candidates for upgrading to a cycle highway, especially when considering where to locate pilot routes; this approach has been taken in Denmark, the Netherlands, and England. In Denmark, a step further is taken: a spreadsheet is provided to municipalities that provides guidance on what upgrades need to be made to meet the standards of a cycle highway. This could be adapted to the context of Metro Vancouver. It is helpful to clearly convey standards and how they can be met, like a spreadsheet or otherwise, to municipalities to assist in infrastructure implementation decisions.

Suggested Routes to Upgrade to a Cycle Highway

The GIS analysis included in this report is meant to serve as a data-informed preliminary analysis, to propose favourable routes for the future construction of a cycle highway and to inform the subsequent similar analysis. The GIS analysis on potential routes was informed by the preceding GIS analysis investigating transportation equity across the region.

The Metro Vancouver region was analyzed for routes with the potential to be developed into cycle highways. The assessment included comparing a group of pre-selected routes, including four pre-existing bike 'routes' (plus two proposed extensions and six potential 'corridors.' Each route was assessed with respect to six variables of interest: route directness, length, connections to major destinations, gradient, number of intersections and stops, and the road type/posted speed limit, which were weighted, based on relative importance, and scored. The software was additionally queried, based on the defined variables, to find additional possible routes across the region that may have been missed.

Our analysis concluded that the following should be given consideration to upgrade to cycle highways:

- BC Parkway (plus extension to the Arbutus Greenway)
- BC Parkway
- Central Valley Greenway
- Adanac + Francis Union Bikeway (plus extension from Downtown Vancouver to the North Shore)
- Tri-Cities to the North Shore

These routes fell into the top-performing category of routes assessed, supporting further investigation as candidates for implementation of a cycle highway; however, routes that scored lower should still be given consideration, as they are still considered preferential routes within the region.

The BC Parkway and the Central Valley Greenway also mirror aspects of TransLink's 2018 Major Bikeway Network (MBN); Adanac + Francis Union Bikeway plus extension and Tri-Cities to the North Shore closely follow the updated MBN, included in the Transport 2050 plan adopted in 2022. As municipalities seeking funding for cycle projects get additional consideration by TransLink if it's part of the MBN. In addition to performing well on our ranking scheme, all four of these routes would be more likely to receive funding for upgrades as they are already included in the MBN (or upcoming updates) than some others.

These routes transcend jurisdiction boundaries, have pre-existing bike infrastructure, and already have people cycling along with them. These reasons overlap with the justification for early cycle highway routes in Denmark, the Netherlands, and London, England.

In terms of transportation equity, these routes also link disadvantaged areas; of note is the BC Parkway, connecting regions that could benefit from improved transportation such as North Surrey, parts of Burnaby, and the south and east parts of Vancouver. These routes may be eligible for funding from TransLink, further supporting their candidacy. However, any cycle highway project in Metro Vancouver needs to be done considering regional and context-specific factors, in addition to being supported by the local municipalities and First Nation groups.

As results of the analysis investigating cycle highway route candidates found notable overlap with TransLink's MBN, and many of the intentions of TransLink's MBN and the goals of cycle highways align; their integration is suggested. For example, TransLink's MBN proposes bike infrastructure route paths across Metro Vancouver. However, how they are implemented could take the form of the high-quality, accessible, and attractive design of cycle highways. This is an effort to ensure simplicity in bike network planning and outcome. In the Netherlands and Denmark, both bike infrastructure generally and cycle highways are held to a consistent and high standard, leading to simplicity in use. Comparatively, London has gone through many iterations of bike network plans of different standards and under different names, complicating the process and resulting in an additional process of merging outcomes. In Metro Vancouver, we already see complexity in our bike infrastructure, such as the 'comfortable for most, some, few, and very few' and the 'All Ages and Ability' designations. The connection between these two concepts is likely to benefit the end result and ensure a simplicity in outcome for users.

Project Limitations

Limitations of this report include team size, covid-19, and project duration. Research was conducted by a master's student working from home due to covid-19. The research was conducted over a six-month period under the supervision of an individual within HUB Cycling. Case studies of regions that have successfully implemented cycle highways and that are contained in this report reside in Europe. Although recommendations were generalized, the political structures within these countries and in the European Union may differ and affect the methods possible and effective for the implementation of this type of infrastructure. As there is no known example of a cycle highway that has been developed in North America, case studies within this region focussed on greenways and trails that displayed traits akin to cycle highways. The methods

employed to develop these routes, which tend to have a more significant recreation than transportation focus as seen with cycle highways, may not translate directly to the implementation of a cycle highway. The recommendations drawn from case studies are meant to prompt discussion and inform the initial steps taken to develop cycle highways in the region.

Furthermore, the GIS analysis was contracted out and conducted within a short time frame. The GIS analysis contained in this report means to act as a preliminary analysis. Further analyses are required to gain a more comprehensive picture to inform cycle highway route and network planning decisions.

Contribution

This report is the first and only report to investigate the concept of cycle highways with specific reference to the context of Metro Vancouver. Through a literature review, a working definition of cycle highways is proposed and to be used as a reference point to develop a more defined and context-specific definition for the region. Clear recommendations for the initial steps to take towards developing a cycle highway network in the region are made, and through conducting an analysis of the region, candidate routes for development into cycle highways in Metro Vancouver are proposed.

This is also the first report to make a context-specific case for cycle highways in the region. Research into user preferences of bike infrastructure within Metro Vancouver is drawn upon, and similarities with cycle highways are highlighted. Cycle highways and their potential contribution to addressing challenges faced within Metro Vancouver, including congestion, climate change, and equity, are outlined. The growth of e-bikes and micro mobility, both stimulated by consumer and provincial government initiatives, is investigated, and their potential to positively reinforce each other is highlighted, in addition to the potential of cycle highways to stimulate cycle tourism within the region.

VIII. Supplemental Background

A. Research Findings – Route Preferences

When comparing the bike infrastructure types currently being cycled with those people that prefer to be cycling, clear trends begin to appear. This was investigated by Teschke and Winters[20] within Metro Vancouver; they found that that off-street paths were clearly the most preferred: 85% of respondents were likely/very likely to choose 'paved off-street paths for bikes only', 77% for 'paved MUPs', and 71% for 'unpaved MUPs'.[20] Unpaved MUPs stacked up comparatively to 'cycle paths next to a street with a physical barrier' (see Figure 7).[20]

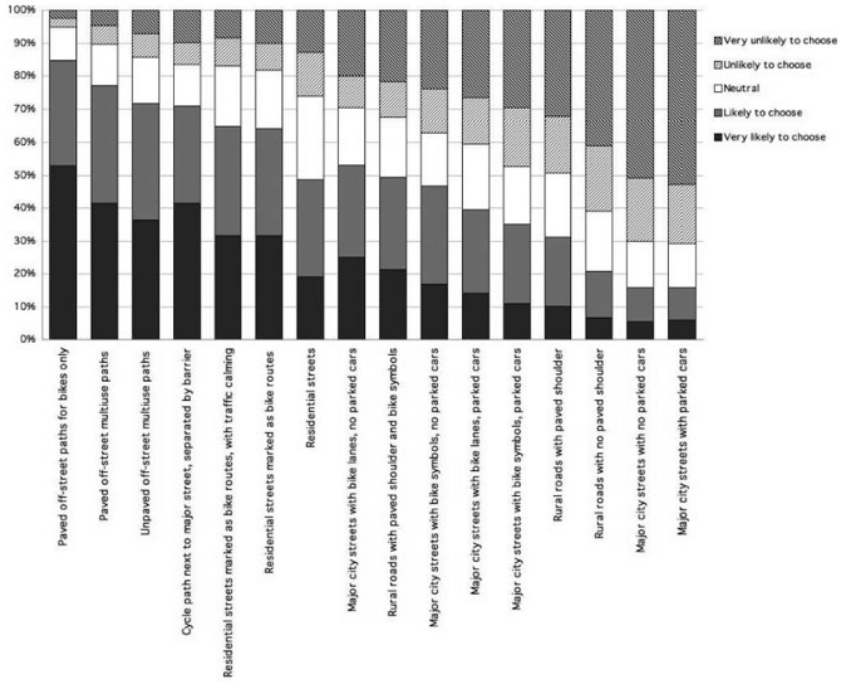


Figure 7: Likelihood of choosing route type (if all route types were available) for 16 cycling route types among current and potential cyclists in Metro Vancouver (n=1402)[20]

Winters and Teschke[20] also draw attention to the varied preferences found in different demographics of people cycling for A) cyclist segment, being regular, frequent, occasional, and potential cyclists, and B) Gender, male and female (Figure 8). Regarding the former, it was found that the regular cyclists do not like unpaved MUPs and residential streets (unmarked bike routes); they ranked these bike routes options markedly lower than other route types (Figure 8 A.).[20] When comparing preferences between women and men, there was virtually no difference in preference for the 6 most preferred route types, however, female preference tapered off sooner - preference scores were comparatively lower - in the 'less comfortable and safe' route types than men (Figure 8 B.).[20] This finding was echoed by respondents with children in their household, ranking low preference routes even lower than those without children.[20] Overall, there were similar route preferences across frequent, occasional, and potential cyclists and similar support for the top route types (paved off-street paths; cycle paths next to major streets separated by a barrier; and residential streets marked as bike routes, with traffic calming) between men, women, and respondents with children.[20] Winters and Teschke stress that these commonalities in route preference simplify and make things relatively straightforward in guiding future infrastructure development.[20]

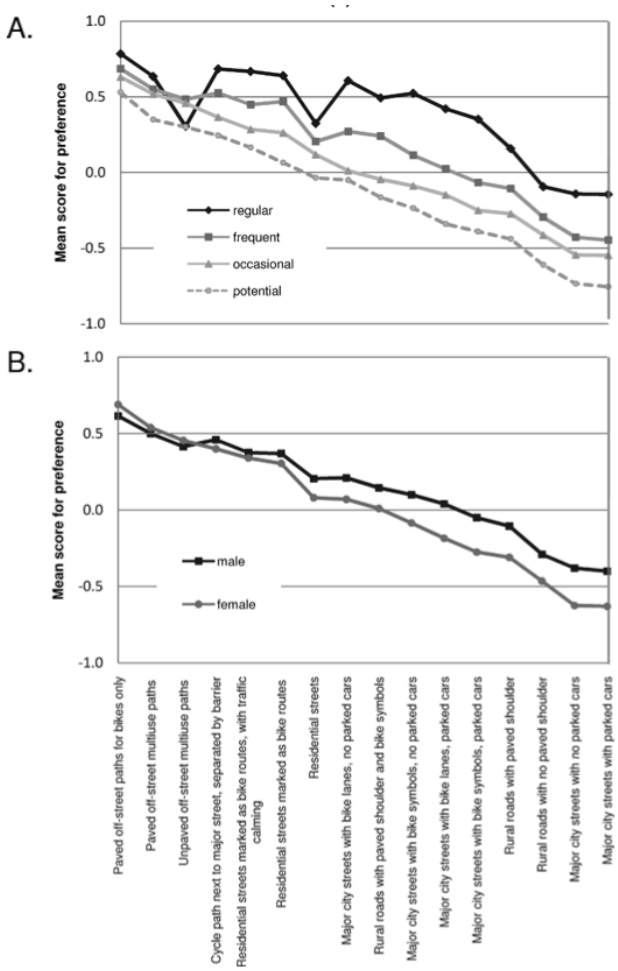


Figure 8: Mean preference score for 16 route types according to cyclist segment (A) and Gender (B)[20]

Additionally, there is a lack of congruency between what types of routes an individual prefers to ride on and where they actually ride. When the current usage of bike route types is compared with their preference rank, we begin to see clear potential for the needs of people cycling to be increasingly met via increased implementation of certain infrastructure types (Table 3). The crossing lines indicate a discrepancy between where people are currently riding and where they would choose to ride given an availability of all route types. For example, we see the top three most used route types in Metro Vancouver are on residential streets (Table 3), however, these are deemed moderately preferable by people cycling and less preferred than off-street paths.[20] Comparatively, three types of off-street paths are ranked highest in terms of preference, but are used less than routes ranked as less favourable. This data highlights the gap in infrastructure provision and user needs.

Days/ year	Current Use Rank	Preference Rank	Score
51	Residential street	Paved off-street cycle paths for bikes only	0.6
42	Residential streets marked as bike routes	Paved off-street multiuse paths	0.5
35	Res. streets marked as bike routes, with traffic calming	Unpaved off-street multiuse paths	0.4
31	Major streets with parked cars	Cycle path next to Major street, separated by barrier	0.4
27	Paved off-street multiuse paths	Res. streets marked as bike routes, with traffic calming	0.4
27	Unpaved off-street multiuse paths	Residential streets marked as bike routes	0.3
24	Major streets with no parked cars	Residential street	0.1
23	Paved off-street cycle paths for bikes only	Major streets with bike lanes, no parked cars	0.1
20	Major streets with bike symbols, no parked cars	Rural road with paved shoulder and bike symbols	0.1
19	Major streets with bike symbols and parked cars	Major streets with bike symbols, no parked cars	0
17	Major streets with bike lanes, no parked cars	Major streets with bike lanes and parked cars	-0.1
16	Major streets with bike lanes and parked cars	Rural road with paved shoulder	-0.2
12	Rural road with paved shoulder	Major streets with bike symbols and parked cars	-0.2
11	Rural road with paved shoulder and bike symbols	Rural road with no paved shoulder	-0.4
10	Rural road with no paved shoulder	Major streets with no parked cars	-0.5
9	Cycle path next to Major street, separated by barrier	Major streets with parked cars	-0.5

Table 3: Current Use vs. Likelihood of choosing 16 cycling route types in Metro Vancouver[20]

However, two marked findings stand out in Table 3. Firstly, we see the absolute least preferred route type, major streets with parked cars, rank as the fourth most used route type – it can be concluded that currently people cycling are turning to these routes due to the absence of any other option, as almost every other route type was deemed more preferable.[20] Secondly, 'cycle paths next to major street, separated by barrier' was ranked third highest in preference, however, they are currently used the least in Metro Vancouver, highlighting that they are not commonly available.[20] This great disparity between the route types in high usage and those most preferred delineates a clear way to adapt the current road network to be more supportive of the needs of people cycling.[20] Overall, the current and potential people cycling in Vancouver prefer routes separated from traffic; this is in line with cycling infrastructure design in European centres with high cycling modal share.[20]

B. Cycle Highway Design Characteristics

This section aims to both identify and describe, with reference to recent relevant literature, the characteristics that define and distinguish a cycle highway from other bike infrastructure. The characteristics outlined above, pertaining to both infrastructure and planning elements, are further detailed and explained below.

As cycle highway projects are largely found in North-Western Europe – some prominent examples include the *snelfietsroutes* in the Netherlands, the *supercykelstier* in and around Copenhagen, the *cycleways* (previously *cycle superhighways*) in London, the *fietsostrade* in Flanders, and the *radschellweg* in North-Rhine Westphalia (DE) – the literature reviewed and referenced within this section is largely based within North-West Europe. A notable portion of information within this section has been contributed by the following documents: Koncept 2.0 by the Office of Cycle Superhighways,[187] the London Cycling Design Standards by Transport for London (TfL),[188] and the Design Manual for Bicycle Traffic by CROW[189]. The design guidelines and associated references that are included below specifically refer to cycle highways; guidelines for general or other types of cycle infrastructure were excluded.

Design Characteristics of Cycle Highways:

1) Directness

It is commonly stated that cycle highways should aim to provide the most direct route, reducing and avoiding detours.[21,187,189–195] The directness of cycle highways contributes to cycling being competitive with other modes of transport over longer distances and better serving commuters.[187,188] However, in the Netherlands, the CROW Manual further defines a limit to the extent of detours that can be realized within a route considered a cycle highway. The detour factor should be less that 1.2, and is defined as the length of the cycle highway divided by the length of 'as the crow flies' (detour factor = L_{ch}/L_0).[189] This metric for directness is also being employed within Austria to plan their cycle highways (Rad-Langstrecken).[193]

2) Length

Another often cited requirement of a cycle highway is that it spans longer distances, to support long distance bike travel and induce a modal shift. Cycle highways greatly vary in length, however, many reach 10 and 20km. An especially long cycle highway, the Radschellweg Ruhr (RS1) in Germany, measures more than 100km. However, in order to help facilitate longer distance travel by bike, an often cited minimum distance of cycle highways is 5km.[29,30,187,192,196,197]

3) Connections Between Major Destinations

Connections between major destinations are considered crucial to the effectiveness a cycle highway has as a transportation infrastructure.[21,66,187,195,198] Cycle highways should serve people moving between their homes and the places they need to frequent. This contributes to the cycle highway being the backbone of the regional cycling network. Frequented destinations that have been noted to be considered in the route planning of cycle highways include: residential areas,[66,152,187,191,198] employment areas,[66,152,187,191,192,198] amenities and commercial areas,[191,192,198] and education facilities[191,192,198]. It has been also highlighted that cycle highways should also consider proximity and connection to the transportation network and hubs in order to help facilitate multimodal trips.[152,191,192,195,198]

4) Capacity for Speed

Cycle highways are intended to be designed so that they can be ridden at higher speeds (design speed) and allow individuals to maintain a decent speed of travel (average speed) when compared to other bike routes.[21,66] Design speeds consider the shape of the route (*e.g.* curve radii) and are often 30km/h.[188,189,195,196,199] Average speeds should also be aimed to be kept comparatively high to other types of cycle routes; cycle highways are often designed to ensure that an average speed of 20km/h or more can be maintained[29] and in the Netherlands an average speed of 30km/h is aimed for[66].

5) Mode-separation and Path Types

It is widely agreed that cycle highways, and the paths they follow, are a dedicated infrastructure built for people cycling and are largely separated from other modes, including motorized traffic and pedestrians.[21,29,30,187,188,195] This predominantly refers to higher traffic speeds and volumes and to ensure safety of people cycling along the route.[189] Mode separation ensures people cycling are prioritized and protected, including those of all ages and abilities. Generally, when bikes travel on roadways, speed limits for vehicle traffic are recommended to be 30km/h or below.[189,195–198,200] Outside urban areas the limit can be increased, up to 50km/h[196] and 60km/h[189] for example. Overall, mode separation should be prioritized but is not required for cycle highways. Upon discussion with the Cycle Highway Working Group, it was

agreed that generally and within the context of Metro Vancouver, "*Mode separation from traffic and pedestrians where appropriate*, *and interventions to limit conflicts with other modes where not"* would be a reasonable standard to set.

In the Netherlands, the CROW manual sets the minimum threshold for meeting the criteria of a cycle highway to have fewer than 500 cars along the route over 24 hours and if car speeds are greater than 50km/h, grade separation is required.[189] However, they additionally lay out that the preferred standard for a cycle highway route is car-free and grade separated if vehicle speeds are greater than 30km/h.[189] Comparatively, within Denmark, it is suggested that two-way cycle paths in their own route are used for cycle highways (Figure 11).[187] However, when this is not possible, such as within the confinements of built up urban areas, one-way cycle paths along roads are suggested; two-way paths along roadways are not recommended, due to the presence of side roads and driveways.[187] Each of the aforementioned infrastructure designs are mode separated from both vehicle and pedestrian traffic, unless both cycle and pedestrian volumes are extremely low (*e.g.* country areas); otherwise exemptions can be made for short stretches where there is a limited possibility for other solutions.[187] Bicycle lanes along roads (defined by a lack of grade separation) are recommended against, as they provide less safety and security.[187] Additionally, passing a cycle highway along less busy roads is considered unfavourable as it is more difficult to prioritize people cycling over other road users and should only be used when it is the only option.[187] The concept of separation for cycle highways is supported in London as well, stating that cycle highways will be delivered to a high standard which includes favouring segregation, in order to ensure a right to use a road by people cycling.[188] However, some cycle highway routes in London also share travel lanes with buses.[188] In London, cycle highways can be routed along secondary roads, provided they are still direct, in order to separate them from high volume traffic.[188]

Figure 11: An example of a two-way cycle path in its own route and pedestrians are clearly separated by a grass space; a high-traffic corridor for both people cycling and pedestrians, (Indre Ringrute, Frederiksberg Municipality)[187]

6) Intersection Treatments and Minimal Stops

It is important that cycle highways have minimal intersections and stops and when there are intersections, they are addressed with intersection treatments as much as possible.[21,189,195,196] Intersection treatments are methods, either at grade or grade separated, in which intersections are adapted in order to reduce the need for people cycling to slow their speed or stop. This means people cycling can maintain consistent speeds and make for a more enjoyable experience and less energy expenditure.

An example of an at grade intersection treatment is the 'GreenWave,' which times the green lights at traffic signals to change at the average speed of travel along the route (approx. 20km/h); this allows people cycling travelling at an average speed to hit green lights consistently and limiting the need to stop.[187] Other treatments include giving people cycling an advance green signal or displaying the waiting time until the light turns green.[187] Another relatively simple at grade treatment is giving the right of way to people cycling along the cycle highway.[29] Examples of grade separated intersection treatments are bridges and tunnels. These are extremely effective as people cycling are allowed to bypass an intersection all together and are important to consider when large numbers of people cycling would reap notable travel time improvements, however, are often associated with higher costs than at grade intersection treatments.[187]

In the Netherlands, cycle highways are allowed to a maximum 0.4 stops per kilometer, however, ideally aim to have no stops along the route.[189] Sometimes tunnels and bridges, especially to avoid crossing larger intersections such as motorways, are also implemented along cycle highways (Figure 12).

Figure 12: Tunnels along the Rijnwaalpad, the Netherlands: a tunnel under the A15 motorway, with outward leaning walls creating a feeling of roominess (left), and the Kattenleger tunnel, which makes the route 250m shorter and avoids crossing a busy road (right)[201]

Danish standards for intersections state that ideally a cycle highway should not cross areas with other traffic modes, however, as space and construction costs limit the feasibility of this, it is suggested that a) the number of stops to be minimized and when stopping cannot be avoided, b) signals are modified to ensure ease and safety and c) safety considerations are made in the design of the intersection.[187] In London, standards slightly differ, for by example the use of a 'shared nearside lane', which takes shape as a bike path, and denoted as such, with the width and markings for use of cars turning left; this suggests to vehicles that they are merging into a cycle route and encourages cyclists to take a primary position.[188] Cycle highways in London consistently use lane markings and colouring that continue through the intersection to denote the throughfare at conflict points (Figure 13).[188]

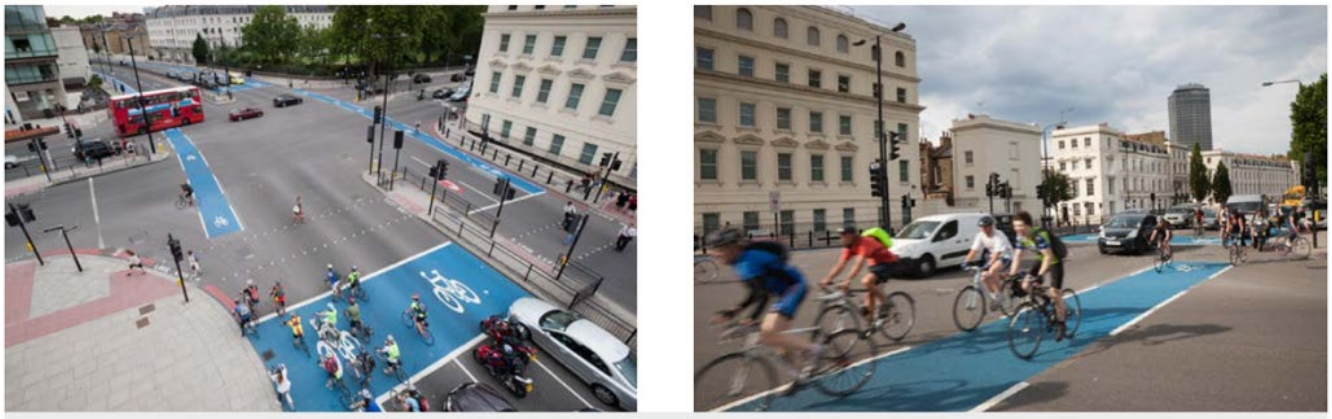


Figure 13: Lane markings and surface colouring used to show the path of cycle highways through an intersection in London[188]

7) Consistent and Ample Widths

Width is an important consideration to ensure that the route can accommodate certain volumes of people cycling, in addition to allowing for people cycling to overtake or ride alongside one another.[21,187,189,195] Ample widths contribute to people cycling being able to maintain consistent speeds, as well as contributing to safety and comfort for all ages and ability levels. The ECF highlights that for cycle highways, bidirectional paths should be at least 4m wide, and unidirectional paths, at least 3m wide.[29] However, commonly there is reference to recommended widths for two way paths being between 3 and 4m wide[187–190,195,196,199] and for one way paths, between 2.5 and 3.5 m[187–190,195,196,199].

This is consistent with suggestions from the Netherlands, 4.0m for bidirectional and 3.0m for unidirectional paths.[189] In Copenhagen, however, widths of the routes (two way bike paths, one way bike lanes along roads, and two way bike lanes along roads) are also considered with relevance to the numbers of riders expected per peak hour (pph) in one direction.[187] For example, a bidirectional path with under 200 cyclists pph is recommended to have a width of 2.5-3m, up to 1,500 cyclists pph, 3.0-4.0m, and if more than 1,000 cyclists pph are expected, a minimum of 4.0m is suggested (Figure 14).[187] Additionally, increases in cyclist volumes must be addressed to ensure the cycle highways continue to function.[187]

Figure 14: People cycling at Dronning Louises Bridge, Copenhagen, Denmark, with more than 1,500 people cycling per peak hour[187]

8) Paving is Preferred and of High-Quality

For cycle highways, it is preferred that the surface is paved and of high-quality.[187–189,195,199] This is considered important as it contributes to the routes being of overall high quality, it makes it easier for people cycling to maintain speed, and ensures the safety and comfort for people of all ages and abilities. In the Netherlands, asphalt/concrete is preferred, but at a minimum it is required to be even and skid resistant.[189] Cycle highway guidelines from Denmark further specify that high quality paving should be consistent across the path width and therefore things that impede this (*e.g.* drainage grids, ramps) should be located outside the width designation.[187] They further outline the allowance for irregularities of different sizes in the paving surface per 100m, in addition to stipulating that unevenness due to covers and joints (*e.g.* manhole covers) should not exceed 3mm.[187] Comparatively, in London, cycle highways undergo a colour surface treatment that has been predefined (*e.g.* Barclays cycle superhighways are colour Barclays blue).[188]

9) Lighting

It is largely agreed upon that cycle highways should be lit.[29,66,187,189,195,199] This ensures that their use is not limited by daytime hours and that nighttime usage and during the shorter days of wintertime is possible. Lighting, especially important at nighttime, contributes to these routes being of high quality and ensures safety and comfort for all, around the clock. In the Netherlands and Belgium, a lighting standard has been specified by delineating a lux level standardization required of cycle highways.[66,199] In Denmark, a class system for lighting requirements is used and specified for urban areas, tunnels, and the countryside.[187] In London, all cycle routes require an appropriate level of lighting, which is determined by consulting the highway authority's lighting unit; in areas such as parks/conservation areas where lighting is not acceptable for aesthetic or conservation reasons, low-level time, motion-sensitive, or solar stud lighting is suggested.[188]

10) Minimizing and Alleviating Gradients

Generally, cycle highways should avoid steep inclines and prioritize mild grades.[29] By minimizing and alleviating gradients it help riders maintain consistent speeds, ride comfortably, and accommodate for various ages, abilities, and fitness levels. Guidelines from Germany are consistent in recommending a gradient of less than 4%, and a maximum of 6% for cycle highways.[192,196] Within the Netherlands, a gradient between 2 and 10% is considered acceptable, however, this recommendation comes along with the concept of slope severity (S), defined as the square of the height (H) divided by the length (L) ($S=H^2/L$).[66] A cycle highway is recommended to have a slope severity of less than 0.075, and a maximum of 0.200.[66] Another method of mitigating an incline, when it cannot be avoided, is to interrupt them with 'breaks'. This ensures greater comfort for the rider throughout the incline.

11) Clear Signage and Branding

Clear signage and branding is an important design aspect for cycle highways[21,66,187–189,195] and contributes to them being readily identifiable, intuitive, and easy to use. Branding also ties into how the route is marketed and perceived by individuals, including people new to cycling. Signage on a route advertises it and ensures other road users are aware of people cycling.[188] Signage has been deemed important for wayfinding as it gives directions, confirms the route after a decision point, and gives reassurance between links of the route (Figure 15).[188] A lot of the cycle highway signage and branding takes inspiration from vehicle highways in terms of the numbering systems of the routes within a network, *i.e.* they are often a number followed by a letter.[66] Implementing signage, including nearby locations and distances, helps with wayfinding.[66,188,195]

In the Netherlands wayfinding and recognizability is required of cycle highways through route signs, signposting, and route symbols.[189] In Denmark, signs and markings along cycle highways follow the orders

that pertain to all road markings, uniformity is prioritized, and directions contained within routes include important destinations and public transport.[187] Logos are placed consistently along the cycle highway and include the route number and arrows for guidance at intersections. This is consistent with cycle highways in London, which stress that the signage strategy should be part of the route planning and design process, opposed to an afterthought.[188] Signage has clear guidelines on dimensions, spacing, and locations they should be placed. Cycle highways also can have bike symbols, route numbers, and direction arrows painted onto the pavement.[188] Early branding in London, for the 'Barclays Cycle Superhighways', included surfacing in Barclays blue, effective in distinguishing them.[188]

Figure 15: Various signage used on cycle highways in London, United Kingdom, including direction signs at decision points, route confirmation signs, and painted pavement markings (left to right)[188]

12) Regular maintenance and winter service

Regular maintenance and winter service are important to ensure that the cycle highway continues to be a reliable route to travel along, at all times of the year.[29,187,188] This ensures cycle highways continue to be the highest quality bike routes, that people cycling can maintain consistent speeds, and that they are safe and comfortable to ride, even in winter (Figure 16). Operating conditions should be considered already in the planning phase of the route in cooperation with all road stakeholders involved in the route.[187]

In London, maintenance and servicing of cycle highways falls under the established and rigorous framework for the maintenance of cycle routes and facilities generally: they are held to a higher standard than vehicle roads.[188] Additionally, cycle highways are at the highest level and get priority for maintenance and servicing compared to other routes.[188] This includes regular resurfacing, integration into planned road maintenance programs, community reporting, and aims to address obligations under the regarding equity of use and, overall, ensuring people cycling are not deterred from a route.[188]

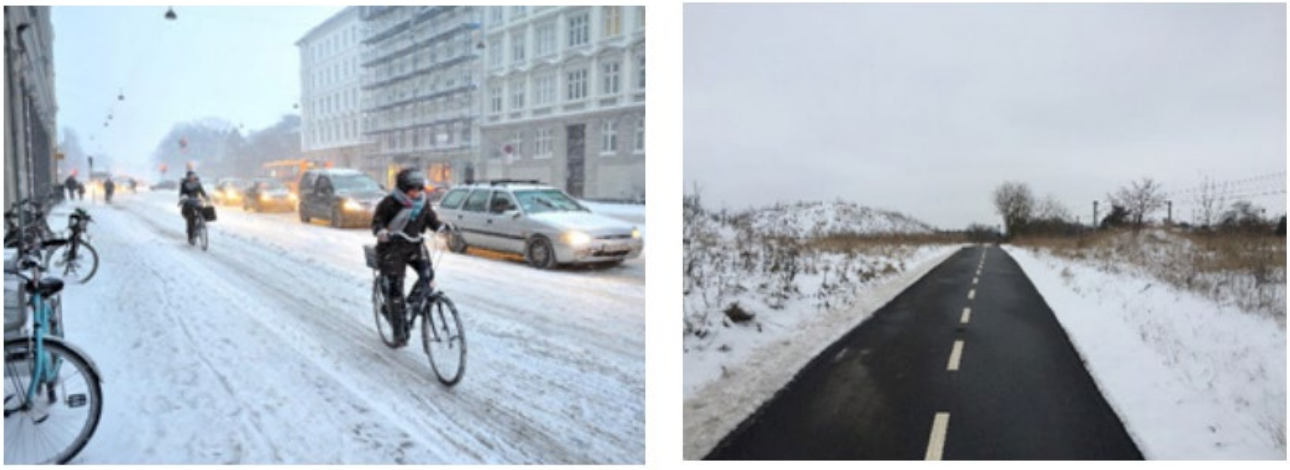


Figure 16: Examples of winter maintenance: unplowed path along a road (left) and plowed path in its own route, depicting good winter operation (right)[187]

13) Service Stations

As cycle highways are considered the highest quality bike infrastructure, they also come with the provision of various services that contribute to an enjoyable.[29,187] In Denmark, service stations can include washing and repairs stations, bike pumps (Figure 17), information boards, drinking water, and bike parking, to name a few, and are usually grouped together at nodes: where cycle highways cross, at public transport with bike parking, or places people cycling gather and meet.[187] It is recommended that they are decided upon and designed through close collaboration with test commuters and bike-affiliated organizations.

Figure 17: A service station with an air pump (Albertslund route, Denmark) (left)[187] *and a bike tube vending machine on a EuroVelo route, Austria (right)*

C. Case Studies – Detailed Background

Each case focuses on the one/two earliest routes implemented, identifies the key stakeholders involved, describes what the process entailed before construction, funding sources, and the route selection process. For each case a relevant practitioner was interviewed to acquire missing information and discuss factors contributing to project success.

Capital Regional of Denmark, Denmark

The first two 'cycle superhighways' constructed in Copenhagen and nearby regions are the Albertslund route and the Farum route.

Albertslund Route C99
2012
18km
Route description: Largely green surroundings, road sections through Frederiksberg, Copenhagen, and Rødovre. Comprised of traditional Copenhagen separated bike paths along roads, painted bike lanes, and paths in their own route; sometimes is not the most direct possible.[146] See Appendix A for route map.
Municipalities: Albertslund, Glostrup, Rødovre, Copenhagen, and Frederiksberg
Cost: Facilities DKK 25 million; Annual operation DKK 2 million[145]
Facts and figures:

- Saw a 14% increase in cyclists after construction (2010 to 2018)[145]
- Numbers of cyclists have increased by 61% during weekday morning rush hour and by 73% on weekday evening night rush hour[22]
- 10% of new cyclists used to travel by car[145]
- Average trip length on the route is 7.5km[202]

Farum Route C95
2013 (Farum to Bellahøj); extended 2017 (Bellajøj to Kongens Nytorv)
21km
Route description: Along motorway, and open country and forest, 13 tunnels, multiple lighting facilities. See Appendix A for route map.
Municipalities: Furesø, Gladsaxe, Copenhagen
Cost: Facilities DKK 41 million; Annual operation DKK 2 million[145]
Facts and Figures:

- Saw a 68% increase in bicycle traffic after opening the route (2012-2018)[145]
- 28% of new cyclists used to drive[145]
- Average trip length on route is 14.7km[203]; on cycle superhighways (in general) it is 11km[27]

Who

The Cycle Superhighways Collaboration:
In 2009 with 16 municipal regions joining together on the potential of long-distance interconnected and cohesive cycle routes within the capital region of Denmark. The Cycle Superhighways Collaboration was subsequently created in 2011.[147] Now there are 30 member municipalities, with another joining in early 2021.[146] The collaboration includes multiple groups, namely:[148]

1. Steering group: Collectively decides what direction to take and approve new projects and cycle superhighway routes. Comprised of 1) heads of planning and traffic from each 30 member municipalities, 2) a representative from the Capital Region of Denmark (CRD), and 3) a representative of the Danish Road Directorate.

2. Project group: helps develop and implement concrete solutions and contribute professional knowledge. Comprised of representatives from 30 member municipalities (often road/traffic planners that handle implementation of municipal cycle superhighways daily).
3. Operations group helps develop new cooperative solutions and ensures coordination of operations. Comprised of representatives from 30 member municipalities (often operations personnel who carry out day-to-day maintenance and operations of municipal roads and paths).
4. Office of Cycle Superhighways: facilitates cooperation, ensure plans have political backing, and coordinating municipal cooperation during various project phases. Documents impact of cycle superhighways and develops new solutions to improve cycling conditions. They conduct an annual meeting including all municipalities along each route to discuss and update each other on the condition or concerns of the route.[146]

Early Stages

Copenhagen had set an ambitious goal of increasing the modal share of bikes trips to work and education to 50% around 2005, however, within a couple years of making efforts towards this, they realized that the vast majority of people driving cars in Copenhagen were not residents, but rather those coming from the municipalities surrounding Copenhagen.[146] Without jurisdiction over the neighbouring regions, they knew they needed to work in collaboration. To increase bike ridership and reduce the influx of cars from the neighbouring cities into Copenhagen, they decided to develop high class commuter routes for people cycling from the suburbs to the city centre.[146,148]

In 2008, the City of Copenhagen initiated an analysis outlining the notable potential of long distance bike commutes across municipal borders in the Capital Region.[147] The analysis was contracted out and the consultants identified numerous radial routes, which were outlined within a report and included distances and approximated ride times.[146] David Rønnov highlights that at the time they knew that people were willing to bike 5km to work but distances to the suburbs were much more than this, so the challenge was to encourage people to bike those longer distances.[146]

As the routes, at minimum, transcended municipal boundaries, Copenhagen knew collaboration was required and key; in 2009 Copenhagen joined with 15 other municipalities.[147] David highlights that in order to create the collaboration it required a lot of 'tiptoeing', as there are many feelings surrounding the topic; this includes conflicting interests, politics, differing levels of car reliance, and also, because some municipalities are smaller than Copenhagen, they might feel a power dynamic.[146] Copenhagen entered discussions with a lot of humility and was careful not to be perceived as telling other municipalities what to do and rather presented the concept as an option. It was made clear the project did not aim to limit car driving but rather improve cycle facilities.[146]

In 2011, the Cycle Superhighway Collaboration was developed along with a conceptual strategy for the project.[147] This was the basis that existed when the first two routes, the Albertslund route (2012) and Farum route (2013), were launched. 2013 also saw the establishment of the first national cycle superhighway fund: it provides 50% of the investment for cycle highways throughout Denmark.[147] Before the establishment of the Cycle Superhighways Collaboration, municipalities would build short local routes and longer commuter routes were difficult to conceptualise – the Office of Cycle Superhighways steps in to provide guidance on the latter.[146]

Albertslund Route

The Albertslund route was constructed in 2011 and the first cycle superhighways constructed in the Capital Region. Figure 23 gives a sketched-out representation of what the process entailed. The first of the four lines shows the Albertslund route fragmented both visually and functionally; it is a stretch of bicycle infrastructure with missing links in between. The second line, comprised of small dots, depict the addition of various physical measures addressing missing links. The third line show a functionally complete and physically cohesive route. The last line depicts the completed route, after signage, wayfinding, and a visual identity have been added, making it functionally and visually coherent.

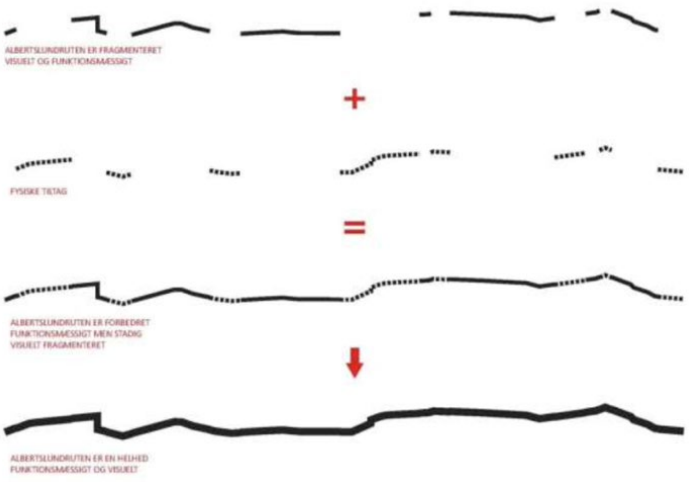


Figure 23: Visual representation of the upgrades made to the Albertslund route, including filling missing links and creating a cohesive visual identity[147]

Farum Route

A bike route that was largely built in the 1970's, during the construction of a motorway to connect some of the suburbs north of Copenhagen, preceded the construction of the Farum route. This meant there was already people cycling along this route before it was developed into a cycle highway. Some improvements were made, namely to the urban stretches before the motorway, and signage was posted along the route. Once the route opened as a cycle superhighway, however, it led to a 68% increase in bike traffic - this stands out compared to the other cycle superhighway routes.[145] David highlights that not so much was done to this route in term of infrastructure upgrades but rather selling the idea and communication around the route can be attributed to its succes.[146]

Funding

Financial support from regional and national governments is considered important as inter-municipal cycle superhighway projects address regional challenges. Even though construction may occur at the municipal level, they are difficult to prioritize with a municipal budget. The national and regional government support for the cooperation and co-financing of the network was crucial for the success of the cycle superhighways project and ensures it continues to be a success.[148]

The construction of the cycle superhighways themselves is in principle funded by the municipality in which it takes place. This is because the roads have either federal or municipal designation in Denmark and the roads people bike along are largely municipal roads. Municipalities are able to apply for funding on a yearly or biannual basis for approximately half of project costs.[146] The cycle highways constructed to date have

received between 40 and 50% co-financing by the state.[148] The municipalities are responsible to pay the operation and maintenance costs.[148]

Route Planning Process

Route planning was initiated by the City of Copenhagen: consultants identified numerous radial routes, which were outlined within a report and included distances and approximated ride times.[147] Routes were decided upon by developing a heat map (Figure 24). The red areas depict places with more than 10,000 activities in the radius of 2km; activities are defined as residencies, workplaces, and adult education facilities ('S' denotes city train stations). This map clearly depicts areas to connect by the cycle superhighway routes, as the routes were focussed on commuter cycling and not children or recreation.[146]

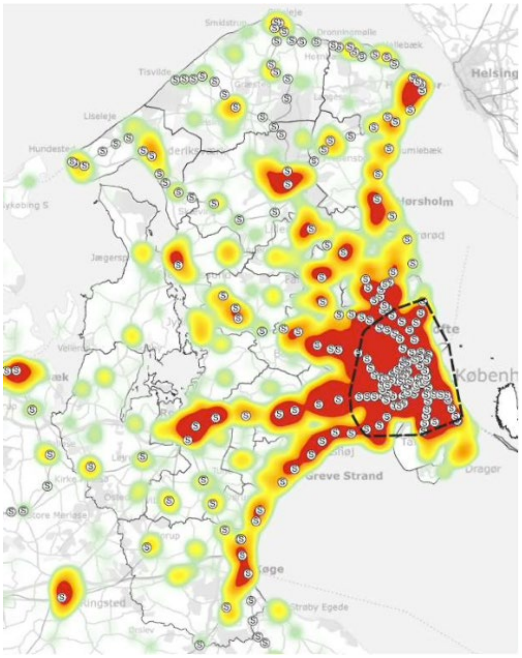


Figure 24: Map depicting areas of the Capital Region with high levels of activities (red >10,000 within 2km)[204]

Generally, route research is done by public sector organizations. It also includes partnerships with universities on data collection; one project conducted entails calling approximately 5,000 individuals and asking them to describe each trip they took in a day.[146] This project helps estimate traffic flows within the region and is considered important data in developing the network.[146] However, lots of routes focus on expanding and improving the pre-existing cycle infrastructure and developing them into a cycle highway.

A potential route is first screened, looking at satellite images/google street view, to report on what needs to be remedied. The route is then ridden with stakeholders to see what needs to be changed or upgraded (*e.g.* widths, wayfinding). Routes are often ridden by an individual, collecting data, and then entering it into a rating spreadsheet. The features of a cycle route are entered and assessed and only once a pre-determined threshold is reached, they can be deemed a cycle highway. The criteria of a cycle superhighway is defined in a design manual, Koncept 2.0[187], outlining specific guidance on construction and design of cycle highways.

Gelderland, Netherlands

Rijnwaalpad (F325)
2015
17.7km
Route description: 4m wide path, smooth red asphalt[138]; passes through two tunnels and 'green bridge', along the A325 road with separation of noise barrier[205]. Can be considered an upgrade to a largely pre-existing route.[138] See Appendix A for route map.
Municipalities: Arnhem, Lingewaard, Overbetuwe, and Nijmegen.
Cost: 17,000,000 euro[205]

Who

Many parties came together in the order to realize the cycle highways in Gelderland. Development of the *Rijnwaalpad* included the central government, the province of Gelderland, the Arnhem-Nijmegen urban region and adjacent municipalities, along with interest groups, such as Fietsersbond.[155] The Ministry of Infrastructure and Environment and ProRail collaborated on construction of bridges and tunnels.[155]

Fietsersbond (Dutch Cyclists' Union):
Fietsersbond is an organization representing the 13.5 million cyclists in the Netherlands and aims to create more and better opportunities for cycling. They are comprised of 35,000 members, 1,500 active volunteers and spread over 150 local branches throughout the Netherlands. They are active in research, lobbying, consumer information, and publicity. They play a big role in campaigning for cycling with numerous local advocates and experts in infrastructure development and design.[133]

Fietsersbond was given a grant from the national government to fund the investigation and development of cycle highways to combat car congestion; congestion in the Netherlands is largely contributed to by short car trips.[133] This was closely followed by pilot projects.[133] *Fiets Filevrij* (Cycle Traffic-Free) by Fietsersbond started a campaign with 5 promising, comfortable fast routes where there is often traffic jams.[151]

Now, as a strong supporter of *snelfietsroutes,* Fietsersbond works with the Ministry of Infrastructure and Water Management, local authorities, and many others to promote and realize new routes.[206] They often help with the early stages of getting *snelfietsroutes* projects started but are not so much involved once the project gains momentum.[133] They also help independently assess whether fast bike routes meet quality standards.[206]

Tour de Force:
The Tour de Force aims to increase the kilometers cycled in the Netherlands by 20% from 2017 to 2027. They began in 2015 as a joint government initiative to invest more attention, priority, and money into bicycle policy and consider the wider social benefits. The joint leadership is overseen by a representative from each of the Association of Netherlands Municipalities (VNG), Provincial Authorities (IPO), Transportation Regions (Vervoeregios's), Dutch Water Authorities, and the Ministry of Infrastructure and Environment. This team collectively works on agreements within the National Bike Agenda.[133,207]

The Bicycle Agenda outlines various goals, including boosting the quality on busy and important regional cycling routes, and outlines clearly main points and actions towards the realization of these goals.[207] The organizations associated with each goal are also delineated; regarding regional cycling routes these are[207]:

1. Government organizations: municipalities, provinces, Transportation regions, Dutch Water Authorities, Ministry of Infrastructure and Environment, ProRail, National Institute for Public Health and Environment (RIVM), Rijk (I&M)

2. Market sector: BOVAG[b], FIPAVO, RAI
3. Civil Society organizations: ANWB, Fietsersbond, Nederlandse Tour Fiets Unie
4. Collaborations: National Bicycle Platform Foundation
5. Knowledge institutes: CROW-Fietsberaad
6. Teams Tour de Force: Regional Route Selection / Financing Team

Early Stages

The developments of cycle highways in Gelderland began with a local chapter of Fietsersbond going to the vice-mayors and aldermen in 2008 and asking for better cycling connections between the cities.[138] But, at the time, the local government did not know how to handle the project, involving 4 municipalities, so it was offloaded onto the regional agenda and risked being shelved.[138] This changed when the National Government made a budget amendment towards investing more into cycle infrastructure, directly leading to notable funding for the region.[138] In Gelderland, the *Rijnwaalpad*'s formal objective, and prerequisite from the national government, was to reduce congestion on the main highway.[182]

The support within the national budget occurred as cycle highways crept up the national agenda, as a strong case was made through a focus on congestion amelioration.[133] This budget is supported by the current national government: a right-wing party, reigning since 2010, and the most pro-car party in the Netherlands.[133] The connection between motorists and people cycling is simple: by improving conditions for people cycling, you thereby reducing traffic and also improve the conditions for the drivers that remain on the roads.[138] Now, many bike officials and municipal governments are convinced that cycle highways are a beneficial development.[133]

Fietsersbond was involved in the project before funding was allocated and very early on as a primary project leader, helping in collaboration talks to create a network of cycle highways.[133] As there is not a government model on how to go about collaborations, this means that things are discussed and agreed upon on a case-by-case basis.[133] This can be a difficult process and it can take quite some time for all the stakeholders involved to come to an agreement.[133]

Funding

In Gelderland, and all of the Netherlands, cycle highways have been created with subsidies from the national government, province, or city region, along with some EU subsidies, and air quality/climate subisides.[152] In early meetings pertaining to the *Rijnwaalpad*, monetary contributions were agreed on by the National Government (€5 million), the province of Gelderland (€5 million), and the Arnhem-Nijmegen urban region (€5 million) and this was followed by commitments from municipalities (€4 million total).[208]

Wim Bot has noted that there is not fixed government model for the process of developing cycle highways so discussions can take quite some time, especially pertaining to monetary contributions.[133] Issues also arise when small municipalities may not see the benefit they receive from a route passing through their region.[133] It has been suggested for cost to be separated based on cycling potential, with larger municipalities contributing more.[152]

Although the funding for the *Rijnwaalpad* was obtained quite easily, this was not likely to happen again.[138] For subsequent routes they were forced to identify, assess, and pursue individual funding schemes.[138] Making an economic case and convincing the public played a big role in securing subsequent

[b] *a Dutch trade association of various vehicles and associated activities*

funding.[138,133] Gelderland stacks up very well compared to other provinces in the Netherlands in term of total investments secured (€59 million) and a comparatively low proportion not covered by investments (€2 million) in their regional cycle route plans. However, Wim Bot highlights that to date national funding has been incidental and that long-term funding is needed for a normal running program, as it would allow for security in planning.[133]

Route Planning Process

Route mapping is done by a collaboration between local governments and Fietsersbond by taking factors such as the origin and destination of traffic, workplace density, and future housing developments.[133] Within the Netherlands, an important argument is often accessibility: 61% of the population lives within 15km of work but the bike modal share up to that distance is only 10%.[152] This highlights that there is a lot to gain, especially with e-bikes allowing coverage of longer distances. Fast cycle routes also a viewed as a way to connect urban and rural areas, creating opportunities of recreation to the urban resident.[152]

The theme of congestion alleviation, a national issue, has played a significant role in fast bike route funding and planning. In Gelderland, this has motivated work into defining a network of links, up to 15km, between residential and work areas, along with policy goals.[138] They aimed to reduce car dependency and provide drivers alternatives to sitting in traffic jams; this was directly linked to accessibility to the main nodes (*e.g.* city centre).[138] Following defining a network, predictions were made on how these routes would impact congestion, including traffic modelling and cost-benefit analysis.[138] These became the transformative tool used to secure financial partners.[138] For example, the road department funded one bike tunnel near a major intersection because of such large reductions in travel times for road users.[138]

Overall, regions that are candidates for cycle highways have high population centres.[133] More recent discussions in Gelderland proposes that in order to justify creating a *snelfietsroute,* it must have the potential of 2,000 cyclists per day (busiest point) and an average of 1,000 cycles per day over >70% of the route.[183] Additionally, most of the cycle highways in the Netherlands have been developed from previously existing bike routes, meaning routes are upgraded to cycle highway opposed to being built from scratch.[133] Sometimes a pre-existing bike route reduced by just 2-3km makes it a cycle highway and a good alternative to the car.[133]

London, England

CS3
2010
12.3km; extended 2016 (Tower Gateway to Parliament Square) and 2018 (Parliament Square to Lancaster Gate) to 24km.
Route description: segregated from traffic for almost entire route, runs along shared footpath, parallel to A13 (major road), small streets, and parallel to river Thames. See Appendix A for route map.
Municipalities: City of Westminster, City of London, Tower Hamlets, Newham, Barking and Dagenham.

CS7
2010
13km
Route description: colliers wood tube station, along each side of A42 road, painted lanes with no physical separation, Tooting Broadway tube station, along Tooting High Street in vehicle traffic and then into widened cycle lane with parking restrictions, past Clapham Common tube station, along A3, Stockwell tube station, Oval tube station, avoids busy Elephant and castle roundabout along footpath, controlled crossing, to Southward Bridge and near Cannon Street tube station (inner city). See Appendix A for route

map.
Municipalities: Merton, Wandsworth, Lambeth, Southwark, City of London

Cost: Both the CS3 and CS7 together, and supporting measures (cycle trainings, maintenances, and parking), cost £18m. Generally, one Barclays Cycle Superhighway, including supporting measures, costs between £8 and £11 million.[209]

Who

Ken Livingstone (Mayor of London 2000-2008)
Plans for 12 'cycle highways' in London were first announced by mayor Ken Livingstone in 2008. During the time Livingstone served as mayor, many foundations that laid the groundwork for the Barclays Cycle Superhighways were established.[162] Prior to the work of Livingstone and through the 90's, cycling levels and provisions for cycling were extremely low; the first National Cycling strategy was launched in 1996.[164] Livingstone's activities included creating the Cycling Centre of Excellence at TfL in 2002; they were to manage the proposed 900km of the London Cycle Network (LCN), being in development since 1996 but progressing slowly.[162] This occurred along with the London cycling action plan (2004)[210] from TfL, which changed policy and set clear targets regarding cycling. Additionally, a team was also set up to bid for major events and, in tandem, a bid to host the Tour de France Grand Depart in 2007 was put forward.[162] Livingstone also proposed a cycle hire scheme for London.[164]

Boris Johnson (Mayor of London 2008-2016)
During the election and at the beginning of Boris Johnson's term as mayor of London, pressure was put on transportation issues and continue cycle infrastructure developments made by Livingstone. In 2009 Johnson called for a 'cycling revolution'[164] and in 2009/2010 a record investment of £111m into cycling was planned.[211] This included rebranding Livingstone's original cycle hire plan with support from Barclays for 2010[c].[164] Johnson pulled funding to finish the LCN+ network and shifted focus onto 16 Cycle Superhighways between inner and outer London.[164] This included the two pilot cycle highway routes, the CS3 and CS7. At the end of his term, he stated his 'single biggest regret' was not opening cycle highways sooner and can be quoted as saying "Knowing what I do now, we would have blasted ahead with our new segregated cycle lanes from the beginning."[212]

Transport for London
Transport for London (TfL) was established in 2000 as a local government body to manage transportation across London.[213] A management board is selected and appointed by the Mayor of London and their role is to implement the Mayor's transport strategy and manage transport services.[213] This includes transportation infrastructures, including buses and the London Underground, the congestion charge scheme, has responsibility for a network of main roads, all of the traffic lights, and taxi regulation. Since early on, they have also focused on cycling and cycle infrastructure within London[159]; the National Cycling Strategy Board was established in 2001[210] and the Cycling Centre of Excellence in 2002[162]. TfL also offered cycle funding for businesses within 1.5km of a Barclays Cycle Superhighway Route.[214] The scheme included a number of funding credits, averaging in worth of £4,000 that could be exchanged for cycle parking, staff commuter cycle training, and mechanic cycle safety checks.[214]

[c] *Done by Montreal-based PBSC Urban Solutions (scheme based on a feasibility study by German Dector-Vega and Charles Snead in November 2008).*

Barclays

The development of cycle highways in London was sponsored by Barclays Bank. They agreed to make a monetary contribution of £25m over 5-years.[165] The project was named after them: 'Barclay Cycle Superhighways,' and they also lent their corporate colour to the project, most notably in the surfacing of the paths. The initial cycle hire program launched in London came in parallel with the first cycle highways (2010) and were also sponsored by Barclays: 6,000 blue bikes with 400 docking stations.

London Cycling Campaign

The London Cycling Campaign (LCC) is an independent charity that lobbies for better cycling conditions in London. They have pushed to get numerous cycle routes built within London. Their vision is to create a world class cycling city and organize campaigns around reducing carbon emissions, low traffic neighbourhoods, ensuring perceived safety for all users, along with improving safety through education and road design. They have 11,000 members, who are covered by third-party liability insurance and connections for legal advice. The LCC were supportive of the routes and were directly involved, via discussions and meetings, in the development of Barclays Cycle Superhighways.[166] TfL involves them in discussions and they are consulted regarding cycle infrastructure developments.[159]

Sustrans

Sustrans is a UK-wide walking and cycling charity organization. They are best known for the project of the National Cycling Network, where they coordinate development, maintenance, and improvement of routes, however, are also small percentage owners (2%). They publish numerous guidelines and suggestions regarding cycling and cycle infrastructure, including education and outreach programs, assessment of the UK cycle network, and a Handbook for Cycle-Friendly Design[167], pertaining to design, including cycle highways.

Early Stages

The developments of cycle highways in London come subsequently to shifting transportation motivations; those specifically pertaining to cycling can be traced back to the 1990's. Cycling had been moving its way into the transportation agenda and city plans for some time, leading to the creation of various cycle infrastructures, which provided an opportunity for upgrades into a cycle highway network.

The London Cycling Action Plan was published in 2004 and outlined objectives for cycle developments and the London Cycle Network.[210] This network laid much of the groundwork to be later upgraded into cycle superhighways. Prior to the London Cycling Action Plan, The National Cycling Strategy (1996) provided a framework for cycle developments, the National Cycle Network (NCN), and ambitious targets to increase cycling.[210] The parts of the NCN's quiet lanes, on-road routes and traffic-free paths and parts were also later upgraded to cycle superhighways. In 2001, the Transportation Strategy was released by the mayor, outlining a basis of changes and improvements to transportation in London; cycling was an integral part and a key action of the establishment of the Cycling Centre of Excellence, to develop cycling in London.[210]

In 2008 Mayor Livingstone set the target of a 400% increase in cycling by 2025 and proposed £400 million for construction of 12 'cycle superhighways'; he can be quoted as saying "We want nothing short of a cycling transformation in London".[163] Shortly following, Johnson became mayor: Livingstone's original cycle highway plan was adapted and Barclays joined as a monetary sponsor. An approach to design and implement cycle infrastructure was developed; this included adaptations of European designs to the UK context, lobbying to change UK regulations surrounding cycling, on-street roll-outs, and learning from others via city visits and an international benchmarking study.[161]

For cycle superhighway developments within Greater London, TfL hosts discussions and brings together representatives.[159] TfL identifies stakeholders across London and local stakeholders for each route to engage with, including: elected representatives, representatives of road users (*e.g.* London Cycling Campaign, Sustrans, Freight Transport Association, *etc.*), London-wide organizations representing interest groups*.,* and frontages (those with property along routes).[215] Sophie Edmondson highlights that TfL, acting as the meeting host, creates a neutral ground for discussion and also conveys the interest they have in active transportation for Greater London; this contributes to city departments being receptive to conversation.[159]

The first 'Barclays cycle superhighways' were comparatively low cost and minor street changes to better accommodate people cycling. The schemes were coordinated by TfL and the 32 London boroughs and agreement was obtained from local councils before proceeding with the cycling schemes. The first two cycle highways constructed, the CS3 and CS7, were closely followed two more in 2011. The initial routes were part of a pilot program that was already embedded within intentions and plans for a larger network throughout London. TfL has continuously worked on the cycle highways program to research and learn from mistakes and improve pre-existing routes through continued improvemnts.[161] Around the time and following the developments of early cycle superhighways, there was pressure from campaign groups, bloggers, and commuter cycling though social media and on street demonstration that brought London's cycle routes to the media's attention.

Funding

Funding for the Barclays Cycle Superhighways came largely from national government grants and TfL for cycling improvements.[159] The eight London Borough and businesses along the pilot routes were provided additional funding from TfL, for bike parking, cycle trainings, and maintenance sessions.[216] Barclays bank also agreed to contribute £25m over 5-years.[165] This kind of funding – named brand urbanism – is a relatively new strategy within the urban public space[170] and has not been seen often in the development of cycle infrastructures. This source of funding can help provide a greater possibility for local governments to realize ambitious projects, as the brand shows its involvement and responsibility for a city.[170]

Route Planning Process

The 12 original radial routes expanding from central London were selected to provide geographical coverage, upgrade routes with existing cyclists, and with future commuter potential (Figure 28). Various criteria was included in informing route selection, including[209]:

- Safe, straight, direct, continuous routes between central and outer London
- Space for high volumes of cyclists
- Good geographical coverage of London (*i.e.* 'clock- face' layout)
- Market research based on census information
- Corridors popular with existing cyclists
- Corridors with potential to attract more cyclists
- Lots of 'trip attractors' (*i.e.* destinations people might want to cycle to)
- Presence of existing cycling infrastructure that would benefit from upgrades

Local councils, cycling groups, and other parties are then consulted regarding each of the proposed routes. However, many of the 12 originally proposed routes were not built due to opposition from respective London boroughs.

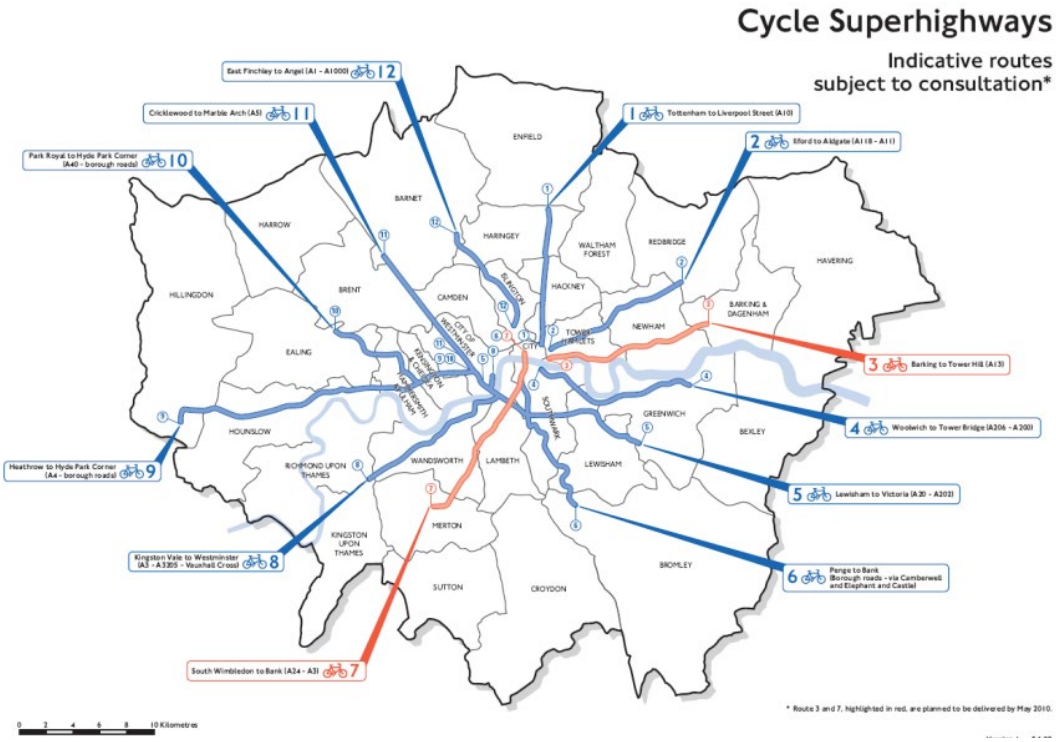


Figure 28: Cycle Superhighway network as proposed in 2009; orange routes denote those to be delivered in 2010[161]

The CS3 route from Barking to Tower Gateway already had cycling provision but was not continuous and underused.[209] This route was chosen by TfL to better connect the pre-existing infrastructure in order to increase facility use and considered a good value investment.[209] These upgrades came with other measures, including cycle parking.[209] Comparatively, the CS7 route was chosen following a study done by TfL, looking at travel options served by the Northern Line (tube).[209] It was concluded that door-to-door bike journeys were faster than those via the tube.[209] Now cycle superhighways (now called cycleways) are informed by a data and evidence led approach: the Strategic Cycling Analysis.[171]

Minneapolis

Midtown Greenway

2000 (phase 1); 2004 (phase 2); 2007 (Hiawatha Bridge connection)
8.9km (5.5 miles)
Route description: two one way bike lanes, and one two-way walking path, most of route is grade separated.[175] See Appendix A for route map.
Municipalities involved: City of Minneapolis
Cost: 36 million USD[185]

Who:

Midtown Greenway Coalition (MGC):

The Midtown Greenway Coalition (MGC) is a non-profit organization focused on developing and maintaining the Midtown Greenway.[217] They are 100% supported by donations and grants and receive no operating funds from the government.[217] Established in 1995, they worked to get each section of the Greenway built between 2000 and 2007 and advocated for engagement from public agencies.[217] They were the main community partner of the Midtown Greenway development.[173] After completion of the

Midtown Greenway their work continues, including making the Greenway safer, working with proximal building developers, improving signage and wayfinding, advocating for a streetcar along the route, coordinating clean-ups, and extending the Greenway (over the Mississippi River and through Saint Paul).[217]

Midtown Community Works (MCW) Partnership

Midtown Community Works, created in 1998, is a public-private partnership, including executives of corporations and non-profit institutions (*e.g.* MCC, Wells Fargo Bank), the Mayor of Minneapolis, and various elected officials from Minneapolis City Council, Hennepin County Board of Commissioners, and the Metropolitan Council.[173] They help guide redevelopment, by providing leadership, integrating planning, and mobilising resources, for the Midtown Greenway-Lake Street Corridor.[173] The partners are committed to a unifying public policy, based on a vision for the Midtown Greenway-Lake Street Corridor.[173] They help ensure targeted investments and coordination of public and private investments by the provision of a forum.[173] The goals of the partnership are: 1) enhance economic vitality within the corridor, 2) support a balanced transportation system and improve the integrations of the corridor within the city and the region, 3) enhance public safety and community vitality within the corridor.[173] The implementation of recommended projects are then carried out by the 'Implementation Committee.'[174]

Hennepin County Regional Railroad Authority (HCRRA)

The HCRRA is a political subdivision and local government unit that was established in 1980.[218] This effectively means that, and at the time of the Greenway Project developments, The HCRRA was comprised of 7 members which overlapped with the Hennepin County Board of Commissioners; this overlap meant that the politics were consistent and made things easier.[184] The HCRRA aims to acquire abandoned railroad corridors and preserve them for future transportation use along with planning, design, and implement light rail transit in Hennepin County.[218] They have authority to establish levies to fund rail project, as they are a unit of government.[218] They own 46 miles of corridors, including the Midtown Greenway.[218] They purchased the unused rail corridor in 1993.[219] Corridors are acquired for future transportation needs, although several recreational trails have been created for interim use; interim use is decided in collaboration with government agencies and public and non-profit partners.[218] The HCRRA, unable to construct or operate recreations trails themselves, partners with the City of Minneapolis and the Three Rivers Park District in order to complete projects.[218] The HCRRA played a significant role in funding the Midtown Greenway. Currently, there are tentative plans to build a light-rail alongside the bike and pedestrian trials.[219]

Early stages

What later became the Midtown Greenway was a non-operational (since the early 1990's) freight rail corridor, littered with trash.[175] The rail corridor was built approximately 125 years ago and part of Milwaukee Railroad's main line to the west coast.[217] The rail line faced more and more conflicts as the city grew and Minneapolis City Council directed the railroad to undertake a grade separation.[217] Prior to any formal discussions of a greenway, there was already an idea for some time of having a lakes to river connection via and East-West Greenway in Minneapolis.[184] At one point George Puzak was investigating having a throughfare street with traffic calming measures one block north of the busy Lake Street and Tim Springer was investigating the street one block south, 31st street.[184] Through this, George and Tim came together to work on realizing their shared Greenway vision.[184] In the late 80's, individuals who later founded the Midtown Greenway Coalition, began meeting with neighbourhood stakeholders along the corridor.[217] Discussions of turning the rail corridor into an amenity rich bike trail began with a group of volunteers and in parallel to a reduction in rail traffic.[217] The Midtown Greenway Coalition was founded by Tim Springer, George Puzak, and Joan Vanhala. Tim recollects the different visions each had for the future of the corridor: George was aiming for a green connection between the lakes and river, Joan wanted to improve the lives of people living in the urban core, and Tim wanted a fast, safe, and pleasant bicycle

transportation and recreation corridor.[184] These informed the future vision of the corridor. In 1993, the corridor was purchased by the HCRRA for future transit devopments.[217]

By 1995, the corridor was recognised for its potential as an active transportation route and prompted the formation of the Midtown Greenway Coalition (MGC).[175] The MGC advocated for the railway's transformation into the bike freeway of today.[175] This was closely followed by the development of the Midtown Community Works Partnership (MCWP) in 1998, during which a purpose and plan was emerging.[174] However, the challenge was "how to tell this story, how to reach a wide and very mixed audience - how to capture the imagination, energy and commitment needed to turn plans into projects and dreams into reality."[174] Within the MCWP, there were elected officials from each of the municipalities that the greenway ran through, along with representative from multiple interest groups along the route.[184] The MCWP engaged with stakeholders, created connections, and facilitated engagement with the project.[184]

Early on, the MGC and the MCWP operated in parallel, but not together; the MGC did not have a seat in the MCWP.[184] Collaboration between the two groups began as the MCWP needed to know more about the on-the-ground work, hence engaging with the MGC.[184] This led to the MGC being offered a seat in the partnership and future collaboration.[184]

Once there was broad-based commitment from various stakeholders in the corridor, the Lake Street Midtown Greenway Corridor Framework Plan (1999) outlined the collective vision and the steps required in order to realize the Midtown Greenway.[174] In parallel to the stakeholder commitment, there was a strong community and public interest in developing the rail line into a shared greenspace, along with commitment from a number of elected officials and council members.[184]

A strong focus and core value of the project was on 'placemaking and connections' and it outlined numerous other development activities in the proximal areas of the greenway.[174] Goals of the Midtown Greenway development included general improvements to the neighbourhood, housing stock, and the look and feel as well as better quality of life for neighbours and addressing environmental concerns, namely water quality.[173] Springer[184] highlights that changing an old railway corridor into a greenway is an urban planners dream and would want take advantage of its potential, ensuring that the project was integrated with its surrounding through careful development and time spent on visualising the goals of the project.[184] There was a multi-pronged strategy and everyone worked together to tackle problems and develop a new vision.[220] In many respects it is an easy project for politicians to support, as there is really no downside to it: it is a transition from a garbage filled rail corridor to a clean and pleasant travel and recreation corridor, recollects Tim Springer.[184] During its development, the example of Minneapolis's Cedar Lake Trail (constructed 1995-2011) was followed, which was the first implementation of the concept of a bicycle freeway with separated travel lanes in the United States.[175]

In parallel to advocacy for a bike and pedestrian route along the corridor, in 1999 the Metropolitan Council received funding for a busway in the Twin Cities from the Minnesota Legislature and the Midtown Greenway Corridor was selected.[217] The MGC responded in opposition, or rather passed a resolution calling instead for a light rail or streetcar line.[217,184] This was closely followed by a public meeting and the Metropolitan council agreed to conduct a feasibility study; some assumptions of this study were disagreed upon by the MGC and they decided to conduct their own.[217] A nationally prominent consultant, Jim Graebner (Lombardo Group), was contracted and concluded their findings in *The Feasibility of a Single-Track Vintage Trolley in the Midtown Greenway*[221].

Phase One of the Greenway opened in 2000, between 31st Street and Chowen Avenue to 5th Avenue, before rail service in the corridor ceased.[217] In 2001, trains stopped operating and the last railroad tracks between Hiawatha and Chowen Avenues were removed.[217] This segment became part of the Greenway (Phase Two) and was opened in 2004.[217] This was follow by the last segment, between Hiawatha Avenue and the Mississippi River, opening in 2006.[217]

During the process of planning and construction, the MGC worked with the city of Minneapolis and other public agencies. This collaborative group of stakeholders continually engages with residents, businesses, and private developers, ensuring continued improvement.[175] Since, 2006 the HCRRA began re-evaluating implementing LRT along the corridor and, since 2012, the MGC is working towards a vision for a turf track streetcar along the corridor.[217]

Funding

The Midtown Greenway, cost 36 million USD (including land acquisition, engineering, and construction costs) and was funded by a combination of Federal, State, County, city governments, and the HCRRA; the largest portion of costs were paid by Hennepin County the HCRRA.[185] Individuals from different levels of government were connected to the projects – connections that were made through personal communication throughout the development process - and contributed to providing continued support to the project.[184] Much of the funding from higher levels of government was obtained through grant proposals.

The HCRRA funded both Phase 1 and II land acquisitions of 4.2 miles (9.3 million USD), as well as the remaining, Phase 3, acquisition, of 1.3 miles, totalling 10.3 million USD.[185] The trail engineering and construction costs for Phase 1, 2, and 3 (5.5 miles) cost 9.8 million USD, which was funded by Federal transportation focused grants (4.5 million USD) and Hennepin County (6 million USD).[185] The engineering fees for the trails and Hiawatha Bridge were funded mainly by Hennepin County, along with a Congressman earmark for the bridge of 3 million USD.[185] The trail entrance site land purchase was paid for by Hennepin County (6million USD) and the construction of the entrance ramp paid for by the HCRRA (1.2 million USD).[185]

Past the initial construction costs, operations and maintenance costs have also been broken down and totaled (up to 2007). Trail infrastructure (pavement, signs, lights, security) was paid for by the City of Minneapolis Public Works (150,000 USD). Corridor vegetation, litter, graffiti costs have been paid by Hennepin County (310,000 USD). Policing has been done by the Minneapolis Police and funded by the Federal 'Weed and Seed Strategy[d]'.

Route Planning Process

The project of the Midtown Greenway revolved around its potential transformative ability of the divisive and segmenting abandoned ditch running through the community. The project, creating an active public space and recreational amenity, promised increased cohesion and revitalisation for the community. The route of the Midtown Greenway entailed retrofitting the pre-existing, albeit then largely unused, grade-separated railroad line (Figure 29). Therefore, the selection of the route itself was relatively straightforward and confined to the abandoned train line, although were the Greenway crosses Hiawatha Avenue, there is a diversion.[184] Tim Springer notes that this diversion, going north a block to avoid colliding with the train bridge over Hiawatha Avenue, was not the ideal decision and could have been better if the Greenway would have been allowed to continue in a straight line.[184]

[d] *"The goals of Weed and Seed are to control violent crime, drug trafficking, and drug related crime in designated high-crime neighborhoods and provide a safe environment free of crime and drug use for residents"*[244]

Figure 29: 29th Street Rail Corridor (1997), looking south towards Sears Roebuck Building, prior to construction of the Midtown Greenway (left)[222]; and the Midtown Greenway Trail Opening (2000) (right)[223]

However, the project was entangled with numerous development and revitalisation projects that elevated its value to the community (Figure 30). Proximal to the Midtown Greenway sits Lake Street (blue line); the two corridors run parallel, just a block away from each other.[174] Once upon a time, the railroad corridor served proximal businesses and helped retain jobs.[174] Historically, neighbourhood success and decline could be compared to the vitality of Lake Street, especially east towards the Lakes District.[174] Now, we see the Midtown Greenway interacting and contributing to life on Lake Street, especially at commercial centres and main intersections along Lake Street. Within the Lake Street Midtown Greenway Corridor Framework Plan (1999) each of the regions circled in yellow have been given a list of action steps for development, including things such as public art, recreation facilities, transit stations, and infill housing (Figure 30).[174] Effectively, the 'Greenway Renaissance' provided a range of opportunities for development, recreation, and regional connection.

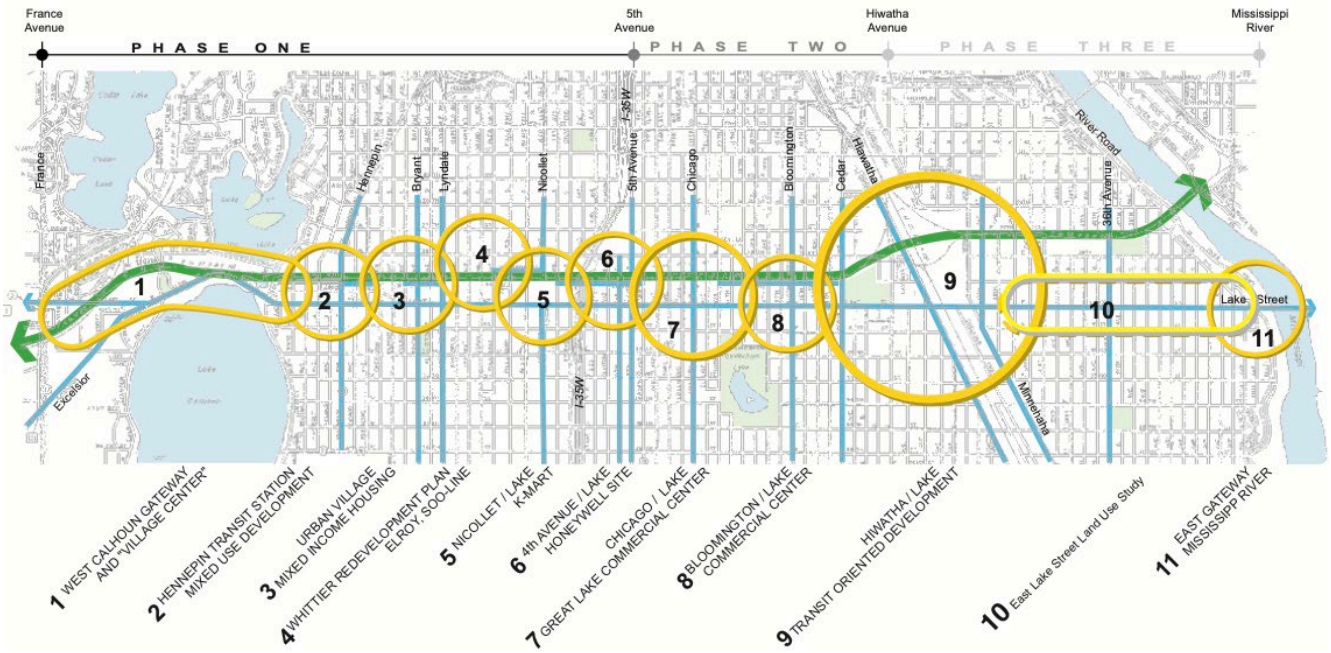


Figure 30: Recommended focus areas on key projects (yellow circles). Each project has a variety of initiates associated with it and aim to provide the basic community building blocks – housing, jobs, transit, and recreational amenities – making active and stable neighbourhoods with a strong sense of identity[174]

Capital Regional District

Lochside Regional Trail
2001
29km
Route description: runs from Swartz bay ferry terminal to Victoria, past beaches, farmland, wetland, country lanes and suburban backyards; mixture of paved and gravel surface, sometimes shared with motor vehicles[224]; stretches from Switch Bridge on the Galloping Goose to Swartz Bay ferry terminal in North Saanich.[225] See Appendix A for route map.
Municipalities involved: Saanich, Central Saanich, Sidney, North Saanich, Victoria
Cost: (see **Funding**)

Galloping Goose Regional Trail
1987 (rural portion)
43km (rural portion)[225]; 55km (1993-today)
Route description: passes through urban, rural, and wilderness scenery between Victoria and Sooke. See Appendix A for route map.
Municipalities: Sooke, Metchosin, Colwood, Langford, View Royal, Saanich, Victoria
Cost: (see **Funding**)
Regarding the Galloping Goose, Andrew Petter can be quoted as saying "Victoria is becoming a greenway capital. It is impossible to underestimate the economic and lifestyle benefits of having a continuous greenway linking the Western Communities with Victoria and the Saanich Peninsula."[226]

Who

Greater Victoria Cycling Coalition

The Greater Victoria Cycling Coalition aims 'to get more people cycling more places more often' including via education, facilitating communication, improving facilities, and improving laws surrounding cycling.[227] Over the past 26 years they have been active in lobbying around bike infrastructure projects including the Galloping Goose and Lochside Regional Trails.[227] They were part of the group which contributed to the initial phases of connecting the Galloping Goose trail and also contributed to the urban portion of the Lochside Regional Trail.[181] This was largely led by Denise Savoie, the chair of the Cycling Coalition at the time. They have also been active developing the Downtown AAA bikeway network, improving bike parking, installation of bike-triggered traffic lights, along with cycling education programs, and bike safety awareness campaigns.[227] Currently they are supporting the CRD's announcement[228] for separation of bike and pedestrian paths, lighting, and improved road crossings along parts of the Galloping Goose and Lochside Regional Trails.[227]

Capital Regional District (Parks)

The Capital Regional District (CRD) includes thirteen municipalities of Greater Victoria and three unincorporated areas. The CRD advocated and coordinated with public agencies, municipalities, and private organizations in order to establish and operate the trails system.[225] In 1988 the CRD proposed a 225km regional trail system from Swartz Bay to Point-No-Point (Juan de Fuca Electoral Area).[225] Part of this proposed network included the 29km that become the Lochside Regional Trail.[225] This included an that municipalities to include the trail in the official community plans and envisioning partnerships for trail development and maintenanance.[225] The CRD Parks now holds the lease on the land the trails reside on and manages both the Galloping Goose and Lochside Regional Trails. Some parts of the corridors were handed over from municipal governments (*e.g.* Victoria and Saanich), who at the time were the portion within their jurisdiction, to the CRD.[181]

Provincial Capital Commission

The Provincial Capital Commission (PCC) was a crown corporation created in 1956 with a mandate of "Connecting and Celebrating the Capital with all British Columbians'.[229] They owned and stewarded multiple heritage buildings and the subsequent revenue generated supported a self-sustaining business model and funded various outreach and initiatives.[229] They established a significant 'Greenways Fund', which spurred early interest and helped create momentum for the trails projects.[230] They also were part of the initial 3 way partnership, composed of the PCC, the Municipality of Saanich, and the City of Victoria, towards the development of the trails.[181] Both Andrew Petter and David Cubberley worked with the PCC and the associated trail developments. The PCC was later dissolved in 2014.[231]

The Ministry of Transportation and Infrastructure (MoTI)

The Provincial Government's Ministry of Transportation and Infrastructure was involved in the development of the trails as they were the landowners for significant portions of the routes. They initially held the land of the Galloping Goose right-of-way for potential future incorporation into highway developments.[181] The rural portion of the Galloping Goose was given to the CRD for management as a trail and subsequently MoTI agreed to lease the urban portion of the Galloping Goose to the CRD (a clause retained rights for highway developments).[181]

Regional Trails Coordinating Group (1980's)

They were established to consider rails-to-trails conversion opportunities and comprised of representatives from each municipality and from key recreations groups (hiking, cycling, equestrians).[172] They identified the Galloping Goose, Lochside, Interurban rail corridors and other inter-connections.[172] They are no longer in existence.[172]

The Municipality of Saanich and City of Victoria, along with the PCC, composed the initial 3-way partnership focused on developing the trails.[181]

Early stages

The corridors of both the Lochside and Galloping Goose trails are built on right of ways established by the Canadian Northern Pacific Railway (CNPR) in 1910.[230] Prior to the Lochside Trail, the CNPR ran a daily train trips, carrying passengers, between Victoria and Patricia Bay, Saanich – the Eastern Spur Line[230] - from 1917 to the 1920's – and freight until 1990.[225] The Galloping Goose trail developed out of a 177km train line running west out of Victoria, running through Sooke, north along Sooke Lake, skirting Shawinigan Lake, to Cowichan Lake, and Youbou (est. 1924). The line, largely used for transporting logs and freight, also had a passenger car known as the 'Galloping Goose'.[225] The Galloping Goose trail now connects Victoria to an abandoned goldrush site, Leechtown.[230]

After the train lines were decommissioned (the last of the Saanich Spur was removed circa 1988), as per federal law, the railways were offered for purchase to other government levels before private sale.[230] This resulted in the Province of British Columbia, Ministry of Transportation and Highways, acquiring the bulk of the right of way; a small piece was sold to the Borden Family.[230]

Galloping Goose:

With regards to the Galloping Goose, the majority of the right of way is owned by the Province of British Columbia and a lease allows the CRD to develop, operate, and maintain a regional trail along the corridor.[225] The rural portions of the Galloping Goose Trail were transferred by the Provincial Government to the Capital Regional District for operation as a recreational trail.[230] In 1987, the year the Galloping Goose opened, the land lease included 43km of the corridor between Atkins Avenue, View Royal and Leechtown, Juan de Fuca Electoral Area,[225] however, the urban portions were kept provincially owned[230]. This meant that there was no cyclable connection between the trail and downtown Victoria. MoTI held onto this piece for its potential future value in widening the Trans Canada Highways Capital Approaches and was coveted by BC Transit.[230]

At the time, the case for transit being compatible with a commuter trail in a 30m wide corridor needed to be made before the Galloping Goose could be realized.[230] The case included drawing on European examples, where corridors often have a shared purpose as a trail and for transit, in addition to the highway corridor already being wide enough for future expansion without including the railway right-of-way.[230] This process of pushing to lease the right of way to operate a cycling and walking trail benefitted largely from public advocacy.[230] This was initially led by Denise Savoie, and accompanied by two councillors from Victoria, Alistair Craighead and Geoff Young, one councillor from Saanich, David Cubberley, the President of the Victoria Cycling Coalition, John Luton, and Chair of the Victoria Cycling Coalition, Francesca van Lune.[181]

This process included bringing together municipal, provincial, and federal players to discuss the trails and come to agreements.[232] Discussions included using the right of way for highway widening and interchange building, the downtown portion becoming a transport 'queue jumper', and funding for the Switch Bridge.[233] In the around the early 90's, Councillor Geoff Young hosted a TV program with Denise Savoie, David Cubberley, and George Heffelfinger on the feasibility of using the rail right of way for the development of a trail, where they floated the idea and advocated for both the Galloping Goose and Lochside trails.[233] Savoie recollects that the advocates present from the City of Victoria, including Alastair Craighead and Geoff Young, were crucial, otherwise, "we in the community who were pushing for the

development of the trail that became the Galloping Goose trail, would have cried in the 'wilderness' for a long time."[232] John Luton recalls his, and Cubberley's, unique and advantageous position, both as an assistant to a Cabinet Minister were able to influence decisions and plans about the highway improvement project.[234]

Ultimately, it was backed by the Provincial Government and Minister Andrew Petter and a lease to use the right of way as a commuter-recreational trail was granted. This portion of the trail, between Atkins Avenue and Switch Bridge and Switch Bridge to the South Side of the Selkirk Trestle was leased to the CRD in 1993.[225] This agreement, however, included a caveat: a clause that allowed MoTI to take back portions of the trail in order to create space for interchanges along the highway.[181] However, David Cubberley highlights that overall it was a benefit that MoTI signed an agreement that ensured the trails continuity: when land was taken back, construction ensured that the trail would continue through the newly developed space.[181] Most recently, the McKenzie interchange resulted in a grade separation for the trail, taking form as a bridge of ample width.[181]

Lochside Trail:

The Lochside Trail came about after agreements with municipalities and the province permitted the CRD to establish and maintain the trail and outlined roles and responsibilities for maintentance.[225] David Cubberley notes that the Lochside developed more easily, subsequent to the establishment of the Galloping Goose, however, it was a more complicated process in some respects, as there were multiple different owners of the land along Lochside Drive.[181] The current 29km Lochside Trail is built on remnants of the old Saanich Spur right-of-way route.[230]

After the Spur line was abandoned, the land was handed over to the municipalities along the route in the form of a road allowance – Lochside Drive; some parts were developed for vehicle access while other parts remained closed off, and other parts became the Patricia Bay Highway.[225] Within the highway right-of-way, in order to build the trail, the key stakeholder to engage and receive permission from was MoTI.[181] However, other parts where Lochside Drive had been made into local/collector roads required permissions from Saanich to retrofit the road and integrate bike lanes.[181] Another portion of the trail had been sold off to Borden Mercantile, who subsequently wanted to build a parkade atop the trail.[181] Due in part to the shared land ownership, David states that the Lochside came together more slowly, took more doing, and numerous challenging baby steps.[181]

David attributes some of the process, or rather how things aligned throughout the process, to luck: there was advocacy at the community level from the Victoria Cycling Coalition, at the council level from Alistair Craighead, Geoff Young, and David Cubberley, and at the political level from Minister Andrew Petter.[181] In the early stages, David also stressed the importance of developing the nearer portions to downtown Victoria and in the heart of Saanich in order to establish a continuity of trail and build a constituency to use it.[181] He argues that this helps avoid argument on whether the project is worthwhile as people see proof of its value whenever they use it.[181]

Throughout this process, in parallel and contributing to its success, multiple visions and strategies concerning the Lochside Regional Trail were developed. In 1988, the CRD proposed a 225km regional trail system from Swartz Bay to Point-No-Point (Juan de Fuca Electoral Area).[225] This network linked major parks, natural and cultural features, and provided opportunity for outdoor recreation and commuters.[235] Part of the proposed network included 29km that became the Lochside Regional Trail.[225] This included an ask of municipalities to include the trail in their official community plans in addition to envisioning partnership for trail development and maintenanance.[225] In the mid-90's things started to take off, when the CRD Parks partnered with the PCC to create the *Regional Blue/Green Spaces Strategy.*[235] Following,

the CRD Parks Master Plan (2000) was developed with 3 years of public consultation and outlined the vision, objectives, and management direction of the regional trail system, the Lochside Regional Trail.[225] In 2001, the Lochside Regional Trail Management Plan was approved by the CRD, after consultation with Saanich peninsula municipal councils, stakeholders groups, and the public; it included a vision for development, management, and operation.[236] Municipalities developed their respective sections and agreement were made, allowing the CRD to operation the Lochside as a regional Trail in cooperation with the municipalities and the MoTI.[225] Now the Lochside Trail is managed by the CRD.

Both Cubberley and Luton recall throughout their development the trails were comprised of multiple smaller projects. These projects would then garner support for further trails developments. Luton[234] recalls how building the Switch Bridge (1997) – an overpass connecting the Goose and Lochside trails – and paving adjacent trails kickstarted further developments on both trails. Luton notes that whenever a piece is added, especially with regards to major projects, traffic on the trail would 'scale up by orders of magnitude'. Picking at significant gaps and barriers also helps, through increasing users, to create pressure to fix other sections along the route. This was seen by developing the Switch Bridge, effectively putting pressure on developing the Blenkinsop Trestle, bike lanes along Lochside Drive in Saanich, and fixes at key intersections.[234] Subsequently, the Blenkinsop Trestle catalysed enhancements to the Lochside Trail as a whole.

Funding

Many funding sources were contributed throughout continued development of the trails to realize them in the condition they are today. David Cubberley and John Luton note that there is no total cost for the project as it was a long sequence of context specific smaller projects (*e.g.* bike friendly signals, shared road bike lanes), involving different stakeholders, that came together to create the trails that exist today.[181,234]

Overall, funding included the PCC who played a significant role. Funding for specific projects was also contributed by the provincial Cycling Network Program.[230] Local municipalities made contributions within their jurisdictions and the CRD contributed based on established regional interest.[230]

The PCC was the first and principal funder of greenways and played an important role in getting the trail project going, helping develop both the Galloping Goose and Lochside Trails.[181] A combination between an initiative from Minister Andrew Petters and the Chair of the PCC, Pamela Charlesworth, helped create a million dollar 'Greenways Fund' (from internal PCC resources) which acted as seed money for the trails project.[181] This galvanised project interest and grew momentum.[230] This meant that there was a provincial entity that could partner with municipalities to help realize the trails; prior there was no precedent for this sort of project.[181] This contributed notably to realizing the first portion of trail – the rural portion of the Galloping Goose.[181]

David Cubberley[181] highlights the importance of '50 cent dollars' for engaging municipalities and getting them on board. Municipalities are receptive to signals from senior governments and are help to be convinced when partners are available and helping indicate a direction.[181] The bottom line of how much the project would cost was less important to convey and Cubberley states has the possibility of deterring project interest.[181] moving incrementally, getting things moving, and convincing people throughout the process worked within the context of the CRD.[181]

Later, in 2001, the Lochside trail project had to face the problem of rebuilding the trestle across Blenkinsop Lake. At this point the Lochside Trail was already largely constructed and addressing the issue of the bridge reconstruction came quite late.[181] Agreeing on this project, and how it was to be conducted, was a

long process and included funding contributions from multiple stakeholders:

Blenkinsop Bridge/Trail Improvements Project (2001)[237] (an example of funding distribution):
Total cost: $925,000
Funding agencies:

- Capital Regional District $150,000
- Cycle Network $200,000
- Millennium Bureau of Canada $265,000
- Provincial Capital Commission $160,000
- Municipality of Saanich $150,000

Additionally, the Highway Island Project contributed significantly to bridge construction, including the Switch Bridge, the Inurban Bridge, the Wilkinson Bridge, and the Helmcken Underpass, which all contribute grade separation from motor vehicles.

Route Planning Process

Both the Galloping Goose and the Lochside trail follow along the old train rail path and largely determined the routes. This notably simplified, and almost removed the process of route selection. With respect to the Lochside trail, it follows the routes of the Saanich Spur line that then became Lochside Drive. Today, some parts follow along the right-of-way of the provincial Patricia Bay Highway, developed in part out of the Saanich Spur Line, and along McDonald Park Road.[225]

Luton highlights that the trails also parallel the major highway corridors in the region. Due to this, communities and neighbourhoods that generate commuter travel along these roadways, also generate commuter travel along the trails to and from downtown.[234] It is somewhat uncommon for rail to trail facilities to align so well and mimicking travel patterns in the way the Lochside and Galloping Goose have.[234]

However, one portion of the Lochside Trail was developed quite late: the Blenkinsop Trestle. Before the bridge was restored, there was a proposal to run the trail out of direction to an adjacent major road, along it, then back to the trail alignment.[181] Although this scenario was argued for, Cubberley highlights that it would have been painful to track the trial out to a major road, have an intersection which would include people travelling in two direction, and track it back to the trail alignment and it would have been all of more expensive, along with increasing the risk and lowering the quality of experience for the users of the trail.[181] The bridge restoration, which is now the most beautiful bridge on either the Galloping Goose and Lochside Trails, turned out to be the answer only through a lot of process and building up of constituencies.[181]

D. Route Analysis – Further Details

Background and Basis of Analysis

A GIS analysis was conducted to investigate routes with good potential for the implementation of a cycle highway. In order to inform the GIS analysis, variables of interest were investigated. Variables were selected based on literature that outlined important traits of a cycle highway, especially those that were considered likely to have a notable and pre-determining impact on its future success and usage. We highlight that these criteria focus on the unchangeable or largely unmodifiable factors of the region, for example topography, versus factors that can be addressed retroactively through design and development, such as paving or separation from traffic.

The criteria outlined below were chosen for the following reasons:

- They have been based off and follow various pre-existing guidelines for cycle highways
- They are considered, or have the potential, to play a notable early-stage role in the development of a cycle highway (*i.e.* favourable route selection) and are deemed worth considering at an early stage as they are difficult to remedy retroactively
- They are feasible and an application of the GIS software
- Data is accessible and able to be imported into the GIS software when not available through GIS

Directness, length, and connecting major destinations all notably impact the viability of cycle highways to be a useful transportation facility. The gradient, intersections and stops, and the road type and posted speed limits also have notable effects on the efficacy of a transportation facility as well as on user comfort while riding the routes, such as energy expenditure or perception of safety.

It is also of utmost importance that cycle highways, in order to serve as a transportation infrastructure, travel through and connect major destinations.[21,66,187,198] Major destinations include residential areas,[66,152,187,191,198] employment areas,[66,152,187,191,192,198] amenities and commercial areas,[191,192,198] and education facilities.[191,192,198] Integration with public transportation helps facilitate multimodal trips, so proximity to transportation hubs should also be considered.[152,191,192,198] The aforementioned major destinations also line up with those listed in the B.C. Active Transportation Guide.[11]

Gradients should be minimized on cycle highways and throughout the literature specific recommendations pertaining to gradient percentage are given.[11,192,195,196] Generally, gradients are recommended not to surpass 4% and have a maximum of 6%.[11,192,195,196] Some jurisdictions employ a measure of gradient severity, calculated dependent on distance.[188,189,238]

Intersections and stops also negatively impact the efficacy of a cycle highway and it is considered important that they are reduced and avoided.[21,189,195,196] This can be done in the early stages of development by selecting a route that goes through areas with fewer intersections, have the right of way, or contain intersections with the potential to be treated retroactively; via this analysis we aim to pick routes with fewer stops and make an effort to treat this challenge proactively. In the Netherlands, cycle highways are suggested to have a maximum of 0.4 stops per kilometer and aim to ideally have none.[189] Reduced stoppages allow people cycling to maintain better average speeds while travelling along the route.

Across the literature, directness is consistently mentioned as an important consideration when planning cycle highways.[187,189–195] This ensures that cycling along a cycle highway can be a competitive mode of transportation. Although in many areas, directness is referenced more generally, the Netherlands has gone a step further in defining a reasonable detour factor (equals the distance of travel divided by the distance of displacement) of a cycle highway to be up to 1.2.[189]

The length of the route should also be considered important, as cycle highways are intended to help foster longer distance travel by bike. Generally cycle highways are considered to be a minimum of 5km in length.[29,30,187,192,196,197]

Road types and posted speed limits are also of concern, as fast travelling and proximal vehicle traffic poses risk to people cycling. In this respect, routes along roads with separated bike lanes are suggested to have a speed limit of 60km/h or below.[13] However, as per context specific cycle infrastructure guidance with British Columbia and Canada, speeds up to 80km/h may be permitted, provided there is adequate protection.[11,239] If people cycling are riding mixed with car traffic, 30km/h or below is suggested.[189,195–198,200]

The six criteria chosen for the GIS analysis of candidate cycle highway routes in Metro Vancouver include:

Major Destinations
- The route travels through and connects major destinations, including:
  - Residential areas
    - *Population density*
  - Employment areas, amenities/commercial areas, and education facilities
    - *Job density*
    - *Number of services/amenities (e.g. medical office, post office) served*
    - *Number of commercial areas served*
    - *Number of education facilities served*
  - Transportation
    - *Number of transportation hubs on route (e.g. SkyTrain station)*
    - *Number of connections to active transportation routes (e.g. other bike routes)*
  - Areas facing higher relative transportation inequity (from VI.A. Equity Analysis)

Gradient
- The route travels across topography with limited or gradual elevations changes; avoid steep inclines
- Gradient percentage of less than 4% is recommended and maximum 6%
- Gradient severity can be calculated dependent on distance

Intersections and Stops
- Route favours passage through areas that have fewer or no intersection or required stops
- If intersections are included, favour those with the possibility to become a bike-right-of-way

Directness
- The route travels as close as possible to the most direct path, or as the crow flies and detours are reduced and avoided
- Detour factor is less than 1.2 (Detour factor = Lch/Lo; Lch = length of CH, Lo = length 'as the crow flies')

Length
- The route is a minimum of 5km long

Road Type and Posted Speed Limit (only applies when route travels along a roadway)
- Route favours lower speed limits on roads
- Give preference for smaller, low traffic roads; avoid arterial roads

- Within urban areas aim for speed limits at or below 30km/h, especially and when bike traffic is mixed with car traffic *i.e.* no separated bike path
- Bike routes along roads with separated bike lanes are suggested to have speed limits of 60km/h or below; speeds up to 80 km/h may be permitted provided there is adequate protection

Data Collection

Much of the analysis was done using the existing State of Cycling dataset. The provincial Digital Road Atlas was used to analyze intersections and stops as well as road type and posted speed. Both directness and length were analyzed using tools in the GIS program, as well as the Road Atlas and State of Cycling dataset. Information on slope was drawn from the provincial Digital Elevation Model.

To analyse major destinations, notable amounts of new data was required. We drew on data from Statistics Canada for population density. We were not able to obtain specific data for most of the employment areas factors such as services/amenities and number of commercial areas. Instead, TransLink's Regional Town Centres as well as Frequent Transit Development Areas were used as a proxy. For educational facilities, post-secondary institutions were added by hand, and high school data was drawn from existing internal HUB Cycling data. Major transit centres (SkyTrain stations, bus exchanges, Rapid Bus stops, SeaBus or West Coast Express stations) were drawn from TransLink's publicly available data; ferry terminals and airports were added by hand. State of Cycling data was used to determine connections to existing cycling facilities.

Scoring Tool

To rank each route, we created a scoring tool which scored each of the six aforementioned variables of interest. This tool assigned points and a weighting helping represent their relative importance. The scoring and justification for each variable is described below. In Table 8, the maximum points available in each criterion, as well as the weighting, are summarized.

Ranking (by weight)	Criteria	Max possible points	Weight
1	Major Destinations - Total	140	30%
	Residential Density	15	
	Employment/Education/Amenities	60	
	Transportation	50	
	Equity	15	
2	Gradient	30	25%
3	Reduced Intersections	30	15%
4 (tie)	Direct	30	10%
4 (tie)	Length	30	10%
4 (tie)	Road Type and Posted Speed	35	10%
Total		295	100%

Table 8: Ranking of each of the six criteria used to assess the routes and corridors with the greatest potential for implementation of a successful cycle highway

Major Destinations

The major destinations criteria included sub-categories: residential areas, employment/education/amenities, and transportation. Regarding residential areas, the most densely populated areas were assigned the most points within the density category, with the points decreasing for each drop in density until regionally average density received 0 points. The employment/education/amenities category was informed by proximity to Frequent Transit Development Areas and Regional Town Centres, receiving the most points, and high schools and post-secondary schools, receiving slightly fewer points. The transportation sub-category received points for being close to major transit centres, ferries, or airports (all receiving equal points). Also, connection to cycle facilities contributed: those rated as 'comfortable for most' received the most points, fewer points were awarded for connections to 'comfortable for some', 'comfortable for few', or 'comfortable for very few' routes. In addition, we considered equity and informed by the previous analysis (VI.A. Equity Analysis). Areas deemed to have poor transportation equity included those that were less advantaged across the social equity measures and did not have good transit, driving or cycling access were included. Routes that were close these areas received points.

The criteria of major destinations had the highest point allocation (due to the quantity of sub-factors) and thus the highest overall weighting. Key destinations are both a major reason for people to ride on a cycle highway and are also not easily changed.

Gradient

Routes within the ideal slope range of less than 4% for most of the route were assigned the most points, with points diminishing as the slope increased. Zero points were assigned for slopes between 6% and 8%. Gradient or slope can be a deterrent to people riding. While you can re-route around the steepest hills in some areas, for the most part the slope acts as a determining factor. Routes with more or steeper hills will not be as attractive to people riding.

Intersections and Stops

Routes with five or fewer intersections every 5 kilometres scored highest, while routes with more than seven intersections every 5 kilometres received zero points. Intersections, while important, were lower in the overall ranking. This is because intersections can be upgraded to grade-separated (more expensive) crossings or intersection treatments can be implemented.

Directness and Length

Simple yes/no criteria's included directness and length and were assigned points if they met the criteria, and zero points if they did not. For directness, our detour factor was defined as biking distance divided by the walking distance; meeting this criteria meant a detour factor of 1.2 or less. In future, routes can be adjusted to make them more direct if needed. Regarding length, all the selected routes were longer than 5 kilometres.

Road Type and Posted Speed Limit

Off-street routes scored the highest. Routes on low-speed roads and protected bike lanes on roads with speed limits up to 50 kilometres per hour were ranked the same. Protected facilities on roads with speed limits of 60 kilometres per hour, as well as up to 80 kilometres per hour got points, but comparatively less. Road type and posted speed are considered important, however, can also be adjusted in future without much trouble.

The above weighting outlined above (Table 8) was adjusted to ensure that a route that scored well on major destinations and average on the other criteria would perform similarly to a route that scored well on

the other criteria and average on major destinations. Both would be somewhat outperformed by a route that scored moderately well across all the criteria.

Initial Route Selection

To start the GIS analysis, some potential routes were selected. Ideas for potential routes were drawn from previous work done by HUB Cycling on potential cycle highway routes, TransLink's Major Bikeway Network, and long-distance routes identified by HUB Cycling along the Ministry of Transportation and Infrastructure's highways.

These potential routes were then broken down into two groups. The first group includes existing bike 'routes'. The second group is denoted as 'corridors'; corridors may include existing bike routes, but also may have an absence of bike facilities or poor-quality facilities.

The potential routes were further refined by the following criteria:

- High quality routes (namely regarding the 'route' group)
- Good potential for ridership
    - Connected destinations such as town centres and were anchored by destinations on each end
- Included more municipalities than just Vancouver
- Connected at least two municipalities
- Included more suburban municipalities (namely regarding the 'corridor' group)
- Were included on TransLink's Major Bike Network

The four routes (and two proposed extensions) used in the analysis include:

1. BC Parkway

This existing route is anchored by Surrey Regional Centre and connects the municipalities of Surrey, New Westminster, Burnaby, and Vancouver. The route connects four town or regional centres. Nearly all the route is rated as 'comfortable for most.' The entire BC Parkway is shown on TransLink's Major Bike Network (MBN).

As there is no strong anchor where the BC Parkway ends in Vancouver, we extended the route via 10th Avenue Bikeway through the Broadway Corridor and ending at the Arbutus Greenway. This extension was analysed in addition to the pre-existing BC Parkway route.

2. Central Valley Greenway

The Central Valley Greenway is another existing high-quality route and connects Lougheed Town Centre in Burnaby to Downtown Vancouver Regional Centre. The route also connects Brentwood Town Centre. The MBN shows the whole route and it is a 'comfortable for most' designation for the entire length.

We connected the Central Valley Greenway to downtown via Quebec Street and the Dunsmuir viaduct; this extended Central Valley Greenway route and constituted the route analysed below.

3. Union Adanac - Frances Union Bikeway (FUB)

This route includes the Union-Adanac Bikeway in Vancouver and the Francis-Union Bikeway in Burnaby. It connects north Burnaby with downtown Vancouver. Destinations along the route include the Burnaby Heights, East Village and Gastown commercial areas. Part of the route is included on TransLink's MBN, and about half of the route is rated as 'comfortable for most.'

As the Burnaby end lacks a strong anchor, we connected it to the Burnaby campus of Simon Fraser University (SFU); this constituted one of the analysed routes. We also analysed an extension to the route: downtown Vancouver to the North Shore, ending at the Ambleside Town Centre. This extension was analysed in addition to the pre-existing Union Adanac - Frances Union Bikeway route.

4. Vancouver to Steveston

This route is anchored by downtown Vancouver and Steveston Town Centre. Additional destinations include the Broadway Corridor and Richmond Regional Centre. The route follows the Arbutus Greenway and the Railway Greenway, both deemed 'comfortable for most' facilities; both of these are included on the MBN.

The six corridors used in the analysis include:

1. Downtown Vancouver to Tsawwassen Ferry Terminal

This route roughly parallels the Highway 99 corridor. The north anchor is the Downtown Vancouver Regional Centre. Along the way the route connects with Oakridge Town Centre and Ladner Town Centre before ending at the south anchor - the Tsawwassen Ferry Terminal and Tsawwassen Town Centre. Connecting Vancouver, Richmond, Delta and Tsawwassen First Nation, this route contains a diversity of jurisdictions. The MBN includes a route roughly along this route.

2. Coquitlam to Maple Ridge via Lougheed Highway

Following the Lougheed Highway, this corridor connects Lougheed Regional Centre to Pitt Meadows Town Centre and Maple Ridge Town Centre. This corridor includes the municipalities of Coquitlam, Port Coquitlam, Pitt Meadows, and Maple Ridge. TransLink's MBN also includes this route.

3. Tri-Cities via Barnet Highway to the North Shore

In the east, this corridor starts at the Coquitlam Regional Centre and runs through the Port Moody Town Centre. The corridor follows the Barnet Highway into Burnaby, and then the Francis Union Bikeway to the Ironworker's Bridge. On the North Shore, the corridor roughly follows the Spirit Trail to Lonsdale Regional Centre before ending at Ambleside Town Centre. This corridor connects several municipalities - Port Moody, Burnaby, Vancouver, and the three North Shore municipalities. Large parts of this corridor are on the MBN including the section in the Tri-Cities, the Francis-Union Bikeway, and the Spirit Trail.

4. Surrey Regional Centre to Langley Regional Centre

Linking Surrey, the Township of Langley and Langley City, this corridor is roughly parallel to the Fraser Highway. Destinations include Surrey Regional Centre, Fleetwood Town Centre, and Langley Regional Centre. The full corridor is included on TransLink's MBN.

5. Surrey Regional Centre to Maple Ridge Regional Centre

This corridor includes the Golden Ears Greenway - an existing route that has limited stopping for about 10 kilometres from Tynehead Park across the Golden Ears Bridge. Anchored in the west by Surrey Regional Centre, the corridor links Guildford Town Centre before ending at the Maple Ridge Regional Centre. Municipalities include Surrey, Township of Langley, and Maple Ridge. This corridor is also included on the MBN.

6. White Rock Town Centre to Richmond Regional Centre

Roughly following the Highway 99 corridor from White Rock to Richmond, this corridor connects the White Rock Town Centre and Richmond Regional Centre. The middle section crosses the Fraser River via the Massey Tunnel, anticipating a future active transportation crossing. Some parts of this route are on the MBN.

Analysis

We broke each route into smaller segments of approximately 1km. This allowed us to see the strengths and weaknesses of the whole route as well as subsections. Using GIS software, we analyzed each route and corridor based on the selected criteria. Results were exported to Excel and scored based on the scoring tool. Results of the analysis were integrated with results from the equity analysis. Lastly, once the selected corridors and routes were analysed, we queried GIS for any other routes that fit the criteria and scored these with our scoring tool.

Results

Scores of Proposed Routes and Corridors

The scores for each segment were added up to get a total score for each route or corridor. The total scores are shown, as well as their percentage of the possible maximum score in Table 9.

Name	Total Weighted Score	% of max score
Route 1 - BC Parkway + Extension	38.9	58.5%
Route 1 - BC Parkway	38.8	58.4%
Route 2 - Central Valley Greenway	37.1	55.7%
Route 3 - Adanac & FUB + Extension	35.0	52.6%
Corridor 3 - Tri-Cities to North Shore	33.0	49.7%
Route 3 - Adanac & FUB	32.3	48.5%
Route 4 - Vancouver to Steveston	30.1	45.3%
Corridor 2 - Coquitlam to Maple Ridge	27.7	41.6%
Corridor 6 - White Rock to Richmond	26.6	40.1%
Corridor 4 - Surrey to Langley	26.6	39.9%
Corridor 1 - Downtown to Tsawwassen	26.3	39.6%
Corridor 5 - Surrey to Maple Ridge	24.2	36.4%

Table 9: Total scores for each route and corridor, including proposed extensions

The scores of the 10 routes (and 2 extensions) and corridors ranged from 36.4% to 58.5% of the maximum possible score. From these scores, we see that the routes and corridors fall into three rough categories. The top third in scoring (denoted in blue) includes four routes: the BC Parkway plus our proposed extension to the Arbutus Greenway, the pre-existing BC Parkway route, the Central Valley Greenway, and the Francis Union Bikeway plus our proposed extension from downtown Vancouver to the North Shore. Scoring in the middle (denoted in tones of green/yellow/orange) were the Tri-Cities via Barnet Highway to the North Shore corridor, Union Adanac and Francis Union Bikeway, and the Vancouver to Steveston route. The bottom third in scoring (denoted purple) were the remaining five corridors, Coquitlam to Maple Ridge via Lougheed Highway, White Rock Town Centre to Richmond Regional Centre, Surrey Regional Centre to Langley Regional Centre, Downtown Vancouver to Tsawwassen Ferry Terminal, and Surrey Regional Centre to Maple Ridge Regional Centre.

Existing routes that scored the highest were the BC Parkway and Central Valley Greenway. Both routes have limited hills, run through several denser populated areas, and link key destinations. In addition, large portions of both routes are off street, thus not required to share a roadway with motor vehicles. Regional connections are met by the BC Parkway, linking four different municipalities, and Central Valley Greenway, connecting three. Also, the our proposed extensions elevated the scores of each of the routes they were applied to.

Aside from the Tri-Cities to North Shore Corridor, the rest of the corridors did not score as high as the routes (and proposed extensions). This, for the most part, was due to the corridors residing in more suburban areas. These areas are less dense and contain fewer major destinations, which was a key component influencing score. On the other hand, it must be highlighted that suburban areas stand to gain from high-quality cycling facilities that connect people to key destinations.

IX. Appendix

A. Meet the Team

Project Team

Transportation Planner and Project Manager– Evan Hammer

Evan is the Infrastructure Planning and Policy Manager with HUB Cycling. He manages the #UnGapTheMap initiative, which includes the Infrastructure Challenge, Adopt-a-Gap, and Gap Priority Map projects. Evan engages with local, municipal, and provincial decision-makers and provides feedback on cycling projects and policy work such as Transport 2050 and Metro 2050. Evan holds a Masters of Arts in Planning from UBC. His sustainable transportation experience includes cyclist route selection, bike sharing and transportation planning.

Researcher and Project Assistant – Giovanna Lanius-Pascuzzi

Giovanna completed an internship with HUB Cycling to research and make a case for the development of cycle highways across the Metro Vancouver region, which served as her thesis to complete her Masters studies During her Masters studies in Bio-Inspired Innovation at Utrecht University, she further developed an environmentally focused, systemic perspective and interest in urbanism. While based in the Netherlands, she directly realised the benefits of biking for transportation and the role infrastructure plays. Giovanna is passionate about sustainability within the urban environment; her interest in cycle infrastructure stems from the numerous systemic level benefits that are realised by fostering cycling as a transportation mode.

GIS Consultant and Statistical Analyst – Cody Gerow

Cody is a multi-disciplinarian urban planner with a background in transportation and GIS. Cody has a Bachelors in Human Geography from the University of Alberta and a Masters in Sustainable Urban Planning from HafenCity Universität in Hamburg, Germany. After gaining professional experience in Germany, Denmark and Sweden, Cody moved back to Canada to work for Vancouver Bike Share and the City of Vancouver, focusing on sustainable transportation planning. Cody now provides international GIS consulting and is based in Austria.

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- Gavin Davidson, Planning and Research Lead, HUB Cycling
- Lisa Josephson, Senior Planner, TransLink
- Paul Kennedy, Director, HUB Cycling
- Erin O'Melinn, Executive Director, HUB Cycling
- Alex Taciuk, Transportation Planner and External Stakeholder

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- Wim Bot – International Policy Advisor, Fietsersbond, the Netherlands
- Sophie Edmondson - Head of Future of Transport Regulatory Review and Programme Office, Department for Transport, United Kingdom
- Tim Springer – former Executive Director of the Midtown Greenway Coalition, United States of America
- Carolyn Stewart – Park/Trail Planner for the Capital Regional District, Canada
- David Cubberley – Politician and former councillor of Saanich, Canada
- Denise Savoie – Politician and former Chair of the Greater Victoria Cycling Coalition, Canada
- John Luton – Transportation Consultant and former President of the Greater Victoria Cycling Coalition, Canada

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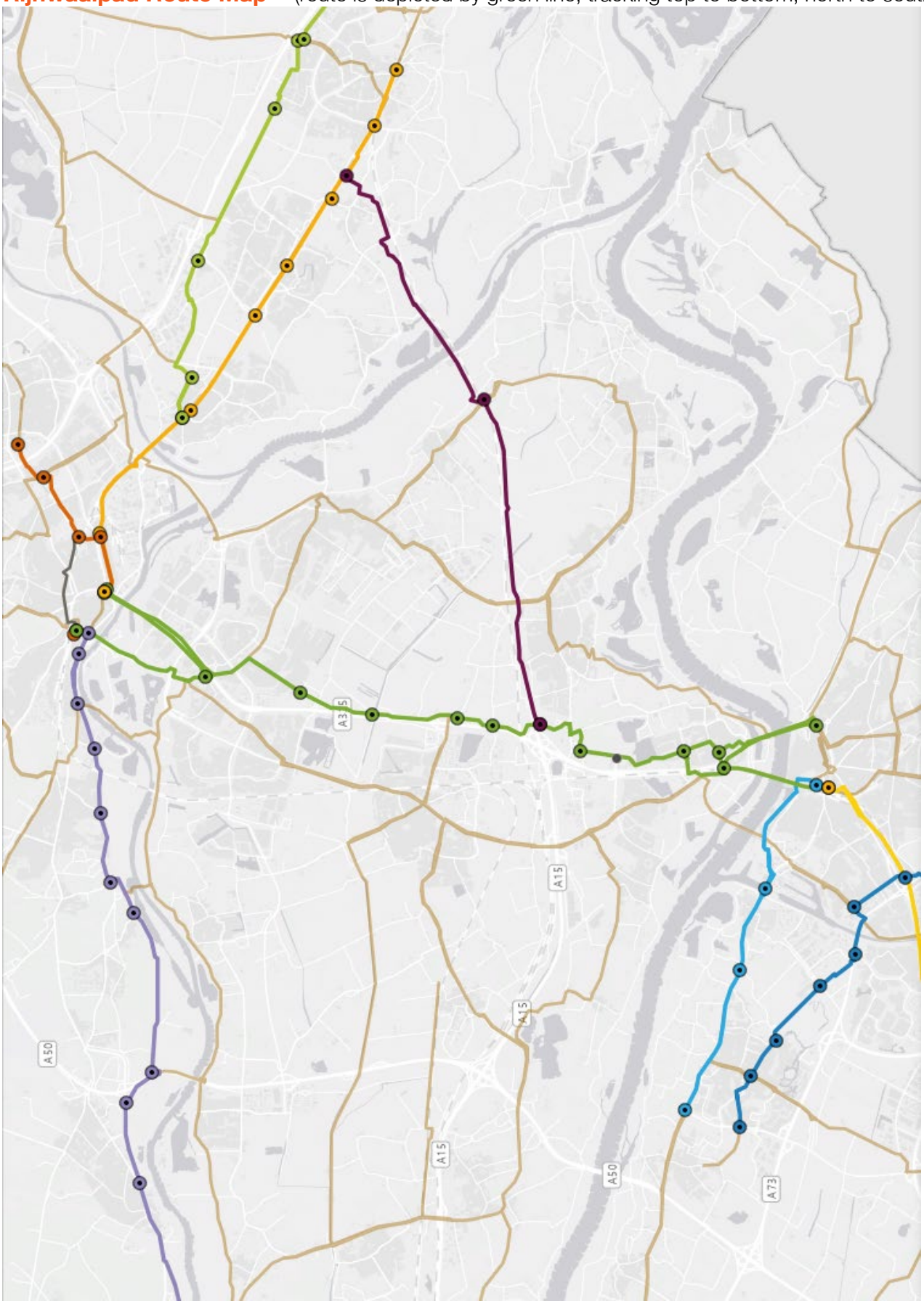
D. Route Maps

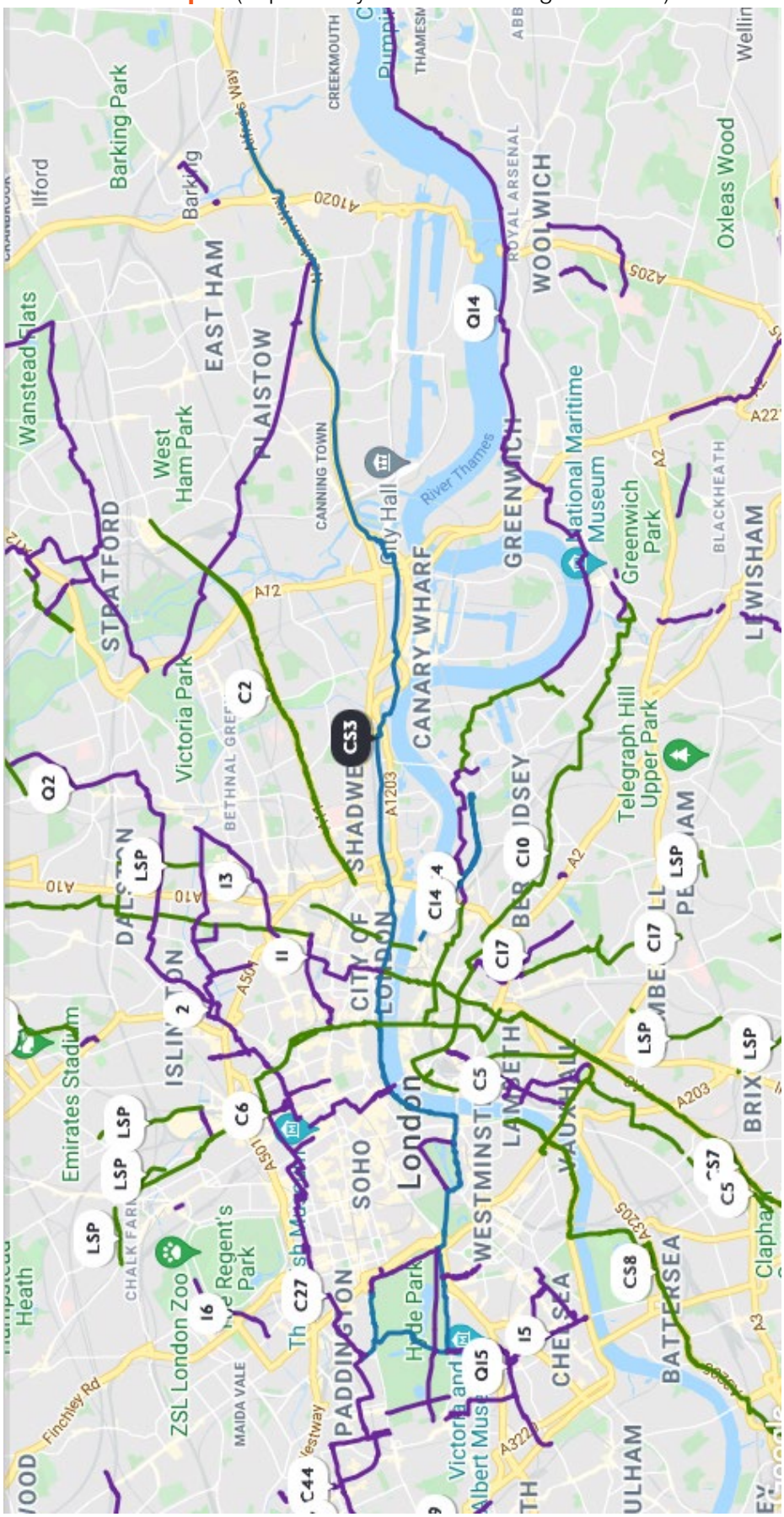
Albertslund Route Map[240]

Farum Route Map[240]

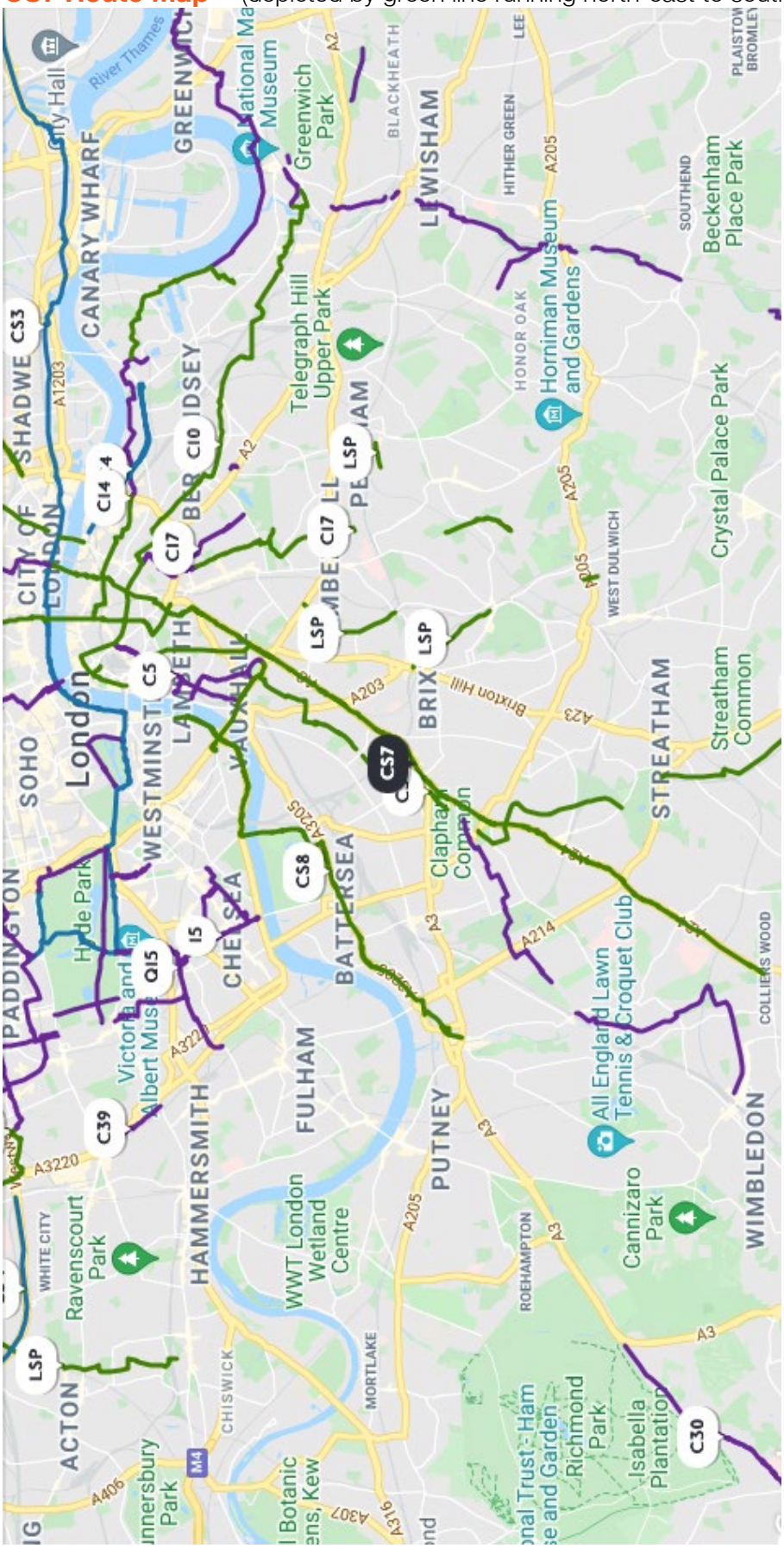
Rijnwaalpad Route Map[154] (route is depicted by green line, tracking top to bottom, north to south)



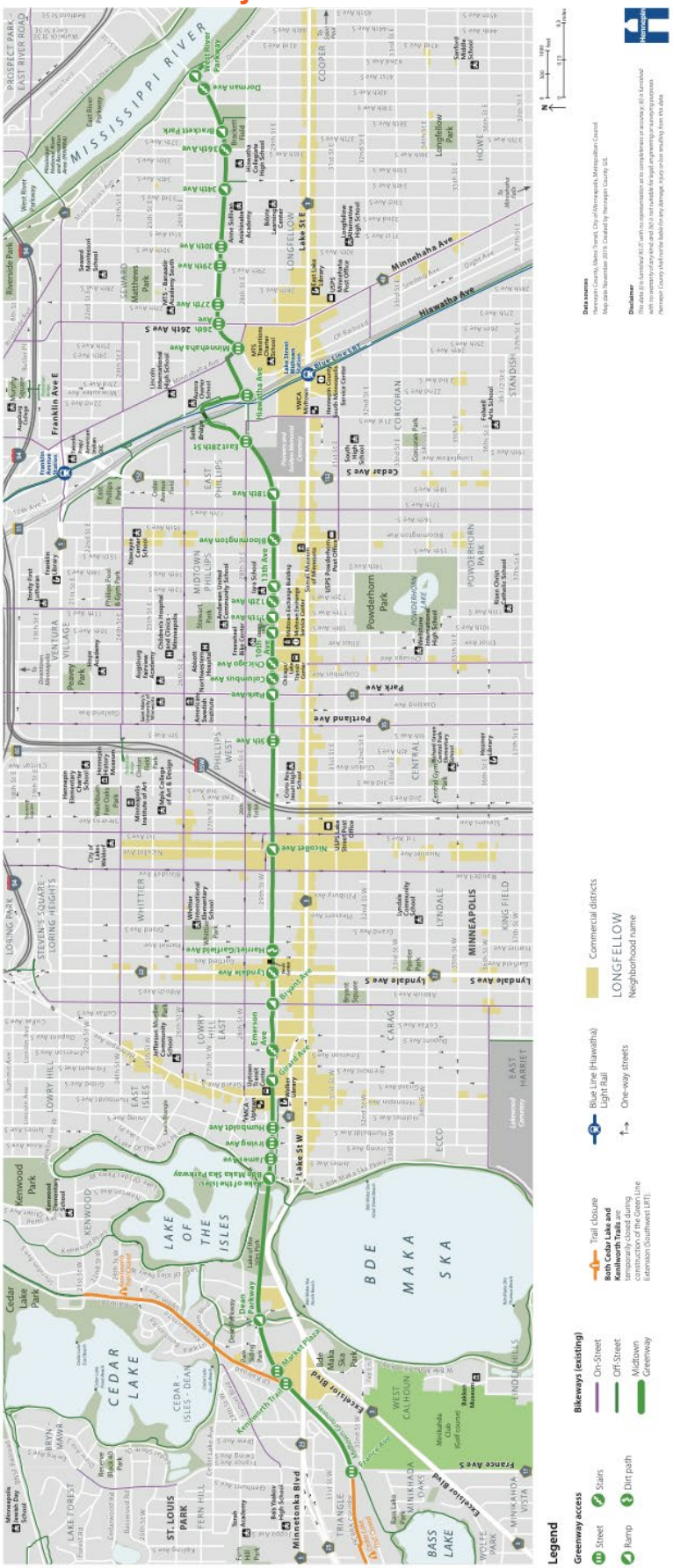
CS3 Route Map[241] (depicted by blue line tracking east-west)



CS7 Route Map[241] (depicted by green line running north-east to south-west)



Midtown Greenway[242]



Galloping Goose and Lochside Routes Map[243] (Galloping Goose trail depicted by red line tracking east out of Victoria; Lochside trail depicted by blue line running north from Victoria)