Cycling in Winter:
Exploring innovative design principles and practices to support all season bicycle commuting for Winnipeg and Winter Cities worldwide

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Abstract

Cycling has experienced a renaissance in cities across North America over the last decade as it is embraced by urbanites for its convenience and affordability, and by governments to mitigate road congestion and climate change. Cycling levels are at their peak during the spring and summer season, yet as more people take up cycling they are adapting to winter weather in order to commute year round. Supporting cycling in winter is an underdeveloped area of municipal policy and the focus of this supervised research project.

Cities in Canada and the northern United States have winter climates with snowfall, ice, and freezing temperatures for significant periods of the year. Cold weather climates present a variety of challenges to city planners in order to maintain sustainable transportation systems. Winter planning for cycling has become the next "hot topic" in Canada and the United States yet many winter cities are just beginning to look at strategies to promote four season cycling.

How can cities determine the best policies, plans and programs to better support cycling in winter? What bicycle route, road network or bicycle facility should a city select to accommodate the requirements of snow removal and winter maintenance? How can these decisions be integrated into long term comprehensive bicycle plans? This project will answer these questions through a literature review, a peer city review and the elaboration of design principles for winter bicycle networks. The design principles will then be tested by developing a winter cycling network and maintenance strategy for the City of Winnipeg.

Résumé

Au cours de la dernière décennie, le cyclisme a vécu une renaissance dans les villes Nord-Américains; ce mode de transport est accueilli par des citadins pour son accessibilité sur le plan monétaire et pour sa facilité d'usage. De plus, le cyclisme est mis de l'avant par les gouvernements pour mitiger l'engorgement du réseau routier ainsi que pour luter contre les changements climatiques. Le nombre de cycliste est à son sommet pendant le printemps et l'été, cependant, au fur et à mesure que le nombre d'adepte du cyclisme dans la population grandi, certains s'adaptent aux conditions hivernales afin de poursuivre leurs déplacements quotidiens à vélo. Les politiques municipales touchant le cyclisme hivernal se trouvent à être sous-développées actuellement, et ces dernières seront l'objet de ce travail dirigé.

Les villes au Canada et au nord des États-Unis ont une saison hivernale qui s'étend sur plusieurs mois de l'année, cette période se caractérise par la présence de neige, de glace et de températures en-dessous de zéro. Les climats nordiques sont pour les urbanistes une source de défis à ce qui a trait à l'entretien des réseaux de transports dans une optique de développement durable. La planification pour le cyclisme hivernale est devenue à la mode au Canada et aux États unis, cela dit, de nombreuses villes commencent à peine à explorer les stratégies de promotion du cyclisme quatre-saisons.

Comment est-ce que les villes peuvent déterminer les meilleurs politiques, plans et programmes afin de mieux soutenir le cyclisme en hiver? Quelles routes, quelles portions du réseau routier, et quels équipements est-ce qu'une ville devrait choisir pour accommoder les besoins en déneigement et en entretien hivernal? Comment est-ce que ces décisions

Résumé

pourront être intégrées dans des plans compréhensifs pour les cyclistes sur une optique à long terme? Ce travail va répondre à ces questions en passant par : une revue de la littérature, un examen de différentes villes et l'élaboration de principes de design pour des réseaux cyclables adaptés à l'hiver. Par la suite, ces principes de design vont être testés en développant un réseau de vélo hivernal ainsi qu'une stratégie d'entretien pour la Ville de Winnipeg.

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1. Introduction

Cities in Canada and the northern United States have winter climates with snowfall, ice, freezing temperatures and limited daylight for significant periods of the year. In the northern hemisphere the winter season occurs between December and April, and winter weather characteristics are notably different across geographic regions. Winter is defined by a few basic elements, including: temperatures below freezing, precipitation in the form of snow, restricted hours of daylight, prolonged periods of these elements and seasonal variation (Pressman, 2004). According to a definition established by Norman Pressman, a Canadian authority on climate-sensitive design and planning, a "winter" city is defined as a city that experiences continuous days of temperatures below 0°C for at least two months in a year (Pressman, 2004). However, the more you discuss winter weather the more it is apparent winter is not a single phenomenon, within one city, oscillating conditions due to air temperature and precipitation leads to fluctuating freezing and thawing of snow and ice. These fluctuations add to the challenge of understanding the local climate and planning for these winter conditions. Adding further complexity to climate responsive design and planning is seasonal weather pattern changes due to climate change.

Climate change and concern for the environment has resulted in new strategies to mitigate the negative impact of transportation related greenhouse gases. Governments around the world are implementing policy measures to shift automobile trips to more sustainable modes, such as public transit, walking and cycling. Dialogue on climate change often centres on the need to reduce energy consumption and lower greenhouse gas emissions. However, sustainable transportation strategies often have a limited seasonal approach that do not extend to winter. In cold weather cities the winter is a peak energy demand period, therefore, there is a greater need for sustainability strategies that reduce greenhouse gas emissions. In winter many people shift from active transportation modes to motorized vehicle modes simply to cope with conditions of constrained sidewalks and roadways to avoid the elements. Cycling has been encouraged in major urban centres through political leadership that recognizes that cycling is an efficient alternative to motor vehicle trips for short distances. As cycling has become a popular urban transportation choice, a portion of the population is adapting to winter weather and continuing to cycle year round.

Cycling has experienced a renaissance in cities across North America over the last decade. The bicycle is viewed by some as a panacea for addressing public health issues of obesity and sedentary lifestyles, environmental concerns and road congestion. Significant government investments in bicycle infrastructure, as well as complementary policies and programs are transforming the landscape of Canadian and U.S. cities into bike-friendly urban spaces. Between 1996 and 2006, the City of Vancouver created a network of bikeways, expanded on-street bike lanes and funded cycling education programs. During this ten year period, Vancouver experienced an increase in cycling mode share from 1.7% to 3.7%. This has grown to a current mode share of 4.4% (Pucher et al, 2011; Statistics Canada, 2011). Similarly in the City of Montreal cycling levels rose from 1.0% to 2.4% between 1996 and 2006, with current regional mode share of 3.15% for the City, reaching as high as 9% in select inner city neighbourhoods (Statistics Canada, 2011; Vélo Québec, 2010). Overall in the United States, cycling comprises a mere 0.6% of commuter trips nationally, with bicycle mode share is higher on the west coast at 1.1% (BBC News, 2014).

Between 1990 and 2009 in the United States, Portland Oregon and Minneapolis Minnesota gained the titles of the most "bike friendly" cities through increases in cycling of 1.1% to 6.0% and 1.6% to 4.3% respectively (Pucher & Buehler, 2012; Dill & McNeil, 2013).

A global movement and paradigm shift is occurring in urban and transportation planning fields from a focus on the movement of the motor vehicle to the movement of people. A societal change is also occurring, as the goal of suburban single-family homeownership is being replaced by a generation choosing car sharing, public transit and a bikeable urban lifestyle. An indicator of this shift is evident in the growth of car coops and bicycle share programs, as well as, the decline in driving among the Millennials - young people aged 16 to 34 (U.S. PIRG Education Fund, 2013). As cities implement policies and practices to encourage cycling as a viable form of transportation, there is an emerging need for an all season year-round approach to planning. As more people commute by bicycle, cyclists expect a higher level of service to support their transportation choice and cities are now under increasing pressure to improve conditions for cycling in winter.

Planning for winter cycling is becoming the next "hot topic" for Canadian and U.S cities as they catch up to what is commonplace in Northern Europe – maintaining bicycle accessibility and mobility during winter. As cycling continues to increase in popularity how can cities determine the best policies, plans and programs to better support cycling in winter? What bicycle route, road network or bicycle facility should a city prioritize for snow removal and winter maintenance? How can these decisions be integrated into long term comprehensive bicycle plans? This research project will answer these questions through a literature review, a peer city review and the elaboration of design principles for a winter bicycle network. These principles will be tested by developing a winter cycling network and maintenance strategy for the City of Winnipeg.

The peer city review is organized by four thematic design principles or 4 "P's" - plan, prioritize, procedures, and promote. A final section focuses on the need to monitor and evaluate a planning program. Detailed practices from cities in Northern Europe and premiere winter cities in Canada and the United States will provide new ideas and better approaches for winter planning and policy.

2. Literature Review

As cycling continues to grow there is an emerging need for an all season year-round approach to bicycle planning. Previous studies investigated motivators, deterrents and the impact of the built environment and facility design on cycling. A select number of studies have highlighted weather conditions that affect cycling including temperature and precipitation, yet, few studies have focused on climate and the impact of winter weather on cycling. The variable conditions of winter increase the level of difficulty for cycling in winter and this area warrants further research. The following literature review extends the existing body of research and focuses on cyclist's profiles, weather and climate, distance, bicycle facility design and winter maintenance practices.

2.1 Type of Cyclists

In order to effectively improve the conditions for cycling it is important to understand the different types of cyclists, their motivation and decision to ride a bicycle. Classifications and categories have been developed in order to gain a greater insight into this segment of the population. As bicycling grew in popularity in the City of Portland a typology was developed by Bicycle Planner Roger Geller to categorize cyclists based on their skill level rather than the trip purpose. The four typologies selected were: "strong and fearless", the "enthused and confident", the "interested but concerned" and the "no way no how" (Dill & McNeil, 2013).

The "strong and fearless" group are dedicated cyclists who will ride regardless of the roadway conditions. The "enthused and confident" group are comfortable to cycle in traffic with vehicles but prefer dedicated bicycle infrastructure. The "interested but concerned" group are curious and would like to cycle more but have concerns over safety which prevents them from cycling on roads with motor vehicle traffic (Dill & McNeil, 2013). In the survey of adult cyclists in the City of Portland the strong and fearless composed 1%, the enthused and confident 7%, the interested but concern 60% and the no way no how 33%. Of the strong and fearless category, an estimates 80% were male and 86% were between the ages of 18 and 34, the enthused and confident category were predominately individuals between the ages of 35 to 54, and of the interested but concerned category 43% were female (Dill & McNeil, 2013).

This is representative of many North American cities, the largest portion of the population are interested in cycling but have a variety of concerns and identifiable barriers. Dill & McNeil (2013) recently re-examined the methodology for Geller's typology and confirmed this classification is well suited to people based on their skill level. This typology has been used extensively across North America by academics, advocates and planning professionals as it helps establish a target market for cycling and has proven a successful motivator in designing bicycle infrastructure geared towards individuals who will bicycle more with safer and more comfortable facilities.

Trip purpose and trip frequency are common categories used to classify cyclists and understand their travel behaviour. Winters et al. (2011) defined four categories of individuals - those who have not cycled in a previous year but would consider it as "potential cyclists", those who cycle a few times per year as "occasional cyclists", those who cycle at least monthly as "frequent cyclists", and those who cycle cycled at least once a week as "regular cyclists". Heinen et al. (2011) examined influences of travel behaviour and categorized cyclists that bicycle to work every day as "full-time cyclists",

and those that cycle occasionally as "part-time cyclists". Recent analysis from a team at McGill University in Montreal has posited four distinct cyclist types: dedicated cyclists, path-using cyclists, fairweather utilitarians, and leisure cyclists (Damant-Sirois et al., 2014). This typology is based on trip frequency and intensity of bicycle use or purpose. In addition, Bergström and Magnusson (2003) based their typology on seasonal frequency of bicycle trips to work and described as: "winter cyclists", "summer-only cyclists", "infrequent" or "never" cyclists. As illustrated, there are a variety of terms for describing the different types of cyclists based on skill level, purpose of trip, trip frequency, travel behaviour or season. Overall the analysis of cycling typology reveals similar subsets of the population; hardcore or dedicated cyclists, regular or confident cyclists, occasional or leisure cyclists, and those uninterested in cycling. The former categories are often predominately commuter or utilitarian cyclists while the latter categories are recreational or infrequent cyclists. The volume of each group of cyclists will vary city to city based on infrastructure, cycling culture and supportive programs. Understanding the cycling demographic in an urban population helps planners, decision makers and advocates make the case for investments in bicycle facilities and programs.

For the purpose of this project, individuals that commute by bicycle to work and use a bicycle as their primary mode of transportation, versus recreation or occasional cyclists, are of the primary focus. Research into the correlation of cyclists' type and winter cycling levels is an underdeveloped area in North America. The portrait of a winter cyclist is important in order to understand the market and demographic characteristics of the cycling population. Bergström Magnusson (2003) define a winter cyclist as "a person who uses a bicycle for traveling to work at least two cases out of five from November to March" (p.119, 2003). While a "strong and fearless", "enthused and confident", "regular" or "full time" segment of the population may be willing to endure the winter climate, the majority of cyclists stop cycling due to temperature, weather and road surface conditions.

Individual cyclists have different comfort and confidence levels, as well as, interest and frequency of cycling. Understanding the characteristic of cyclists influences the type and design of bicycle facilities. A robust body of research has found that bicycle facilities - such as bike lanes, multi-use paths, or separated cycle tracks - correlate to higher rates of cycling (Pucher & Buehler, 2006; Dill, 2009; Pucher et al., 2010; Winters et al., 2011). As infrastructure improves more people are attracted to bicycling for transportation, recreation or shopping. These studies propose a comprehensive approach to cycling interventions rather than individual measures leads to higher levels of cycling. Common deterrents to cycling are safety concerns regarding motor vehicle speed and volume, and adequate separation from moving vehicles. Addressing safety concerns and creating safe and comfortable spaces for road users of all ages and abilities will lead to higher rates of cycling; however other barriers to cycling exist such as topography and climate (Winters et al., 2011).

2.2 Weather and Cycling

Geographic regions experience different types of winter weather and winter climate is not a homogeneous phenomenon. The typical winter in the northern hemisphere occurs between November and April, while the southern hemisphere winter happens between June to September. Topography, geography and climate all factor into different winter weather, from mild temperatures and precipitation in the form of rain for some cities, and freezing temperatures with snowfall in others. Weather is a commonly cited barrier to cycling and in "winter" cities many bicyclist retire their two-wheeled machines for another form of transportation. A growing body of research contributes to understanding how specific weather impacts cycling and the next section summarizes the relationship between weather conditions and bicycle ridership. The research from Australasia, North America and Europe is not exclusive to winter cities, and a final section focuses on winter weather and cycling research.

AUSTRALASIA. A number of studies from Down Under have linked weather to temporal cycling levels. Nankervis (1999) conducted one of the first studies into seasonal patterns of cycling among students in Melbourne, Australia, finding wind, rain, and temperature were the main deterrents affecting bicycle commuting during the winter months. More recently, Ahmed, Rose and Jakob (2013) surveyed 738 cyclists throughout the state of Victoria Australia to analyze commuter cyclists' travel behaviour and responses to changes in weather. The study found that decisions to cycle were most impacted by weather, particularly for casual or recreational cyclists. In Auckland New Zealand, Tin Tin et al. (2012) used automated bicycle data counters over one year comparing local weather data, concluding wind and rain impacted cycling level. The studies from Australia and New Zealand highlight the impact of rain and wind on cycling levels in mild winter environments.

NORTH AMERICA. Comparable studies in the Pacific Northwest region in Vancouver BC and Portland OR also found that precipitation (rain), wind and low temperatures lead to a reduction in utilitarian or commuter based bicycle trips (Winters et al., 2007; Miranda-Moreno & Kho, 2012). While geographically distinct, the weather in Vancouver and Portland is similar to Melbourne Australia and Auckland New Zealand. Conversely research has found that hot summer weather of extreme heat or humidity will also lead to reduced cycling levels (Pucher et al., 2011; Miranda-Moreno & Nosal, 2011; Nankervis, 1999). The studies from select North American cities similarily find weather factors including low air temperature, precipitation, humidity and wind, negatively affect cycling.

EUROPE. Evaluating climate effects on recreational and utilitarian bicycle trips was the focus of two studies in Europe. In Vienna Austria, Brandenburg et al. (2007) used an onsite questionnaire combined with video surveillance to analyze cycling patterns on multi-use paths with a focus on weather conditions. Their analysis found that the travel behaviour of recreational and commuter cyclists is significantly different finding weather more adversely affected recreational cycling. Thomas et al. (2008) used time series and flow data collected at sixteen cycle paths in the Dutch cities of Gouda and Ede in the Netherlands, over an extended period of time (four years at some locations and ten years at others). This longitudinal study found recreational cyclists are highly sensitive to weather, while utilitarian cyclists are less affected by weather.

The European studies contribute to the body of literature on weather effects on cycling. They reiterate that a recreational cyclist will chose not to cycle in poor weather conditions.

WINTER. In 'winter cities' weather conditions are characterized by freezing temperatures, snow and restricted hours of daylight. Bergrström and Magnussen (2003) conducted one of the first direct surveys of cyclists in Sweden regarding winter cycling preferences and travel behaviour. Their research included two surveys over two years and focused on commuter cycling trips to major employment hubs in the Swedish towns of Umeå and Linköping. Bergrström and Magnussen concluded that low temperatures, wind and precipitation (in the form of snow) were the weather conditions that deter bicycle trips. Interestingly, most survey respondents indicated they commuted year round for cost savings, environmental reasons and exercise. During the two year study period winter cycling rates increased by roughly 28%. Flynn et al. (2012) completed a longitudinal study of adult cyclists' trips to work in and around Burlington Vermont USA. The study determined that precipitation, temperature, wind and snow conditions had significant impacts on trips to work by bike. Through a survey conducted during winter with commuter cyclists in Calgary Alberta, Amiri and Sadeghpour (2013) looked at the characteristics, motivations and concerns of cyclists in colder weather. The targeted study reported that 60% of the frequent winter cyclists indicated that they bicycle regardless of the temperature. Another 33% stated that they felt comfortable cycling in temperatures between −10°C and −20°C (Amiri & Sadeghpour, 2013). For commuter cyclists in winter cities, temperature is less of a factor as cyclists have a higher tolerance to cold, partly based on their bodies generating heat as they travel. Miranda-Moreno and Kho (2013) surveyed cyclists in Ottawa Ontario and Montreal Quebec and found that of the targeted sample, approximately 80% cycled regularly between January and March, the coldest months of winter. The respondents identified themselves as regular commuter cyclists, meaning they cycled five-times per week in non-winter months (Miranda-Moreno and Kho, 2013). This research on winter cycling contributes to a greater understanding of the motivators, deterrents and preferences of year around commuter cyclists in winter cities. Weather is a significant barrier to cycling during the winter, while conditions are variable. Without predictable road surface conditions many cyclists chose not to cycle. While weather is a significant factor in an individual's decision to continue cycling through the winter season, their other concerns include safety, maintenance, connectivity and distance.

2.3 Distance

Commuting to work by bicycle in winter is motivated by many factors including cost savings, health, travel time, weather, and distance. Cycling is most popular in urban cities with high density, mixed land use patterns, where origins and destinations are closer together, meaning trip distances and travel times are also shorter (Pucher & Buehler 2006; Winters et al., 2007). Individuals chose cycling as it is a convenient, efficient and fast mode of transportation for trips between 2 km to 10 km. Studies on cycling in winter cities highlight that there is a threshold of distance cyclists are willing to travel in cold weather conditions. Cycling in winter is not necessarily an enjoyable experience all the time; it takes confidence, concentration and determination, thus distance plays a greater factor in winter than during a summer season. Miranda-Moreno, Nosal and Kho's survey of cyclists stated that distance is definitely a factor for winter cyclists; the farther people live from work the less likely they are to cycle in poor winter weather conditions. The findings highlight that with "... [people who cycle distances] greater than 10 km cyclists were 18% and 20% less likely to bike in the winter than those whose commute is only 0 to 5 km" (p. 11, 2013). In Linköping and Umeå Sweden, distance was also a factor during winter for cyclists. Compared to summer, when the maximum distance cycled for work was 20 km, in winter for trips over 10km people stopped cycling, and there were significant differences for distance groups above 5km and under 3km (Bergström & Magnussen, 2003).

In the winter cycling study in Calgary, the average distance for a one-way bicycle trip to work was 7km (Amiri & Sadeghpour 2013). An estimated 72% of respondents had trip duration between 10 and 30 minutes, and one-quarter of the participants had travel durations greater than 30 minutes. These findings are distinct from the outcomes in Sweden and this correlates to differences in land-use, density and overall network design. Calgary has a lower population density and lower building density than the cities of Umeå and Linköping. Heinen et al. (2011) assumed cyclists who travel farther have a more positive attitude to cycling due to the greater commitment of time, topography and distance and how these positive attitudes likely correlate to health and environmental values. Two previous studies found that cyclists were willing to increase trip distance and travel time in the peak season to ride within dedicated bicycle infrastructure, compared to taking shorter more direct routes that require cycling on roads with motor vehicle traffic (Pucher et al., 2011; Winters et al., 2011). During the winter (non-peak) season, there is a more distinct distance threshold cyclists are willing to bicycle commute. Distance alone is not the primary factor whereas available bicycle facilities, safety and road conditions are significant key determinants of winter cycling levels.

2.4 Bicycle Infrastructure and Facility Design

Bicycle facilities and infrastructure are designed and exist to provide cyclists with dedicated safe travel routes. Different bicycle facilities appeal and serve different types of cyclists and different type of bicycle trips. Numerous studies have concluded that bicycle facilities reduce risk and exposure of cyclists to motor vehicles, and cyclists want to use dedicated bicycle facilities over cycling on a street without them (Winters et al., 2007; Dill, 2009; Winters et al., 2011; Pucher et al., 2011). Protected bike lanes or off-street paths are deemed one of the most preferred as they physically separate cyclists and motorists. On-street bike lanes are a commonly used utilitarian bicycle facility in North America as they provide an fast travel lane usually on major corridors which serve commuter trips. Multi-use off-street paths are either bicycle only or pedestrian shared facilities, often low-speed recreational trails or routes. (In Canada and the United States, multi-use shared paths are often the jurisdiction of a parks department versus a road or street transportation department.) Low volume residential streets are often assigned bicycle network status called Bikeways or Bike Boulevards as they provide an alternate route and run parallel to higher volume streets.

Separated bike lanes or cycle tracks are designed to provide the combined comfort of off-street multi-use paths with the direct route of an on-street bike lane. Cycle tracks are physically separated from motor vehicles through concrete curbs, barriers, bollards or parked cars see **figure 1**. There is a current trend in North American cities to build physically protected bicycle lanes, or cycle tracks, as they appeal to a wider array of people, genders, age and skill level. Separated facilities provide the highest level of safety and comfort which appeals to a wider cycling demographic. As a result they are considered good bicycle facilities to prioritize for winter maintenance. While cycle tracks are popular they are relatively new to North American cities (except in Montreal where they have been constructed since the 1980's), and therefore they are not the only facility to prioritize in winter. Bike lanes are also an important facility to maintain during the winter as they are usually on major arterial or collector streets which serve commuters. In addition, multi-use pathways thatn are physically separated from motor vehicles therefore require different maintenance procedures. Cycle tracks in particular need special design consideration for winter as the type (i.e., bollard or low curb barrier) and width need to accommodate maintenance vehicles.

Figure 1 - Cycle Track or Separated Bike Lane Types

Source: Urban Systems, 2013

Painted Buffer

Barrier

Bollards

Elevated or Raised

2.5 Winter Maintenance, Road Conditions and Safety

Safety on roadways is often cited as the main deterrent for potential or interested but concerned cyclists. Safety in winter is a real concern and is the reason many cyclists put away their bicycles for three to six months of the year. Bicycle facilities such as bike lanes provide a dedicated space for travel on roads adjacent to cars, while cycle tracks or separated or protected bike lanes, or multi-use paths are physically separated from motor vehicles. During the winter season, roadways and vehicle travel lanes become constrained by accumulated snow and ice. Snow plows push snow to the curb edge and sidewalk plows also push excess snow to the curb. The result is the path cyclists travel (the space between the curb and the vehicle travel lane) on a roadway becomes constrained and more dangerous due to accumulated snow. There is limited space in the vehicle travel lane, in addition, the conditions change from fresh snow, compact snow, to ice or slush.

A study in Montreal QC on the rate of collisions in winter, not surprisingly, found that precipitation and temperature impacted winter road safety, and accidents between motor vehicles increased sharply with increased snowfall (Andreescu & Frost, 1998). Snowfall affects road conditions as winter weather produces a constrained roadway with ice and increased skidding conditions. A different study of six Canadian cites associated higher traffic collisions due to winter precipitation (Andrey et al., 2003). Snowfall reduces visibility, effects roadway friction, as well, creates snowbanks or windrows which reduce available travel lane area and visibility (Andrey et al., 2003). Neither of these studies included pedestrian or cyclist collision analysis yet their findings highlight that if winter weather creates poor unsafe roadway conditions between motor vehicles, then road users are more exposed to winter hazards. Moreover, road collisions occur due to numerous factors, not just weather, such as driver behaviour, traffic volume and vehicle speed. Generally, road conditions in winter are less safe and there is less 'shared' space for motorists, cyclists and pedestrians due to snow storage in the right of way or curb lane area.

A decrease in cycling in the winter season is due to mixed road conditions and assumptions can be made that there is a great potential to increase winter cycling through improved road conditions. Bergström and Magnussen cited a Norwegian survey from 1998 (Gicæver et al., 1998), that asked cyclists why they would not cycle in winter, 53% stated uncleared snow on cycleways. Of interest in the survey responses is that they said "uncleared snow" which indicates snow is not the issues. In the same study 27% said that slippery surfaces would also discourage them, but most said that it would not affect their decision to cycle. Cyclists in Sweden indicated they would cycle more during winter if the maintenance service level of the cycle paths was improved (Bergström and Magnussen, 2003). They concluded there was a potential to increase winter bicycle trips to work by as much as 18% by simply maintaining the bicycle routes (and reduce motor vehicle trips by 6%). This stated preference survey results highlight desired outcomes and do not always translate into actual travel behaviour. However, the study results also found a recurrent desire for snow clearing and de-icing, specifically in the early morning peak commuting hours.

A survey of winter cyclists in Ottawa ON and Montreal QC revealed that cycling levels drop by almost 50% as soon as

the surface of a bicycle facility is partially covered with snow, icy or slush (Miranda-Moreno & Kho, 2012). Analysis of cycle rates, surface conditions and winter weather patterns by Miranda-Moreno and Kho (2012) determined there is the potential to retain an additional 12% to 24% cycling mode share in winter with dedicated maintenance of bicycle facilities. Slipping hazards are of major importance to cyclists as bicycles have different maintenance needs than motor vehicles as they are lighter in weight and have less tire surface; motor vehicles naturally maintain roads and streets through their travel movement (Cebe, 2013).

Motor vehicle movements contribute to road maintenance in winter as the wide tires automatically clear the roadways and disperse snow. As a result, cyclists often travel on major arterials roads and collector streets (without dedicated bicycle facilities) in winter as they have better road surface conditions. Cyclists alter their routes in winter to major streets as they are the only safe, accessible and predictable roads due to priority maintenance and road surfaces are cleared by vehicle tires. However, the right of way of the street is occupied by snow so cyclists are forced to travel in the same path (or rut) as motor vehicles, creating tension between road users. Low volume residential streets often have more accumulated snow and ice due to lower motor vehicle traffic making them less desirable routes for cycling. Amir and Sadeghpour's study (2013) found that 61% of cyclists in Calgary indicated icy conditions and snow in the bike lane were major concerns during winter. Maintenance of bicycle facilities during winter ensures a safe comfortable network is available for peak commuter travel time. Winter causes real safety concerns versus merely perceived safety issues. The implication of this research on bicycle planning is that maintaining select bicycle facilities is important in order to reduce the exposure of cyclists to regularly occurring motor vehicle accidents due to winter weather conditions.

2.6 Summary

Knowledge of the types of individuals that cycle during the winter season – dedicated commuter utilitarian cyclists - is valuable information for planners and decision makers in selecting routes for winter maintenance. Surveys of cyclists reveal that they would cycle more during winter if bicycle facilities are maintained and road surface conditions are safe and predictable. In addition, research also confirms there is a distance threshold that cyclists are willing to travel during the winter. Distance pertains to a length of time and comfort level (i.e. exposure to cold temperatures) for a single trip and this information also contributes to the prioritization of bicycle networks. Cold weather conditions do deter a large portion of the population from cycling as road surface conditions are constrained and become hazardous. A main objective of snow removal is to ensure a level of service for road users and ensure mobility for all modes of transportation. Cities that have a well established population of cyclists and comprehensive bicycle network have a responsibility to offer year-round maintenance of the bicycle infrastructure (Cebe, 2014). Retaining cycle levels all year round contributes to the overall sustainable transportation system, as trips are not shifted to driving or public transit. Selecting appropriate routes and corridors within the bicycle network and maintaining bicycle facilities is necessary to support four season cycling. The following section is a Peer City Review which highlights good practices and policies from winter cities in North America and Europe.

3. Peer City Review

The conditions of winter vary distinctly between geographic regions of the world, with winter weather characteristics fluctuating based on temperature, daylight, snowfall or precipitation (**fig. 2 and 3**). Planning for cold climates must factor in seasonal variation and local weather. As a result there are different classifications for "winter" cities. Categorizing winter cities based on northern latitude does not accurately capture the distinct climatic conditions for each city, as other factors such as ocean currents, topography and air mass all contribute to seasonal weather patterns (Matus, 1988).

A city with consistently very cold temperatures and large volume of snow that does not melt regularly throughout the winter will require intensive snow removal operation (e.g. Winnipeg, Manitoba, Montreal, Quebec). Cities that experience numerous days of above zero temperatures often referred to as a "freeze-thaw" cycle, may focus more on snow plowing operations, which distributes snow out of the roadway to the edges of the roadway and heavier use of surface applications like de-icing agents or salt treatments (e.g. Toronto, Ontario, Chicago, Illinois, Vienna, Austria) (City of Toronto, 2014; Bouchard, 2014).

Peer cities have been categorized based on their average high and low January temperatures and are organized into three categories of mild winter, moderate winter and severe winter **(Table 1)**. Select cities may experiences similar temperatures but very different snowfall volumes, or conversely, similar snowfall volumes but different temperatures. The purpose of classifying the peer cities is that cold weather characteristics vary, as a result tailored approaches and measures are required for planning, design and maintenance operations.

Figure 2 - North America Average Annual Snowfall
Source: City of Toronto, 2014

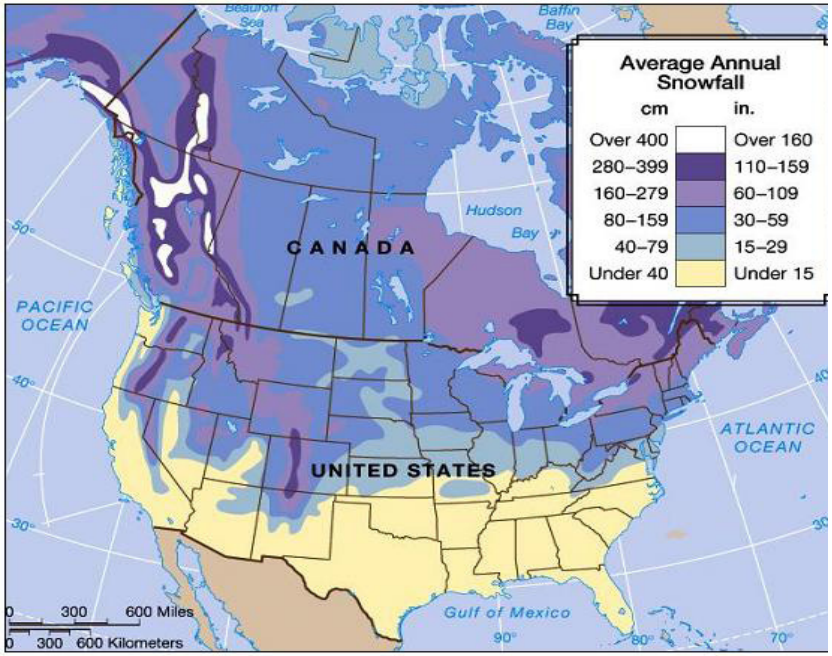
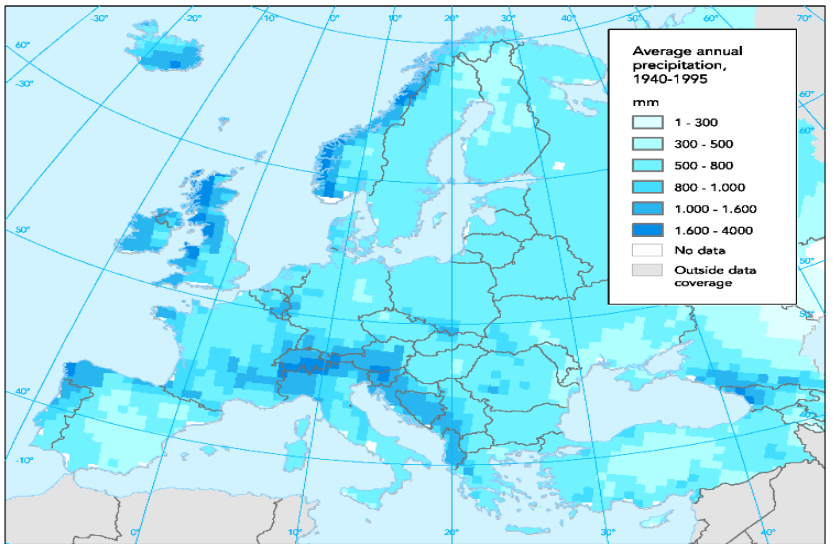


Figure 3 - Europe Average Annual Precipitation
Source: City of Toronto, 2014



Peer City Review

The Peer City Review investigates comprehensive strategies, municipal snow removal bylaws, maintenance of bicycle routes, monitoring and promotion programs relevant to winter cycling. In order to effectively use the Peer City examples, a city needs to have an understanding of local winter maintenance operations, established goals within a bicycle or transportation plan and use these implementation strategies to meet those goals. The Peer City Review and the final section for the City of Winnipeg are based on an expressed vision and goal of increasing bicycle mode share with specific strategies for the winter season.

The following selection of policies and practices from Canada, the United States and Northern Europe feature ideas for policy implementation to improve four season year-around bicycle transportation. While coastal cities in Northern Europe experience markedly milder winters than continental North American cities, each city in the Peer City Review offers a good idea for improving conditions for cycling in winter. The examples presented here were gathered through independent research, participation at the 2014 Winter Cycling Congress and through interviews with municipal planners or engineers.

Cities are organized in the **Peer City Comparison Profile Table 1** based on similar winter conditions; however the Peer Review chapter is structured by policy and practices and is organized by four thematic design principles or 4 "P's" namely: plan, prioritize, procedures, and promote. A final section will explore the mechanisms to monitor and evaluate a planning program. Winter planning and design requires context sensitive application, and knowledge of temperatures and snow volume to find suitable winter maintenance solutions.

Table 1 – Peer City Comparison Profile

City	Population	Density	Elevation	Average January High Temperature	Average January Low Temperature	Average Snowfall (cm)	Bicycle Mode Share (peak season)
Boulder Colorado	98,000	1,524/km²	1655m / 5430ft	7°C	-5°C	200	9%
Copenhagen Denmark	570,000	6,600/km²	1-91m / 3-299 ft	2°C	-2°C	n/a	36%
Vienna Austria	1.7 million	4,002/km²	151-542m / 495-1778 ft	2°C	-4°C	35	6%
Salt Lake City Utah	200,000 (1.1 million)	643/km²	1288m / 4226 ft	2°C	-6°C	147	3.5% - 4.8%
Chicago Illinois	2.7 million	4,447/km²	182m / 597 ft	0°C	-7°C	120	1.3%
Toronto Ontario	2.6 million	4,149/km²	76m / 249 ft	-1°C	-6°C	120	2.2%
Hamilton Ontario	500,000	465/km²	75-324 m / 246-1063 ft	-2°C	-9°C	118	0.8%
Calgary Alberta	1.1 million	1,329/km²	1045m / 3428 ft	-1°C	-13°C	126	1.8% - 2.5%
Minneapolis Minnesota	380,000	2,710/km²	264m / 830 ft	-4°C	-13°C	126	4.3%
Montreal Quebec	1.6 million	4,517/km²	6-233m / 20-764 ft	-5°C	-12°C	200	3.1%
Oulu Finland	190,000	137/km²	15m / 49 ft	-7°C	-15°C	n/a	33%
Winnipeg Manitoba	704,800	1,430/km²	238m / 781 ft	-10°C	-20°C	120	2.1%
Whitehorse Yukon	27,900	56/km²	670-1702m / 2200-5584 ft	-11°C	-19°C	145	2.7%

3.1 PLAN

Today most major urban cities have a master plan for bicycling either independently or as a component of a transportation master plan. Within a comprehensive planning document, the goals are most often communicated as the desired end results, such as increasing mode share. Clear strategies are detailed to achieve the desired goals or outcomes, such as improving cycling safety through education. A survey of the peer cities comprehensive bicycle plans reveals that very few cities communicate a goal directly related to winter, yet many strategic initiatives directly support cycling in winter.

One common approach to bicycle planning is structured around 5 or 6 E's as the essential elements of a comprehensive plan – Education, Encouragement, Engineering, Enforcement, Evaluation and Equity. This inspired the development of four thematic design principles for winter bicycle planning (City of Minneapolis, 2011; League of American Bicyclists, 2014). Planning for winter cycling can especially fit within policies in the areas of encouragement, engineering and evaluation. The following cities offer different methods for communicating their plans for winter cycling; the City of Montreal included a winter network within its Transportation Master Plan, the City of Minneapolis has strategies for winter maintenance in its Bicycle Master Plan and Bicycle Facility Design Guidelines, and the City of Vienna has a priority route map for winter maintenance of the bicycle network. The City of Copenhagen is the one city with a clearly stated goal of comfortable and accessible cycling facilities in winter.

City of Montreal Quebec

Population: 1.6 million

Annual Snowfall: 210 cm

Jan Avg High Temp: -5°C

Jan Avg Low Temp: –12°C

Bike Mode Share (peak season): 3.1%

The City of Montreal has been a pioneer in bicycle facility design, infrastructure implementation and planning since the 1980s. Montreal offers approximately 650 km of bicycle paths throughout the City of Montreal and the region (Ville Montréal, 2008). The metropolitan cycling mode share is 3.1% and neighbourhoods within the city reach mode shares as high as 9 % to 12% (i.e., Plateau-Mont Royal) (Vélo Québec, 2010; Komorowski, 2014). According to Vélo Quebec (2010), the popularity of utilitarian cycling in the City of Montreal has increased from 25% to 53% between 2000 and 2009. Contributing to the continued rise in cycling in Montreal is the density of built form land use in the central city, in addition to the Bixi public bike share system launched in 2009, in conjunction with the continued investments in bicycle infrastructure.

The City does not have a stand-alone Bicycle Plan and their goals for cycling are contained within the transportation section of the city-wide Master Plan and Transportation Master Plan. The "Master Plan" identifies measures for implementing a Plan d'action vélo (Cycling Action Plan) with completing a city-wide bikeway network (Ville Montréal, 2004).

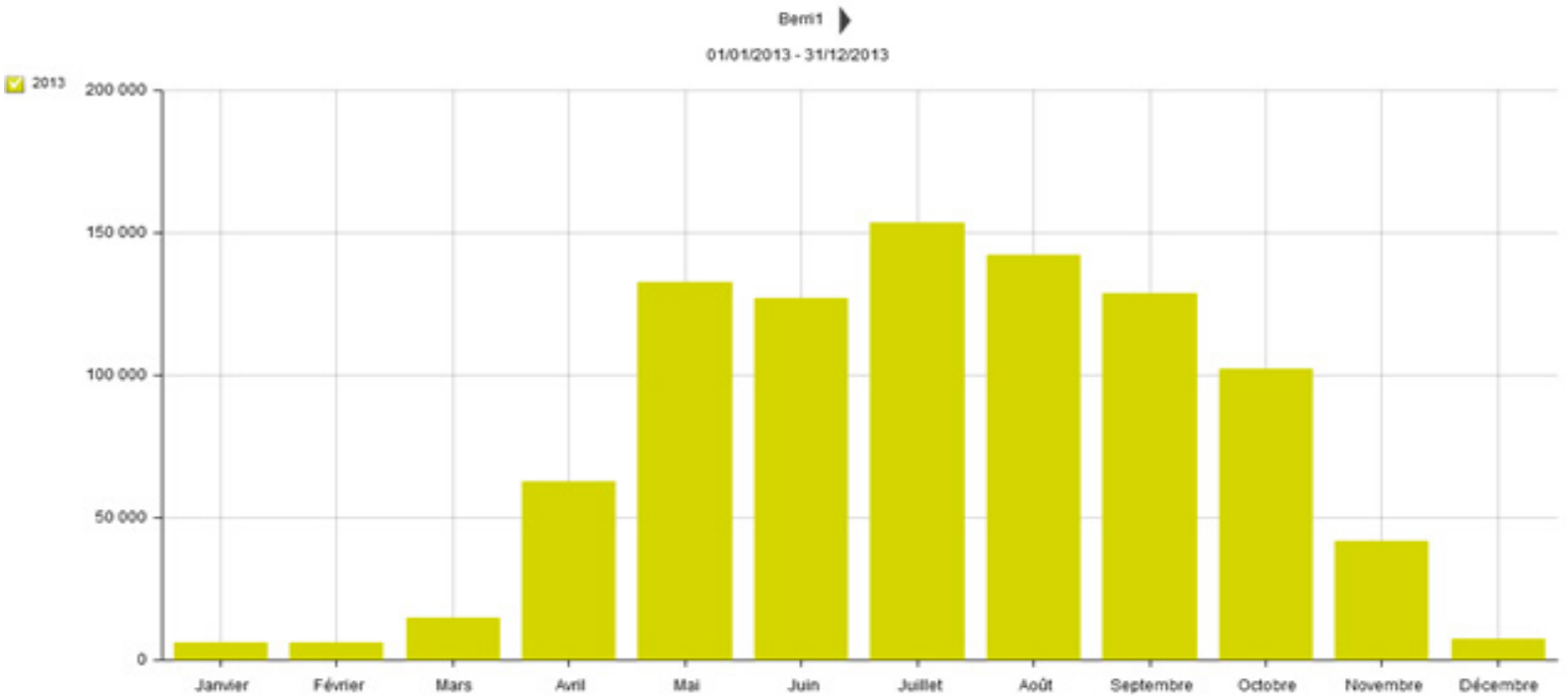
Figure 4 - Reseau Blanc or White Network Map
Source: City of Montreal, 2008

In 2007 the City kept a portion of its bike path system open year-round and the "2008 Transportation Plan" established a *Reseau Blanc* or White Network (City of Montreal, 2008). The *Reseau Blanc*, **figure 4,** is a portion of the bicycle network that is identified for priority maintenance during winter. The transportation plan and policy acknowledged that cycling year round is growing in popularity and that clearing bike routes enhances the safety and allows cyclists to avoid "riskier streets and arterial roads" (City of Montreal, 2008). A map of the white network allows cyclists to plan a predictable route, of which, a significant section includes separated bike lanes or cycle tracks.

Local research at McGill University by Mirand-Moreno, Nosal and Kho (2013), suggest the facilities that are part of the *Reseau Blanc* are more heavily used by cyclists due to winter maintenance and reliable surface conditions. In a complimentary study, Miranda-Moreno and Kho (2012) stated that "Using Montreal's *Reseau Blanc* as a case study, it was found that surface conditions are positively correlated to cycling winter rates...Furthermore, cycling winter rates are higher on facilities that are part of the *Reseau Blanc* in comparison with facilities without any form of maintenance during winter" (p.22). Miranda-Moreno and Kho suggest either cyclists chose to use the white network routes, as they know they will be maintained during winter, or simply that commuter cyclists do not change their routes and continue to use these facilities.

The City acknowledges that cycling through winter is not for everyone yet found that a dedicated portion of the population cycle all year long. Currently, the City maintains an estimated 60km of the bicycle network in winter which has grown from the original 30km in 2008 (Komorowski, 2014). As **figure 5** shows, winter cycling rates logged at the Rue Berri automated counter are significantly lower than summer volumes. However, while the levels are lower, this one counter shows a monthly average of 4000 to 6000 cyclists in December to February. The *Reseau Blanc* is not seamless and while the map identifies a winter network, the reality is that the entire network is not maintained in winter. The *Reseau Blanc* crosses multiple borough (municipal) jurisdictions and in previous years local boroughs have not maintained sections of the route due to the cost of snow removal (Lalonde, 2011). Local responsibility for snow removal results in gaps in the winter cycling network and raises the importance of dedicating more resources to ensuring a comprehensive network is predicable for commuter cyclists.

Figure 5 - Data from the Rue Berri automated pavement counter
Source: City of Montreal, 2013



City of Minneapolis Minnesota

The City of Minneapolis has become one of North America's premiere bicycle friendly cities. Cycling mode share has been on the rise and the City has invested in a comprehensive network of bicycle infrastructure linking regional trails and state pathways.

Population: 380,000

Annual Snowfall: 124cm

Jan Avg High Temp: -4°C

Jan Avg Low Temp: -13°C

Bike Mode Share (peak season): 4.3%

Minneapolis is a winter city that experiences cold snowy conditions for months at a time. The City has a peak season bicycle mode share of an estimated 4.3% (Dill & McNeil, 2013). An estimated 20% of all bicyclists continue to cycle through all winter conditions and 36% cycle through fair conditions (City of Minneapolis, 2011). As a result the city ensures a portion of the bicycle network is accessible. Minneapolis retains a winter cycling mode share of approximately 1.5% to 2%, which is more than some cities peak season mode share.

The Minneapolis "Bicycle Master Plan" and the companion "Bicycle Facility Manual" guide bicycle planning and policies in the city. The 2011 "Bicycle Master Plan" has two specific areas where winter cycling is acknowledged, specifically the maintenance section of the Bicycle Facilty Design Guidelines. The 2011 "Bicycle Master Plan" outlines three very simple goals: #1 Increase bicycle mode share #2 Bicycling in Minneapolis is safe and comfortable and #3 Destinations in Minneapolis are reasonably accessible by bicycle. In order to meet the second goal of making cycling safe and comfortable, the City has indicated one strategy (#7) to: "use the Minneapolis Bicycle Design Guidelines to design and maintain bicycle facilities. Using these guidelines will help ensure bicycling is safe, convenient and comfortable for all travelers" (p.131).

The "Bicycle Facility Design Guidelines" within the Manual is a comprehensive resource on bicycle infrastructure design (on-street and off-street), including bicycle parking, and additional support facilities information. Chapter 8 of the Guidelines describes maintenance of bicycle infrastructure, with a section on winter, outlining basic levels of service for routine maintenance (for a given bicycle facility). The Manual outlines the city's maintenance priorities and policies of plowing, sanding and salting the greenways, arterials trails, and on-street bikeways, **figure 6** (City of Minneapolis, 2010). The Manual does an excellent job of identifying issues for cyclists during winter including snow and hard packed ice in bike lanes, and businesses not shoveling around bike racks.

The City of Minneapolis acknowledges that "adequate winter maintenance remains a huge concern for year-round cyclists" (p.67) and the City recognizes that routine maintenance is an essential service in order to facilitate safe cycling all year long.

Bicycle Facility Design Guidelines
Chapter 8—Maintenance

Maintenance Guidelines

Plowing — Plowing bikeways is an essential form of routine maintenance that must occur to facilitate safe year round bicycling. On average the Twin Cities region receives over 55 inches of snow each year. Nonetheless, over 25% of all bicyclists choose to bike year-round regardless of weather.

Above: Plowing along the Midtown Greenway.

Above: Plowing along the Midtown Greenway.

Plowing Frequency: Minneapolis bikeways are plowed relatively soon after a snowfall. Arterial trails are often plowed before many of the streets. All bikeways are sanded and salted as needed.

Trail Plowing Policy: Bikeways maintained by Minneapolis Public Works and the Minneapolis Park and Recreation Board will be kept reasonably free of snow and ice, with sanding and/or salting as required in the winter season. The bikeway will be plowed once by the end of the next business day after the snow fall.

On-Street Bikeways Plowing Policy: On-street bikeways receive the same level of winter maintenance as the rest of the street surface.

Plowing Vehicles: Smaller trucks and pickups with plows are often used to maintain the trails. Larger snow plow trucks maintain the roadway system and corresponding on-street bikeways.

Figure 6 - City of Minneapolis Bicycle Facility Design Guideline, Winter Maintenance Section
Source: City of Minneapolis, 2010

The priority off-street pathways cleared of snow are the Midtown Greenway (east-west 10 km) and the Hiawatha Light Rail Trail (north-south 8km) (City of Minneapolis, 2011), **figure 7**. The City's dedication to expanding the bicycle network, building different types of facilities and clearing off-street bikeways of snow has led to higher rates of cycling through winter. The City has been able to develop the off-street corridors, both Midtown and Hiawatha, as they are built on an old, industrial rail line running through the center of Minneapolis (Harris, 2013). The networks are below grade, located under major roadways making them quick uninterrupted routes across the city. In effect the Greenway is a bicycle highway and one of the fastest ways to get across town. There are approximate 10 stops across 6 miles that lead to the Downtown, and connecting to St. Paul (Murphy, 2014; Harris, 2013).

Figure 7 - Map of the Midtown Greenway and the Hiawatha Light Rail Trail
Source: Murphy, 2014

The City of Minneapolis has made significant efforts to improve winter maintenance operations through training and knowledge exchange with other cities. The City sent senior operation personnel to Finland to learn more about maintenance for active transportation facilities and this led to a strong cultural shift in the operations department.

In 2014, the new Mayor Betsy Hodges declared Januray 3rd Winter Bike Day in Minneapolis and offered a bold declaration: "Minneapolis winter bicyclists, like Minnesotans in general, are more resilient, more hardy, more 'Die Hard' gritty, just plain tougher and much better looking than cyclists from all those wimpier cities." (Glionna, 2014). Beyond the support of elected officials and senior management, operations supervisors and managers need to offer direction, leadership and guidance of snow removal innovations (Pletan, 2001). A major strategy to improving winter maintenance level of service and delivery in any city is through the engagement and 'buy-in' of operations crew.

City of Vienna, Austria

Population: 1.7 million

Annual Snowfall: 35 cm

Jan Avg High Temp: 2°C

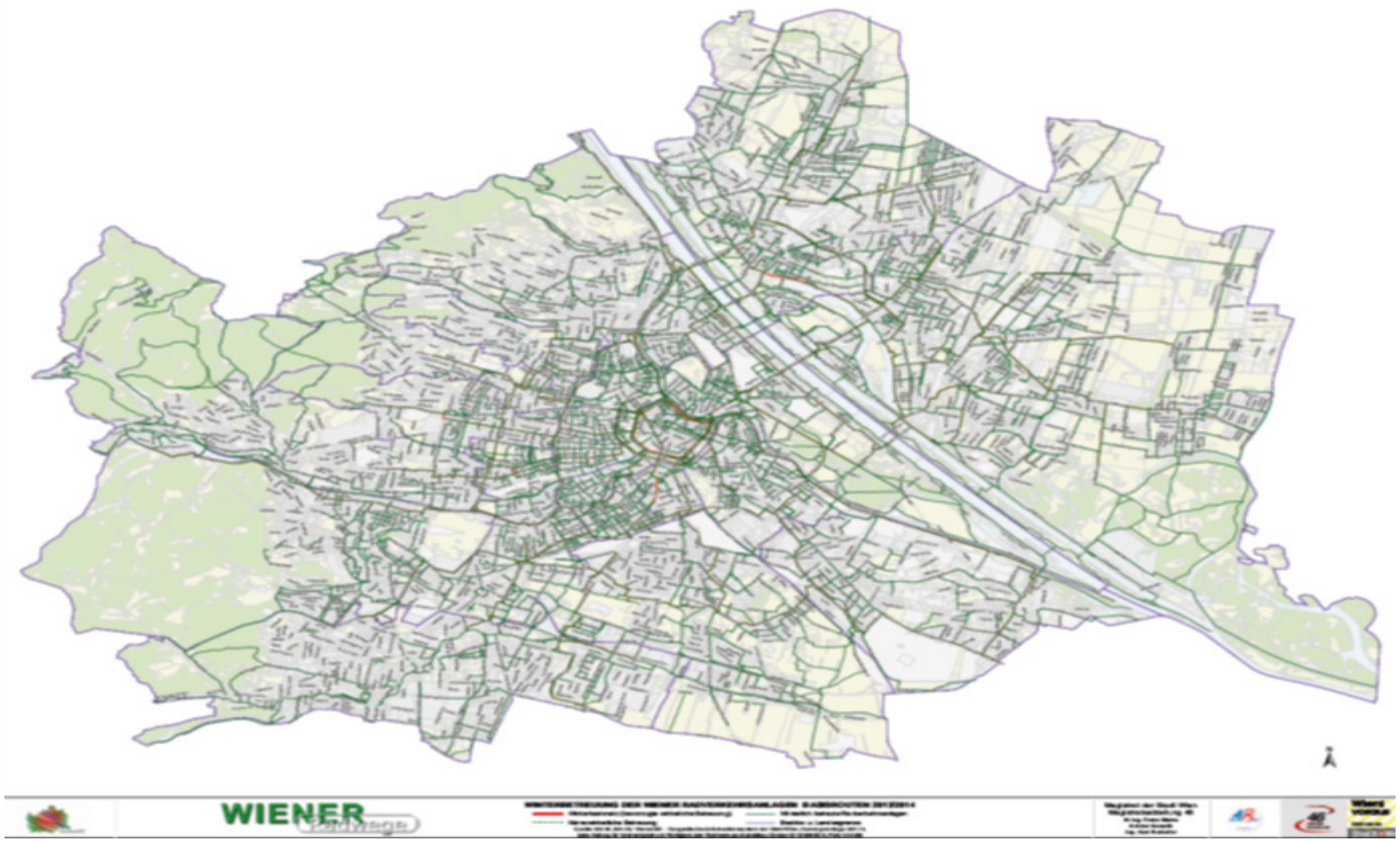
Jan Avg Low Temp: -4°C

Bike Mode Share (peak season): 6%

The City of Vienna has seen a steady rise in cycling since 2010 when the city expanded bicycle planning and implementation of a comprehensive network. Vienna has an ambitious five-year plan to increase cycling mode share from 5% in 2010 to 10% by 2015 through a strategy called the "Vienna Cycling Manifesto" which includes updated facilities, improved safety and dedicated winter maintenance (Lorenz & Posch, 2013). In 2011, the bicycling mode share of trips had reached 6%. In 2013 the City hosted the international Vélo-City Conference which led to a campaign called "Bicycle Year 2013" to support these efforts (Weninger, 2012).

Similar to the City of Montreal, the City of Vienna has prepared a publicly available route map (**figure 8)** to promote the winter cycling network. The priority routes the City selects for winter maintenance are determined based on the special corridors for commuter traffic being of primary importance as well as all paved bike lanes. Unpaved paths are not maintained and the remaining network is maintained as secondary priority (Kutheil, 2014). The City estimates 198 km of separated bicycle lanes, 100km shared-use pedestrian and bike lanes, 409 km of on-street bike lanes and multi-use paths are maintained during winter (Kutheil, 2014).

Figure 8 - Vienna Cycling Map and Winter Maintenance Routes
Source: City of Vienna, 2014



According to **figure 8** the Vienna Cycling Map and Winter Maintenance Routes the legend on the above maps, the red routes are dedicated cycle way network with prioritized winter service (266km), the green routes are cycle network with winter service, green dotted routes have no winter service, and purple routes indicate district borders.

The winter conditions are milder than both Montreal and Minneapolis allowing for regular thawing periods which reduce the demand for snow removal and maintenance. Vienna has refined local maintenance strategies based on the moderate winter climate and weather, very similar to the City of Copenhagen.

City of Copenhagen, Denmark

Population: 570,000

Annual Snowfall: n/a

Jan Avg High Temp: 2°C

Jan Avg Low Temp: -2°C

Bike Mode Share (peak season): 36%

The City of Copenhagen is internationally known as a bike-friendly city. The bicycle mode share for the City is 36% meaning bicycle trips to work make up over 1/3 of the daily transportation system. Copenhagen has a bicycle plan titled "Good, Better, Best: The City of Copenhagen's Bicycle Strategy 2011-2025". This comprehensive bicycle plan that includes a goal regarding winter cycling. Through this goal of maintaining a level of comfort traveling from A to B, the city recognizes that cycle tracks need to be accessible and reliable for transporting children or groceries, doing errands or going to work all year. According to the "Good, Better, Best", in 2011 funding for winter maintenance was increased by $10 million and in 2012 by an additional $2 million (p.19). The City aims to have a high level of service and a quality network by 2025. This will meet the needs of all riders through PLUSnet routes, green routes and bicycle superhighways which will have an A+ priority for more frequent snow clearing (City of Copenhagen, 2011).

Cycling is such a common mode of transportation in Copenhagen that individuals do not identify as "cyclists" the way individuals do in North American cities. The 36% mode of share of cycling is impressive, and in addition to this, 17% of families own a cargo bike (a utilitarian bicycle to transport cargo or children).

For families with two or more children a cargo bike is an alternative to owning a car and provides an easy method to safely travel across the city for shopping or transporting multiple children. For a city with such high bicycle ridership, prioritization of cycling extends all year round (City of Copenhagen, 2011).

Figure 9 - Cargo bicycle in winter
Source: Copenhagenize, 2012

The City of Copenhagen designs elevated or raised cycle tracks with an added 0.5m space between the cycle track and road for snow storage, **figures 9** (Karhula, 2014). In Copenhagen the elevated cycle tracks can be maintained by broom brush sidewalk plows. Creating space for snow storage enables plowing or clearing and reduces the costs for snow removal.

The City of Copenhagen is lauded as one of the most bicycle-friendly cities in the world. However, comparisons related to winter maintenance and land use planning must consider the moderate winter climate and the land use context. The city has been designing raised cycle tracks for a long period of time and has the available space between the roadway and sidewalk to include more space for snow storage. Designing bicycle facilities with snow storage in mind offers a good example for North American cities, **figure 10**.

The Cities of Montreal, Minneapolis and Vienna, through planning have prioritized bicycle routes or corridors and committed resources to maintain the dedicated facilities in winter. These cities have policies and practices to provide a high level of service standard with result in predicable bicycle routes. The research of Bergström and Magnussen (2003) in Sweden suggested an 18% increase level in cycling is possible through dedicated road surface maintenance. In addition, Miranda-Moreno and Kho's (2012) research in Canada indicated a cyclists retention rate of 12% to 24% in winter through maintenance of bicycle facilities.

The City of Minneapolis is a colder winter city than both Montreal and Vienna yet it estimates up to one-quarter or 25% of peak season cyclists continue commuting year-round. Cyclists adapt to the local climate, and research concluded that prioritizing bicycle facilities and establishing predictable routes will ensure an accessible year round transportation system.

Consistent design of bicycle facilities that factor in snow storage has led to year-round accessible bicycle networks in Europe. Cites in Denmark, Finland and Sweden primarily build elevated or raised cycle tracks that are parallel to sidewalks and roads (Karhula, 2014). Cities in Finland (Oulu) and Sweden (Linköping and Umeå) aim for consistent design of the bicycle network and homogenous routes (i.e. all on-street or all off-street) as switching back and forth makes maintenance difficult. Consistent design leads to more efficient, effective and less expensive maintenance all year.

Figure 10 – Elevated or Raised Cycle track
City of Copenhagen
Source: Karhula, 2014

3.2 Prioritize

A comprehensive and dedicated plan for cycling is helpful in order to prioritize efforts to increase bicycle mode share. Establishing predictable bicycle routes is quintessential to support cycling in winter as road surface conditions become hazardous and unsafe due to snow and ice. The method for prioritizing cycling within road operations and maintenance in winter is through municipal polices and bylaws.

Winter maintenance is organized in many Canadian cities to operate through the prioritization of the road network as follows: priority one routes are major arterials roads, priority two are collector streets, and residential local streets are priority three. This indicates the level of service a city will ensure during or after a snow event (City of Winnipeg, 2011; City of Calgary, 2014). The priority level of service relates to the maintenance standards that can be expected for a transportation network. By applying a hierarchy by prioritizing transportation corridors cities ensure mobility and accessibility during winter.

The roadway prioritization is communicated through a snow removal or maintenance policy. In addition to the road network, a snow removal policy may also include a level of service priority relevant to the maintenance of sidewalks, bicycle routes, local pathways or trails. Sidewalks often have a prioritization similar to the adjacent roadway or have a special policy, for example, snow clearing is the responsibility of the municipality or property owner. Prioritization of bicycle facilities is somewhat new and varies city to city. Many on-street bicycle facilities, such as bike lanes, may be located on streets with either a first or second priority.

Off-street facilities or multi-use pathways may have a priority two or three and often fall under the responsibility or maintenance schedule of parks agencies versus road departments. Generally, pedestrian and cycling networks receive different maintenance levels than roadways. In order for bicycle commuting to be a viable form of transportation during the winter months, bicycle networks and routes need to be assigned a priority level in the same way as roadways to ensure they are safe, predictable and accessible. The following section highlights the City of Calgary's snow removal and ice control program relevant to the local bicycle network.

City of Calgary Alberta

Population: 1.7 million

Annual Snowfall: 35 cm

Jan Avg High Temp: 2°C

Jan Avg Low Temp: -4°C

Bike Mode Share (peak season): 6%

The City of Calgary is a prairie city based at the foothills of the Canadian Rockies. The city experiences four seasons and typically winters are cold and snowy. Accordingly, the City of Calgary Snow and Ice Control Program outlines the City's process and practices regarding winter maintenance. In 2011, Calgary updated the Snow and Ice Control Policy emphasizing the need to ensure mobility and access for motorists, pedestrians and cyclists, as well as transit and emergency operations. On-street facilities, primarily bike lanes, are often located on roadways and the streets that are priority one or priority two for snow clearance and maintenance. Calgary's Snow and Ice Control policy includes designation and prioritization for bicycle facilities. Calgary's policy includes a section titled:

Sidewalks, Walkways and On-street Bikeways
The policy is also designed to maintain reasonable walking and cycling conditions along City controlled sidewalks and pathways for pedestrians and marked on-street bike lanes for cyclists. The City's Snow and Ice Control program determines how roadways and sidewalks are maintained and includes the following services:

- Removal of snow and ice from roadways, sidewalks and stairways using a combination of sanding and salting, ploughing, and snow removal.
- The provision of winter maintenance services for Stephen Avenue Mall and Barclay Mall.
- The Parks business unit is responsible for snow and ice control on the regional pathway system.

The City's website on winter maintenance also highlights the level of service for the new cycle tracks and on-street marked bike routes under Frequently Asked Questions. If the bike lanes or cycle tracks are on a high volume roadway they have the same higher priority for snow clearance with 24 hour service level indicating that continuous plowing or salt/sand treatments will be applied until bare pavement is achieved. The city off-street pathways are cleared of snow by a separate parks department and it has a 24 hour period it commits to clearing the pathways after a snow event (City of Calgary, 2014). All other on-street bicycle routes will be considered priority two with a 48 hour level of service.

The City of Calgary makes information for all road users easy to access through the city website. The City of Minneapolis similarily also has a good example for a policy with operation procedures for snow clearing and removal for each bicycle facility type, **figure 6**.

3.3 Procedures

Selecting the appropriate procedure and methods for maintaining cycling networks requires flexibility and innovative local solutions. Establishing a priority bicycle network ensures a predicable route for cyclists and a variety of procedures are needed for each unique bicycle facility type. For winter cities, the design of bicycle facilities needs to consider winter weather and winter maintenance, while operational procedures need to be evaluated in order to contribute to future facility design. Cities, such as Salt Lake City, Chicago and Calgary are beginning to recognize the need for facilities to be designed with these context conditions in mind, such as volume of snowfall, required width and materials in mind.

One challenge cities face as they expand winter maintenance to bicycle facilities is having the right equipment for the job. Experts from Northern Europe recommend designing consistent facilities in order to make winter maintenance easier; a consistent homogeneous design or style of bicycle facility can result in more efficient maintenance throughout the year (Karhula, 2014; Vaismaa, 2014). The City of Vienna uses a variety of methods for winter maintenance depending on the type of bicycle facility. Other examples from cities such as Salt Lake City UT, Chicago IL and Hamilton ON, show that pilot winter maintenance projects helps determine what levels of service are possible and creates flexibility in refining policies and improving infrastructure design.

City of Vienna, Austria

The City of Vienna has a number of methods for maintaining their extensive bicycle network. During the winter the City applies four different procedures to the bicycle routes: on the basic cycle way network a pure brine mix is applied using a tractor with a trailer (**figure 11**), on the separated bicycle lanes a pre-wet salt mix is applied by tractor, on multi-use shared paths a combination of brine, salt and grit is spread with a tractor, and lastly, on-street bike lanes receive a pre-wetted salt with a truck (Kutheil, 2014). There are challenges with many methods for different facilities, particularly facilities that loose visibility of pavement markings, such as contra flow bicycle lanes. Multi-use or shared use paths are plowed and cleared of snow, while plowing is a priority snow storage continues to be an issue as it can not always be removed in time. De-icing agents (Cebe, 2014) are one solution to snow storage limitations, showcased in Hamilton Ontario and the Alta Planning and Design illustrating a number of resources available for surface applications.

Figure 11 - Cycle way tracker trailer plow
Source: Szeiler, 2013

Peer City Review

The following cities are incorporating **cycle tracks or protected bike lanes** design in considering winter facilities.

Salt Lake City, Utah

Population: 200,000 (1.1 million metropolitan area)

Annual Snowfall: 147 cm

Jan Avg High Temp: 2°C

Jan Avg Low Temp: -6°C

Bike Mode Share (peak season):

3.5% to 4.8 %

Salt Lake City maintains on-street bike lanes, protected bike lanes, and off-street paths during the winter season. The off-street bike paths are currently maintained by the Parks Division using smaller plows and sweepers. The City maintains on-street bicycle facilities according to the roadway network priority. The City removes snow in bike lanes following the overall vehicle traffic street priority and designation. The winter schedule prioritizes maintenance frmo A to D order, namely A streets are (primary and collector), streets B (secondary and arterial), streets C (local or residential), and streets D (secondary local streets that are less connected)(Quinn-Hurst, 2014).

The City has a current pilot project underway where a protected bike lane is being cleared of snow using existing plow equipment in line with existing snow removal priorities and schedules. The protected bike lane extends two city blocks and was designed to accommodate existing snow removal equipment. The protected bike lane is a post style cycle tracks designed to have flexible bollards positioned a far enough width from the curb to accommodate a small pickup truck plow. Initial observations of winter maintenance have determined that future protected bike lanes will require smaller plow equipment due to the limitations of available road widths (varying road widths and rights-of-way). The City has identified future protected bike lanes should receive a high priority for snow removal as they will be key routes for bicycle commuters. The City still has a need to update the priority routes of bicycle facilities as protected bike lanes may be installed on roads that are currently priority B, C, or D for vehicles (Quinn-Hurst, 2014).

The Salt Lake City Transportation, Streets Division, and Public Services Department are working together on a new model of integration between planning, operations and maintenance, and together are requesting funding for equipment and staff for a bike lane snow removal crew. A dedicated crew could potentially use smaller plows and sweepers to clear the protected bike lanes and all top priority bicycle routes would be classified separately from the overall street priority classification for snow removal (Quinn-Hurst, 2014). The pilot project offers a test to all-season design and maintenance procedures, and will inform future design of bicycle facilities with a winter consideration.

City of Chicago, IL

Population: 2.7 million

Annual Snowfall: 120 cm

Jan Avg High Temp: 0°C

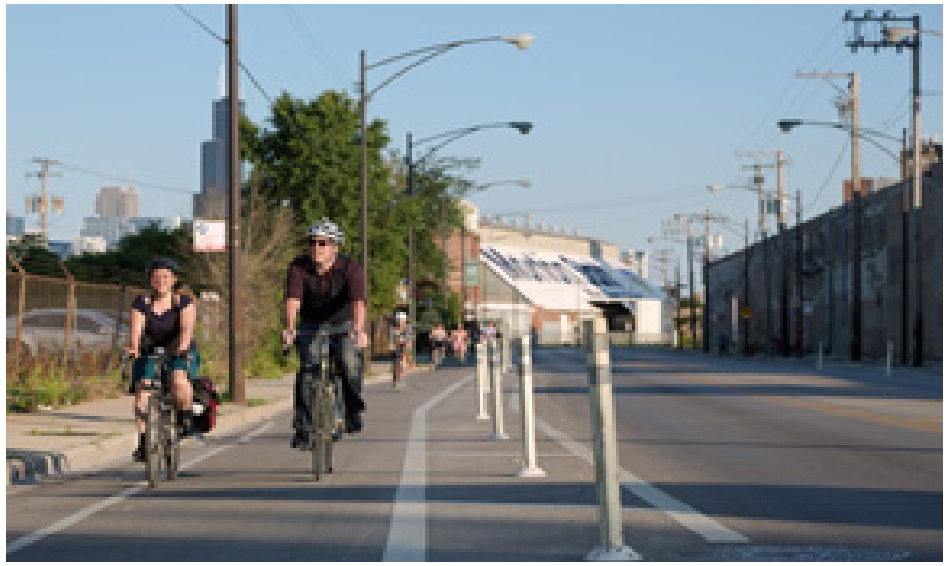
Jan Avg Low Temp: -7°C

Bike Mode Share (peak season): 1.3 %

In the City of Chicago, the Department of Transportation has been maintaining approximately 17km of the new installed protected bike lanes (or cycle tracks) since their construction in 2011/2012. The City of Chicago has a peak season bicycle mode share of 1.3% and winter bicycling has become increasingly common. It is estimated that winter cycling levels are close to half of the summer mode share. Interestingly, women make up 25% of the winter cycling population and and 31% in summer, which is higher than other cities (Dundek, 2014).

The bollard-separated bike lanes have been designed to accommodate pick-up truck plows, **figure12**. The City also adjusted the initial design of cycle tracks to better accommodate winter maintenance. The first cycle tracks were constructed at 7 feet width and a sidewalk plow was used. Following the winter maintenance pilot project the width of the cycle tracks was increased in order for a pick-up truck plow to maintain the protected bike lanes (Cebe, 2014). After one winter season, the city adjusted the design of the separated bike lanes in order to better incorporate the requirements of the local operation and maintenance vehicles.

Figure 12 – Chicago separated bike lane on State Street
Source: Bikes for People, 2013



Peer City Review

The following cities are focused on maintaining **on-street bike lanes.**

On-street bike lanes are a common utilitarian bicycle facility in North American cities and while bike lanes appear to be an easy facility to maintain during winter there are a number of challenges for plowing or removing snow. Bike lanes are most often positioned to the right of a vehicle travel lane and to the left of a vehicle parking lane. Winter maintenance vehicles are designed and equipped to remove snow from the width of one motor vehicle travel lane and commonly push excess snow into the bicycle lane. Bike lanes require extra consideration and procedures often require a "second pass" and lower vehicle speeds from 50km to 30km (Dekker, 2014). As bike lanes are so prevalent in North American cities there is a growing market for innovation to deal with bicycle lane maintenance, such as designing equipment that can attach to standard snow plow vehicles to reduce the need for a second pass.

On-street bicycle lanes seem to be an ideal facility to maintain and prioritize in winter as they are often located on priority one (P1) or two (P2) streets. However, cities face challenges in initiating appropriate methods to clear them, while operation crews predominately view and treat bike lanes as additional snow storage areas. For cities that have heavy snowfall and require regular snow clearing and removal the design of bike lanes (and cycle tracks) require special consideration.

Parked vehicles can be a barrier to clearing snow from the bike lane as snow is plowed into parked vehicles and maintenance vehicles are concerned with damage. Seasonal restrictions may be necessary to manage on-street parking in order to facilitate removal of snow and regular maintenance of bicycle lanes. In addition, consideration for snow storage, specifically drainage as snow melts is an important factor as regular freeze-thaw cycles cause melting snow to flow into bike lanes. In cities with high snow accumulation bike lane pavement marking become invisible with snow coverage and a plan for signage may be necessary for both motorists and cyclists.

Figure 13 – Bike lane in Toronto ON
Source: Winter Cycling Congress, 2014

City of Hamilton, ON

Population: 500,000

Annual Snowfall: 118 cm

Jan Avg High Temp: -2°C

Jan Avg Low Temp: -9°C

Bike Mode Share (peak season): 0.8%

The City of Hamilton has a winter bike lane pilot project evaluating different approaches to winter maintenance of cycling infrastructure. Started in the winter of 2011/2012, the project has tested enhanced maintenance activities for on-street painted bicycle lanes, such as plowing, anti-icing, street sweeping and inspection (Bender, 2014). An estimated 10 km of bike lanes have been maintained over the past three winters, each season markedly different from very mild (2011/12) to extremely cold with heavy snowfall (2013/14).

The maintenance application to the bike lanes through winter has been spreading salt to melt snow and ice and street sweeping of accumulated grit. Although Hamilton's average January temperature is -5°C, with these procedures accumulated snow is not the primary concern. Using salt to help melt snow combined with natural oscillating temperatures has worked in Hamilton to maintain the pilot bike lanes over the winter. The City estimates it cost less than $1000/km to maintain the bike lanes factoring in additional plowing, salting and sweeping (Bender, 2013). This pilot project offers good lessons for mild to moderate winter cities. The City has also been conducting manual counts in winter on select routes in the pilot area confirming again winter cycling rates correlate to fluctuations in temperature and snowfall (see section 3.5)

For cities like Hamilton and Toronto that experience temperatures that fluctuate around zero degrees, natural snow melt is a key part of winter maintenance. Two strategies are used for de-icing; a reactive approach applies treatments after a snow event and a proactive approach that applies materials before a snow event. The latter is deemed more effective as over the winter season less materials are needed (Cebe, 2014; City of Toronto, 2014). Another commonly used treatment in some cities is salt and sand which is a preventative measure for skidding or icy surfaces. Salt de-icers are only suitable for mild to moderate winter environments as the agents do not often work below -5°C (Bender, 2014). In addition, most cities do not use any salt or de-icing agents on multi-use pathways as they are in natural green spaces often near water sources, as the agents are hazardous to the environment.

Salt Lake City, Utah

Salt Lake has many streets that are high priority for motor vehicles that also include on-street bike lanes. While the City estimates 300 kilometres of bike lanes are maintained during winter, the reality is there are many challenges to prioritizing on-street bicycle facilities (Quinn-Hurst, 2014). Currently, on-street conventional bike lanes are considered accessible by snow removal equipment as they are adjacent to the vehicle travel lane. However, on-street parking behaviour creates challenges to maintain bike lanes. Parking is allowed on all streets during snow events but residents are encouraged to park off-street during storms to allow access by plows. Current snow maintenance practices find plows clearing the streets around parked cars which leave a windrow that often extends to obstructing the bike lane and forcing cyclists into the motor vehicle travel lane. During most winters in Salt Lake City, this is not too much of a problem, as snow usually melts within a day or two, and is almost always completely melted by the next storm.

The City recognizes this is an ongoing challenge and safety issue. Different divisions including the Public Services Department, Streets, and Transportation Division, have proposed draft changes to current parking permit times. According to Colin Quinn-Hurst, Division of Transportation, the draft ordinance proposes a pattern of on-street parking restrictions during snow storms to allow crews to clear all parking lanes completely and in the process clear bike lanes. The maintenance and operation crew are in support of the changes, as it makes maintenance of streets and bike lanes much simpler, in addition reducing risks of clearing around parked cars (i.e. damage). To date the proposed parking permit changes have met with some public resistance and the draft proposal is currently on hold for further consideration.

Salt Lake City has made winter snow storage a key consideration for future off-street bike paths and protected bike lanes. For new or proposed roadways, the City aims to include snow storage in the design stage, provided there is enough space in the right-of-way. For a 1.8m bike lane, an additional six foot (or 1.8m) storage space is recommended on the side of the road for snow to ensure the bike lane does not become the de-facto snow storage area (Cebe, 2013). Painted buffer bike lanes are becoming more popular over traditional single painted line bike lanes as they include additional width creating more dedicated safe space. The buffer area, in winter, can be used for temporary snow storage, and a minimum five foot (1.5m) wide buffer is recommended (Cebe, 2014).

For cities that experience more accumulated snow and colder temperatures, maintaining bike lanes is a challenge. In cities like Montreal or Winnipeg, bike lanes become obstructed with excess snow and windrows can freeze solid, often forcing cyclists to travel in the motor vehicle lane. Both Hamilton and Salt Lake City have similar winter climates and use natural warming periods to assist maintenance procedures while cities like Montreal and Winnipeg rely strictly on snow removal procedures to keep bike lanes accessible. One solution is to restrict on-street parking along roadways with bike lanes during snow removal schedules. This is appropriate for a designated "winter or white" bicycle network and does not need apply to all streets with bike lanes and on-street parking. An additional challenge with both regular and painted buffer bike lanes is they become invisible with snow coverage. Signage is needed to indicate to both cyclists and motorists that a bike lanes is present.

Cities with mild and moderate winter temperatures can use melting agents and de-icers applied to the roadway to prevent a buildup of ice. The salt is quite damaging to bicycle components (i.e. drive chains and gears) as bicycle are totally exposed versus motor vehicle components are protected. During the Winter Cycling Congress, cycling experts from the City of Montreal and Vélo Québec were very surprised by the lack of salt used in the City of Winnipeg due to the colder freezing temperatures.

The following cities maintain **multi-use pathways** during winter.

City of Calgary, AB

The City of Calgary has an extensive network of multi-use paths or off-street pathways with an estimated 300km of the 800km pathway network maintained by the Parks Department during winter. A number of the off-street paths are key corridors throughout the city and are snow cleared trails used as high frequency routes in winter. The multi-use path network is not constrained by space so routes are plowed or cleared and the need for snow removal is less necessary than the road networks (Dekker, 2014). The City of Calgary website offers up-to-date information on bicycle programs and networks across the city, including a section for winter see **figure 14**. The City acknowledges that multi-use off-street paths are much easier to maintain as they have a dedicated crew, refined procedures and appropriate vehicles for the facility (Dekker, 2014). Small sidewalk plows or broom snow sweepers are used to maintain the trail network, and these are effective for light to moderate snowfall and are used in other cities like Copenhagen, Vienna, and Toronto. This method of disbursing snow is less harmful to the painted pavement markings and thermoplastic treatments often damaged by snow clearing equipment.

Figure 14 - City of Calgary website "Plan your winter bike trip"
Source: City of Calgary, 2014

City of Oulu, Finland

Population: 190,000

Annual Snowfall: n/a
(120-130 days of snow)

Jan Avg High Temp: -7°C

Jan Avg Low Temp: -15°C

Bike Mode Share
(peak season): 33%

The City of Oulu is one of the most northern coastal cities in Finland with a similar winter climate as Winnipeg MB. Oulu hosted the first Winter Cycling Congress in 2013 when it was recognized as one of the most bike-friendly "winter" cities. The City of Oulu has a winter cycling mode share of 9% which is equal to or greater than any peak season North American city. The peak season mode share is 33% (Perälä, 2014).

Oulu's bicycle network is comprised of primarily multi-use off-street paths which are an estimated 3-3.5 metre wide and are shared with pedestrians. The 800km off-street shared use paths connect the entire city through a series of underpasses, an estimated 98% of the paths are maintained to a high level of service in winter (**figure 10**). The bicycle network in Oulu is unique as it is off-street shared use paths. As a result winter maintenance is primarily plowing and compacting snow, with applications of gravel and sand for textured surfaace. Motor vehicles do not travel on the bicycle network, therefore the hard packed grooming and plowing is not messed up by cars.

The City has a $1.5 million annual budget for winter maintenance with an additional reserve up to $2 million (Perälä, 2014). The land use design and bicycle network enables all major destinations in the city to be reached by bicycle. Oulu is unique as the cycling population, both in summer and winter, is comprised of people of all ages; both families and older adults (**figure 11**). This is unlike most North American cities where winter cyclists are a refined demographic of hardcore commuters predominantly male between the ages of 35 and 55 (Moreno-Miranda et al., 2013; Amiri & Sadeghpour, 2013).

Figure 15 - City of Oulu off-street bicycle network
Source: Timo Perälä, 2014

Figure 16 - City of Oulu winter cyclists
Source: Anders Swanson, 2013

The following section is **on-street pavement marking**, such as bike lane lines (demarcation), bike boxes and the bicycle stencil symbols.

In winter cities, on-street pavement markings experience high abrasion from snow removal equipment and maintenance procedures. Spring, in cities like Winnipeg and Montreal, pavement markings become invisible. Vélo Québec suggests winter cities should test new pavement markings to address the wear and tear of winter (Komorowski, 2014). The City of Montreal is quick to re-paint in the Spring. As of April 18th 2014 many bicycle lane markers had already been repainted. The surface paint method requires city crews to re-apply or repaint every Spring. While this is an affordable method painting requires annual application. One method that is effective over the long term is recessed thermoplastic pavement markings.

The City of Minneapolis uses a technique where the pavement is milled or ground down (recessed) to reduce damage from the snow plows and maintenance vehicles and thermoplastic pavement marking is applied. Installation costs may be higher for thermoplastic but this method is more durable, last longer and will reduce costs over the long term (Cebe, 2014; Zederayko, 2014). The City of Edmonton is experimenting with different applications including oil based paint, water based paint and is exploring recessed thermoplastic applications (Zederayko, 2014).

Each winter city must determine the most appropriate methods and procedures for maintaining the bicycle networks in accordance wit the local climate. This section highlighted different considerations for cycle tracks, bike lanes, multi-use paths and on-street pavement markings.

3.4 Promote

Establishing the portion of a bicycle network that is maintained during the winter season is one step towards building a comprehensive all season bicycle network. One method cities use to communicate winter policies and programs to the public is through their websites. Another method of promoting a prioritized bicycle network is through a route map. Preparing and providing a map of the 'white' network allows winter commuter cyclists to plan a predictable route. Highlighted in the Plan Section are the cities of Montréal and Vienna who produce a network map of the winter cycling routes. The Cities of Toronto and Whitehorse communicate information on winter cycling to the public on their municipal websites.

City of Toronto ON

Population: 2.6 million

Annual Snowfall: 120 cm

Jan Avg High Temp: -1°C

Jan Avg Low Temp: -6°C

Bike Mode Share (peak season): 2.2%

The City of Toronto offers the best example of a comprehensive list of website-based resources for winter cycling. Under the "Safety and Education" section of the Cycling webpage, the City details numerous aspects, namely: how to dress appropriately, riding tips for snow and ice conditions, wet weather, visibility, general safe cycling tips, maintenance ideas and equipment recommendations (**figure 16 and figure 17**). The City of Chicago bicycle website provides links to the City of Toronto winter cycling resources "Cold Cycling Brochure" (City of Toronto, 2014).

Beyond offering a good resource for cyclists on how to prepare for and ride in winter, Toronto maintains the Waterfront Trail and has recently piloted winter maintenance on the separated bike lane on Sherbourne Street. The City hopes to expand winter maintenance to additional areas of the cycling network in the future (Bouchard, 2014).The city-wide cycling mode share is 2.2% however many inner city neighbourhoods have mode shares as high as 10% (McQueen, 2014).

Figure 17 – Cold Cycling Brochure
Source: City of Toronto, 2014

Figure 18 – Equipment tips for winter cycling
Source: City of Toronto, 2014

Warm & Dry
Snow and Ice
Wet Weather
Visibility
Riding Tips
Maintenance
Equipment

Bicycles

- Personal taste but one that fits you and your needs
- Mountain bikes offer good handling
- Let your bicycle get cold outside before riding-less snow will stick to it if it's already cold, and the metal will have a chance to expand before you ride
- Keep your bicycle covered, protected from rain, snow, and slush when parked.
- Consider using an inexpensive (beater) bike for the winter.

Tires

- Lessen tire pressure to the low end of recommended range (written on tire sidewall) to increase traction.
- Thick-tread mountain bike tires will increase traction/grip on snow (particularly good for hard packed)
- Thin tires will cut through the snow (particularly good for slush) to the pavement.
- Studded tires: these are noisy on dry pavement but particularly good for ice; these are rarely needed in the City.
- Full fenders are a must in wet and snow. You will be dryer and warmer. Adjust your fenders for max coverage and leave room for snow build up. Add mud guards to the front fender to keep your toes dry.

Pedals

- Flat pedals work well, and even with heavy boots you can put your foot down fast.
- Toe clips are not recommended in snowy or icy conditions; you may have to put your feet down in a hurry.
- Clipless pedals need to be well lubricated and can freeze up. The metal will draw the heat away from your feet, making it very difficult to keep them warm.

City of Whitehorse, Yukon

Population: 27,900

Annual Snowfall: 140 cm

Jan Avg High Temp: -11°C

Jan Avg Low Temp: –19°C

Bike Mode Share (peak season): 2.7%

Located in Canada's arctic region, Whitehorse is a true "winter" city. Whitehorse has a good cycling mode share for a small northern city of 2.7% despite not having a cycling plan (Pucher & Buehler, 2006). The City lacks supportive policies and plans for winter cycling but it does acknowledge that it is no longer a fringe activity and that people are cycling year-round. The City's webpage titled "Winter Biking Safety" draws attention to the fact that both drivers and cyclists need to focus on safety during the winter season and provides tips to cyclists and drivers on courteous behaviour on constrained roadways, see **figure 19**. Additional advice includes appropriate gear, visibility and rules of the road.

While the City of Whitehorse could benefit from a comprehensive bicycle plan and stronger policy to support winter cycling, the city does provide road safety information and tips for safe cycling in winter. Promoting and publicizing municipal practices, programs and policies that support cycling is essential.

The previous sections were structured around the four thematic design principles and this final section of the Peer City Review is about monitoring and evaluation. Monitoring and evaluation is not specific to winter planning but is a necessary component of any planning program.

Figure 19 - Winter Bike Safety
Source: City of Whitehorse, 2012

- Winter Biking Safety
- Bike Survey Summary
- Purple Bikes
- Cycling and Pedestrian Safety
- Routes and Maps
- Energy
- Waste
- Act Local
- Sustainability Planning and Reporting
- Environmental Grant
- Universal Design
- Contact

Drivers

- Do not drive in bike lanes. There is a dedicated bike lane on Fourth Avenue, but in the winter, drivers tend to occupy this lane.
- Pass cyclists when safe and at a reasonable speed.
- Do not be aggressive towards cyclists. Remember, cyclists are entitled to use streets and roads. Although most like to avoid traffic, there may be parts of their commute where they have no option but to use a busy street.
- Be mindful of cyclists, but treat them like vehicles if they are on the road. For example, stopping in the middle of the road to accommodate a cyclist is kind, but can be dangerous because other drivers may not know what is happening.

Cyclists

Be visible. Wear as much reflective clothing as possible. At minimum, use a rear red light and a front white light. Visibility is also important in daytime, especially in snowy weather. Wear bright colours. Chartreuse is the most visible.

Wear a helmet. Helmets are required in the Bicycle Bylaw. Statistics support that helmet use

3.5 Monitor and Evaluate

A variety of methods are used to monitor and evaluate transportation mode share levels and travel patterns, including bicycle counts, local or national census, and travel surveys. Both the Canadian and U.S. Census' statistics, which record mode of transportation to work are made available in April and May, the beginning of the cycling season. As a result, winter cycling mode share is not captured in the existing census data collection therefore winter levels are not fully understood. The City of Minneapolis has conducted winter monitoring and confidently estimates that 25% of the local cycling population continues to cycle through the winter season (City of Minneapolis, 2011). A visual analysis of the City of Montreal Rue Berri bicycle counter (**figure14**) also reveals similar findings that there is a significant drop in cycling levels, however an estimated 20% of cyclists continue during the core winter months. Expanding data collection and travel surveys to occur throughout the year or more frequently, help planners and decision makers better understand the impact of weather and climate on cycling, as well as, monitor investments in bicycle facilities The City of Boulder Colorado and Hamilton Ontario offer two examples of winter monitoring with automated loop detectors and manual bike counts.

City of Boulder Colorado

The City of Boulder "Transportation Master Plan" identifies winter maintenance for cycling as a priority and the City has a goal of keeping bike lanes and multi-use paths open throughout the year by plowing to a high level of service.

Population: 98,000

Annual Snowfall: 200cm

Jan Avg High Temp: 7°C

Jan Avg Low Temp: –5°C

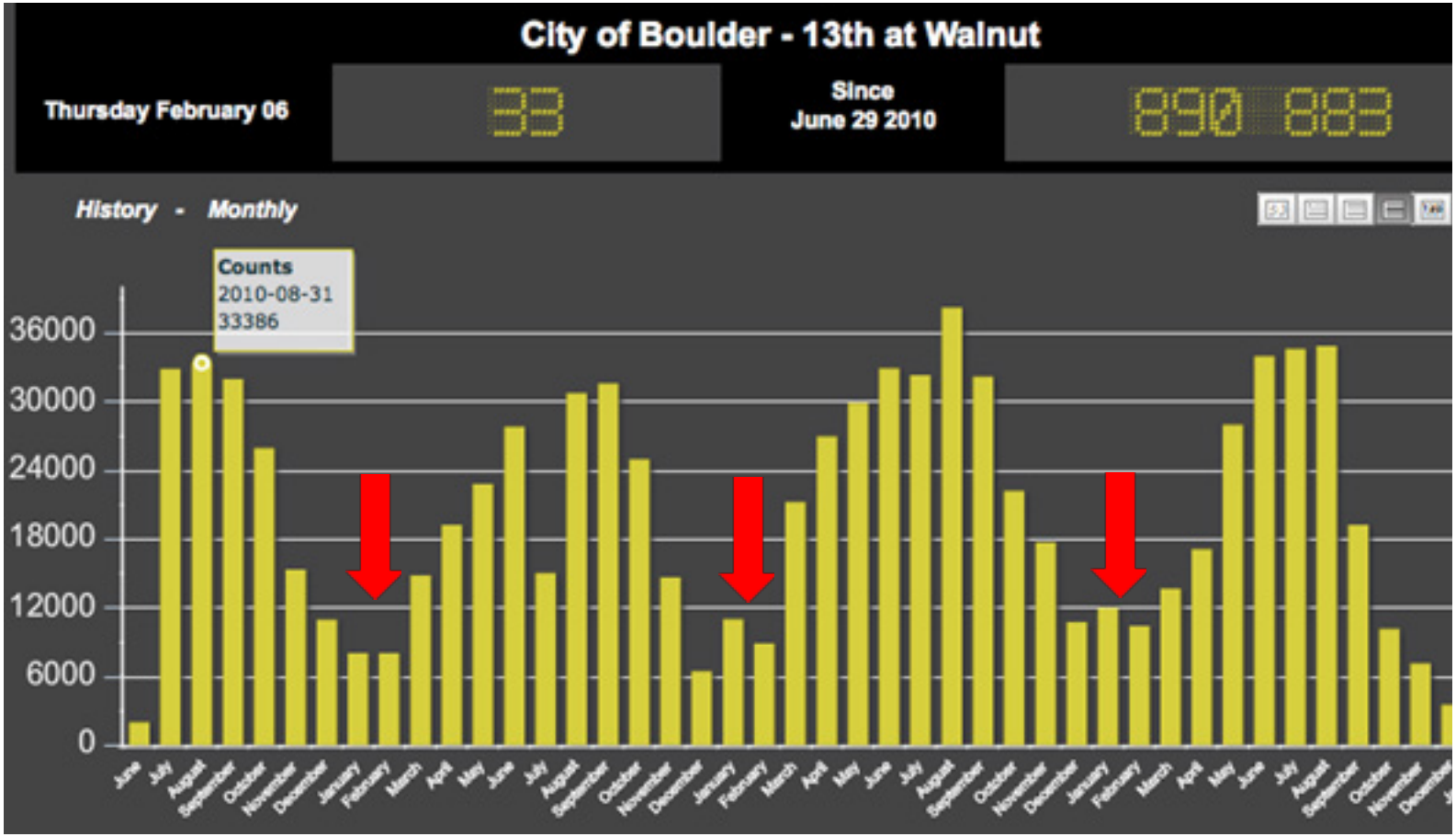
Bike Mode Share (peak season): 9%

In total, the City plows approximately 93 km (58 miles) of off-street bikeway paths in addition to select on-street facilities or routes (City of Boulder, 2012). Boulder's pathway system is silmilar to Oulu Finland as it has a large off-street network connecting the city through a series of underpasses. Winter cycling is possible in Boulder through the City's commitment to efficient and comprehensive snow removal. The City has increased or adjusted the budget over the years to account for unexpected blizzards or snow storms (City of Boulder, 2012).

The City of Boulder captures bicycle mode share data through automated loop detectors at several locations throughout the city, these are automatic permanent counters that run 365 days a year (City of Boulder, 2012). Since 2010, a real time data summary from one Eco-Counter located downtown has been available online (http://boulder13th.visio-tools.com/). The winter mode share does not rival the peak summer period, however, the volume of cyclists riding along this route in January and February has increased each year between 2011 and 2013 (**figure 20**), notably the coldest months of the year (City of Boulder, 2013).

Conducting winter analysis can be challenging based on reliable technology as the cold weather can affect the automated counters, yet automated data collection is better than manual counts. Monitoring is important to do year round so you can track before, during and after a new policy or infrastructure is implemented. Tracking winter cycling levels provides reliable information on volume and use of bicycle routes. This data is essential to make informed future decisions for bicycle planning.

Figure 20 – 13th and Walnut real time automated counter
Source: City of Boulder, 2013



City of Hamilton ON

The pilot bike lane project in the City of Hamilton has consisted of targeted maintenance on 10km of bike lanes across the city. As part of the pilot project the City conducted manual bike counts at select sites to monitor cycling volumes and evaluate the success of the pilot. Counts and analysis of three sections of bike lane, along Sterling Street, Longwood Road, and Dundurn Street illustrates a one-day "snapshot" of morning and evening peak travel periods (**figure 21**). The drop off in 2014 is due to the unusually cold winter season.

Figure 21 – Bike Counts in February
Source: City of Hamilton, 2014

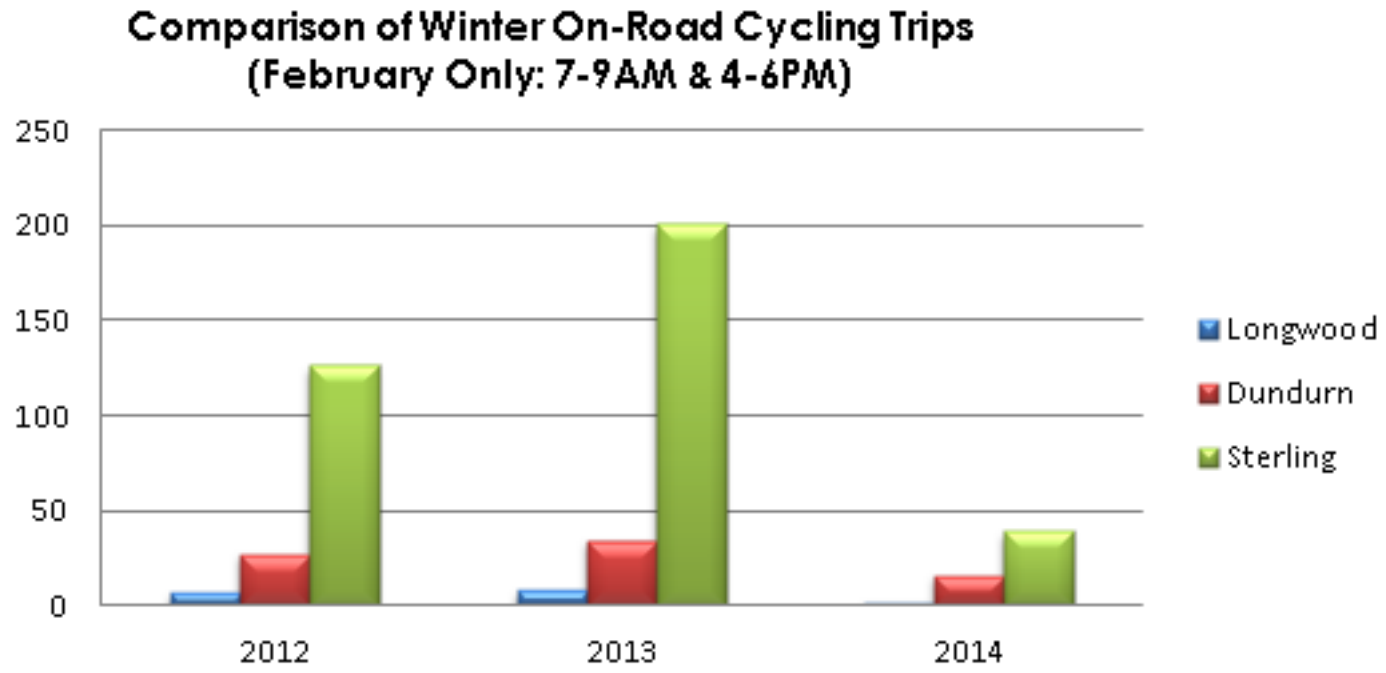
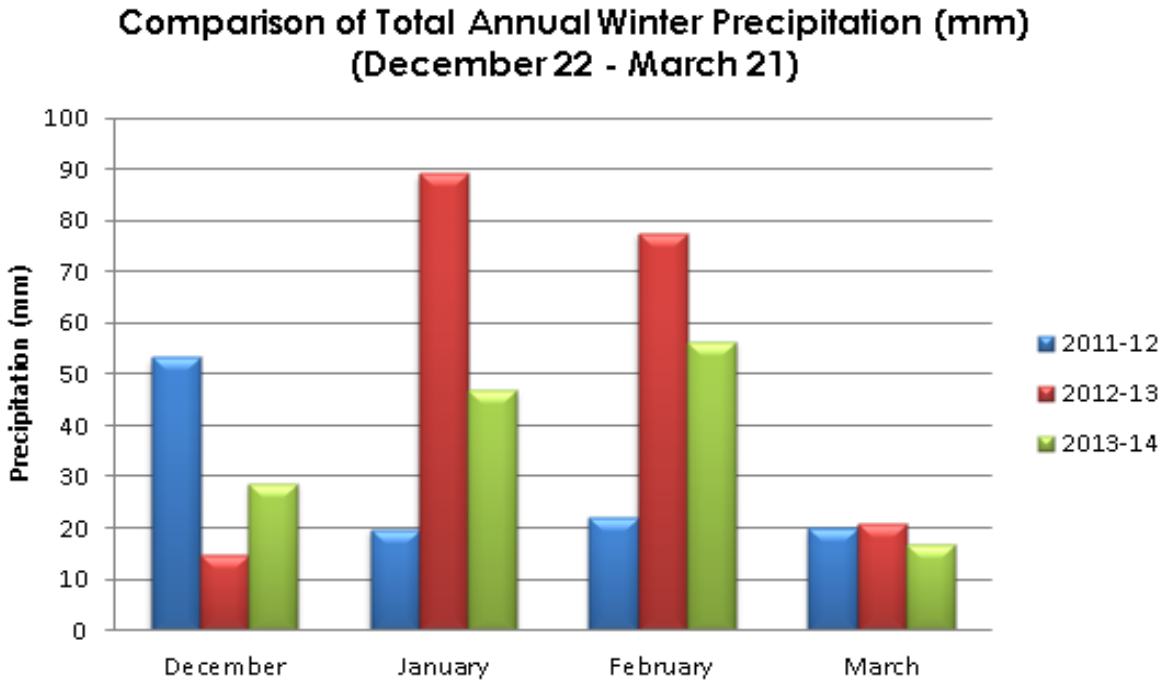


Figure 22 highlights a comparison with winter weather for the last three years. The pilot began over the 2011/2012 and as the chart shows, the higher levels in 2012/213 are due to weather and temperature. As a result, more cyclists became aware of the pilot and used the maintained routes (Bender, 2014). The winter season of 2013/2014 was particularly colder with less snow than the previous two years and is reflected in the lower volumes of cyclists.

Monitoring is predominately a spring or summer activity, however, knowing cycling levels in the winter informs route prioritizations and expansion of winter maintenance strategies for bicycle facilities.

Figure 22– Winter Weather Comparison
Source: City of Hamilton, 2014



3.6 Summary

The Peer City Review investigated and documented policies, practices and programs on municipal bylaws. These include bicycle plans, maintenance policies and procedures relevant to winter cycling. Organized around four thematic design principles or 4 “P’s” modelled on the 5 ”E’s” of bicycle planning, the previous examples present diverse ideas for winter cities worldwide. The methods and approaches are not universally transferable as winter temperatures, snow volume and geography create unique conditions that need context sensitive solutions. Practices from Hamilton, Salt Lake, or Vienna are useful to other cities with similar winter temperatures conditions. The reality is that Copenhagen’s maintenance procedures may not apply in the City of Montreal, but their approach to bicycle facility design that incorporates snow storage may be adaptable to future bicycle facility design in Canadian cities. Lessons can be learned from the winter cities and the Peer City Review offers some transferable elements. However it is important to evaluate how the solutions will work in each city. As North American cities catch up to Northern European cities regarding prioritization, ensuring accessible transportation networks all year, there is a need in North America to find home-grown solutions. These will come with future testing, integrating innovation around on-street bicycle facilities, esspecifically bike lanes and street-level signage. The lessons from the Peer City Review will now be applied to create a winter cycling network and maintenance strategy for the City of Winnipeg.

4. City of Winnipeg
Winter Cycling Network and Maintenance Strategy

The City of Winnipeg, affectionately called Winterpeg by locals, is a true "winter" city. The region usually experiences a winter season for up to half of the calendar year – from November to April. The 2013/2014 winter was particularly brutal with extended periods of freezing temperatures averaging -25° C for most of December and January. Despite the frigid temperatures some individuals continued to commute by bicycle throughout the winter season. Currently during the peak season, bicycle trips to work make up 2.1% of daily transportation mode share (Statistics Canada, 2011; Patterson, 2014).

Population: 704,800

Annual Snowfall: 110 cm

Jan Avg High Temp: -10°C

Jan Avg Low Temp: -20°C

Bike Mode Share
(peak season)): 2.1%

Since 2007 cycling has increased by 28% when Bike Winnipeg began monitoring cycling levels through annual bicycle counts (Hull, 2013). The majority of bicycle related trips in Winnipeg are for a utilitarian purposes, such as commute trips to work (32%), trips to school (5%), and for shopping (14%) (Patterson, 2014). The increase in popularity of cycling in the city is due to infrastructure investments and expanded bicycle facilities. In addtion to promotion programs such as Bike to Work Day and the efforts of local advocates who continue to monitor cycling levels and lobby for safer cycling conditions.

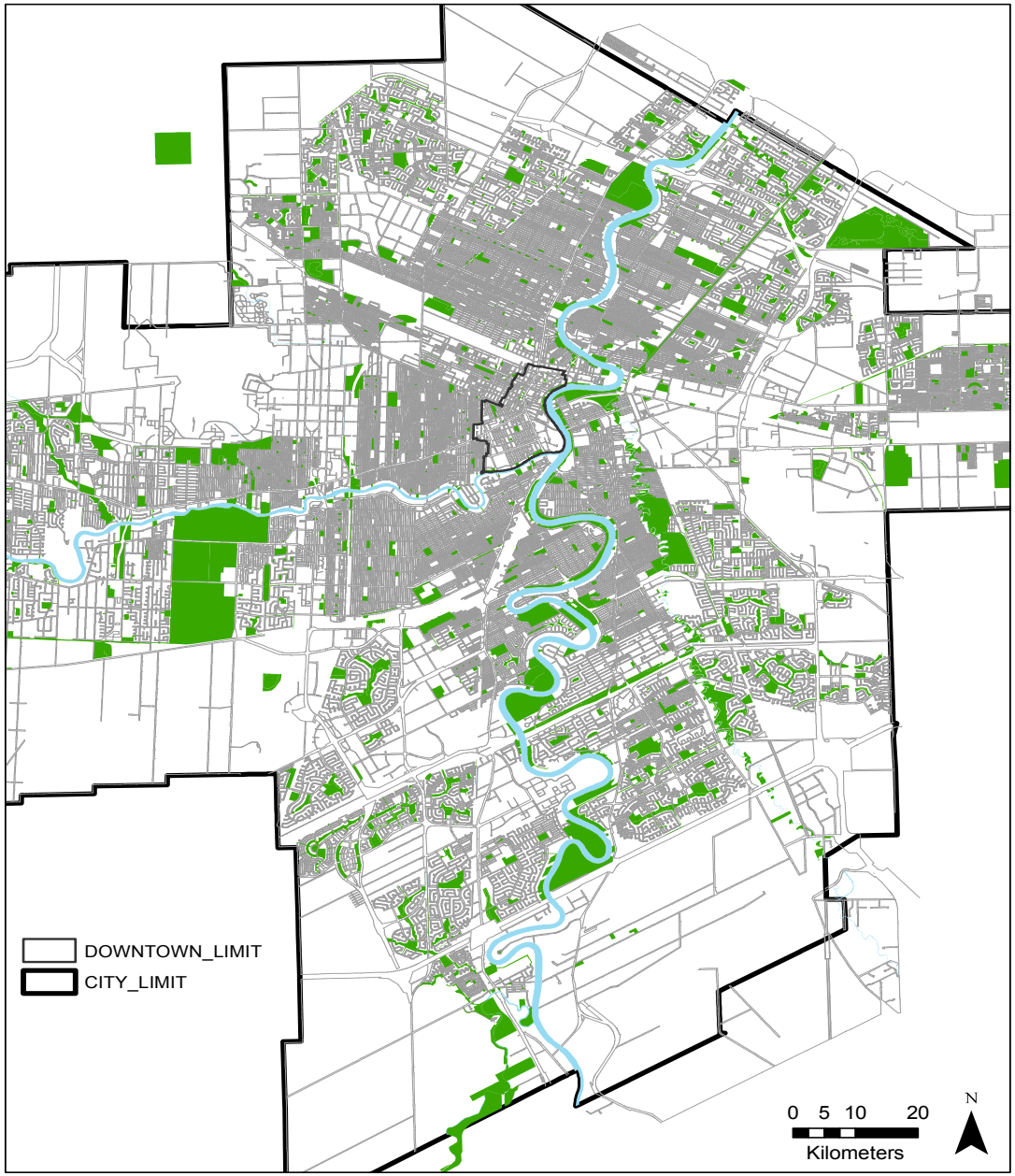
Drawing on promising practices from cities in Canada, the United States and Northern Europe, the following recommendations aim to give the City of Winnipeg initial direction for developing a Winter Cycling Network and Maintenance Strategy. Many of the cities in the Peer City Review have diverse and variable winter weather, and the most comparable climate and topography to Winnipeg is the City of Minneapolis Minnesota and the City of Oulu Finland.

The twenty following recommendations are based on five thematic principles:

- **Plan** a winter cycling network and maintenance strategy with pilot phases that can expand each year
- **Prioritize** bicycle routes and corridors within the existing network to create predictable routes to popular destinations
- Establish winter maintenance **procedures** for bicycle facilities to match operational methods
- **Promote** the City's efforts to improve maintenance for winter cycling and road safety
- **Monitor** and evaluate maintenance procedures and local cycling levels.

The following section is structured based on comprehensive planning processes of identifying a vision and goals, establishing strategic directions, undertaking analysis in order to develop a plan, outlining implementation steps, and follow up with monitoring and evaluation.

Figure 23 - City of Winnipeg Map



4.1 Current Context

Winnipeg is well positioned to develop a year-round cycling environment due to its density, topography and relatively short commute distances between destinations. Over the past year, the City has been completing new Pedestrian and Cycling Strategies to compliment the Sustainable Transportation Strategy and the Transportation Master Plan. The City does not currently have supportive policies specific to winter cycling. However, the City does understand there are ways it can better support winter bicycle commuting, and creating a winter cycling network is an action item in the Pedestrian and Cycling Strategies. The City was a sponsor to the recent international Winter Cycling Congress that took place February 12th to 14th, 2014 in Winnipeg and through this event gained a broader understanding of the challenges and opportunities to support year-round cycling.

Winnipeg is known as one of the coldest cities in southern Canada, therefore many people may wonder why winter cycling should be a priority or consideration? Equitable transportation planning recognizes that all transportation users – transit users, pedestrians, motor vehicles and bicycles – require an accessible transportation system that is available 7 days a week, 24 hours a day, 365 days per year. Extending planning, programs and policies to adopt a four-season year-round approach is the next step in sustainable and climate responsive transportation planning.

4.2 Rationale

Cycling continues to grow in popularity, evidenced by the annual Bike to Work Day event (hosted one day in June) that has been extended to be a part of a Bike Week in 2014. As more people take up cycling during the peak season there are a significant number of new cyclists' each year that will adapt to the local climate to cycle even in the coldest months. During the Winter Bike to Work Day hosted on February 14th 2014 over 300 people registered and the average daily temperature on that day was -24° C. The winter weather conditions in Winnipeg are unique to other North American cities. This presents an opportunity to develop winter maintenance strategies and practices suitable for the local environment.

Currently, winter cycling levels are not directly monitored. However, self-reporting during the public consultation of the Pedestrian and Cycling Strategies, indicated close to one-quarter of commuters continue to cycle during the winter. Based on research from the literature review, this group is characterized as the hardcore dedicated segment of the cycling population. Snow removal and winter road maintenance were also identified by the public as high priority areas (Patterson, 2014). Survey results from the public consultation indicated 37% of the public is "interested but concerned" in cycling, meaning they would like to cycle more often. There is the potential to increase cycling levels across the city all year round. Creating a reliable, consistent and predictable winter cycling network will encourage more people to continue to cycle during the winter season.

4.3 Vision and Goals

The Pedestrian and Cycling Strategies will set the course for improving the conditions for walking and cycling in the city, focusing on increasing accessibility, use, comfort and safety for pedestrians and cyclists.

The **Pedestrian and Cycling Strategies** have established seven goals that align with the City's overarching objectives as stated in "Our Winnipeg" and the "Transportation Master Plan". The seven goals are:

1. Integrate with Land Use
2. Active, Accessible and Healthy
3. Safe, Efficient and Equitable
4. Design and Maintenance
5. Financially Sustainable
6. Environmentally Sustainable
7. Transparent Process

The goals of the Pedestrian and Cycling Strategies are organized into six thematic **Strategic Directions** which are:

1. Improve Connectivity
2. Improve Safety and Accessibility
3. Improve Maintenance
4. Improve Vibrancy
5. Improve Convenience
6. Increase Awareness

Within the Strategic Direction #3 "Improve Maintenance", two winter specific initiatives are identified: **develop a separate snow removal priority policy for sidewalks based on pedestrian demand** and **designate a Winter Cycling Network**. This entire chapter is dedicated to this final initiative, developing and designation a winter cycling network in Winnipeg.

4.4 Analysis

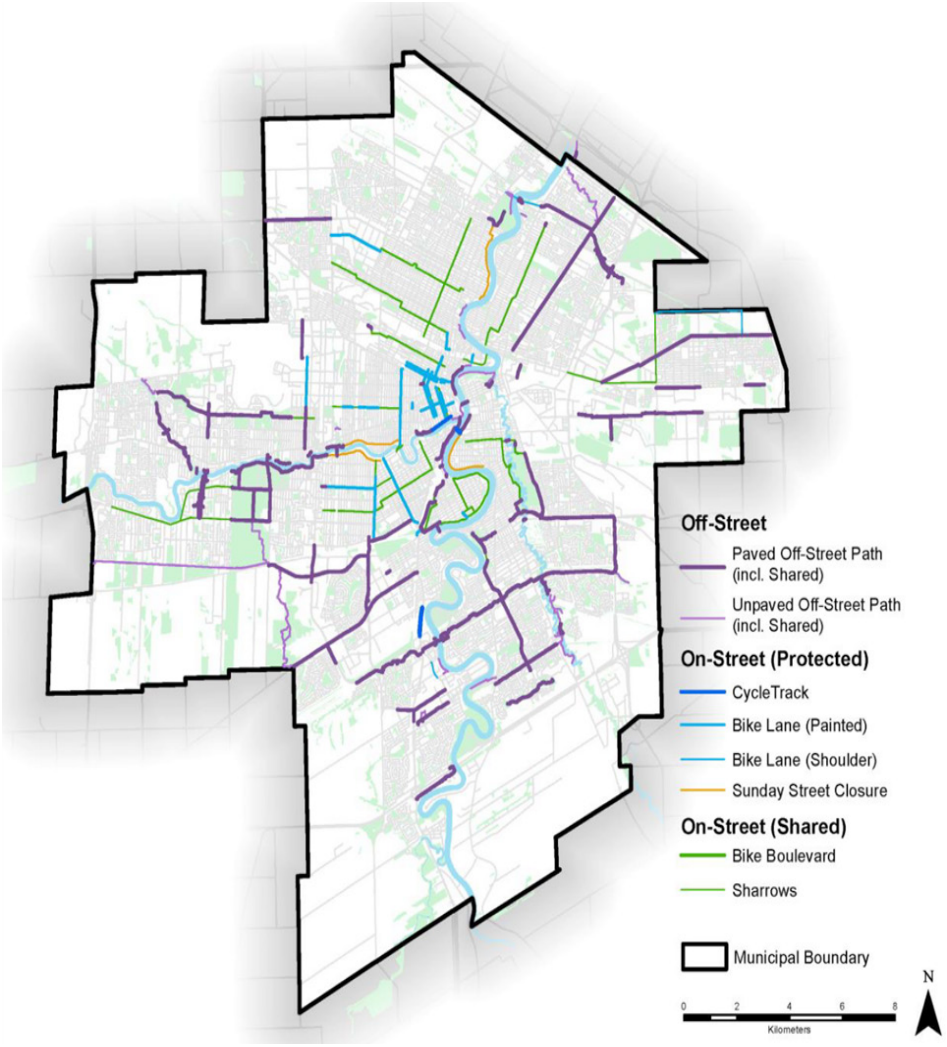
In order to prepare a winter cycling network and maintenance strategy detailed analysis is required to fully understand the local conditions and context. Contextual analysis is a form of pre-planning and research, and a number of existing studies and reports were reviewed in developing bicycle route recommendations, in addition to input from City staff and local cycling experts.

Current and Future Bicycle Network

Planning for a winter cycling network begins with analysis of cycling levels, bicycle counts, existing bicycle infrastructure (**figure 24**), and origin and destination surveys. Understanding the popular routes and corridors that are used by cyclists, in addition to the popular local destinations across the City of Winnipeg informs the recommended winter routes.

Winter cyclists are predominately commuters with an average bicycle trip distance estimated to be 2.5 km to 7 km in length (Patterson, 2014; Hull, 2013; Centre for Sustainable Transportation, 2009). This information assists decision-making for the network. The *2013 Commuter Cycling in Winnipeg* report summarizes the direct observation manual counts completed by Bike Winnipeg. Overall in 2013, there has been a 12% increase in cycling levels compared to 2012. Cycling levels have increased at locations with improved infrastructure and similarly there are no increases at unsafe locations lacking improvements (Hull, 2013). Average daily bicycle traffic in and out of Downtown is 12,648 trips, an estimated 48% of the total city-wide bicycle levels (Hull, 2013). Analysis of the individual counts at key locations informed the selection of the winter cycling network priority routes.

Figure 24 - Existing Bicycle Network
Source: City of Winnipeg, 2014; Patterson, 2014



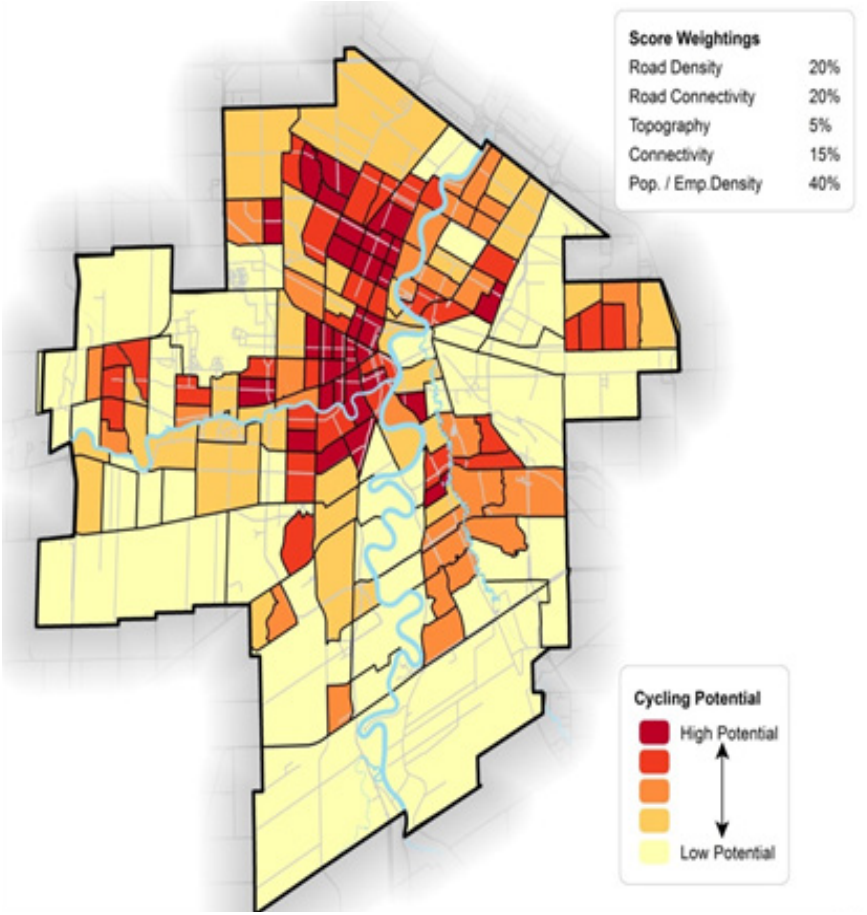
Research and analysis conducted during the preparation of the Pedestrian and Cycling Strategies identified areas of the City of Winnipeg with high cycling potential profiled in **figure 25**. A number of factors were overlayed including road density, road connectivity, topography, general connectivity and population density. The map is based on analysis of the land use characteristics based on neighbourhoods that attract cycling activity. According to information gathered through the Pedestrian and Cycling Strategies, the highest bicycle mode share occurs in the following neighbourhoods: Wolseley, River Heights, Osborne Village, West Broadway and St. Boniface.

The *Winnipeg 2009 OttoCYCLE Study* conceived and designed by the Centre for Sustainable Transportation (CST) used GPS and socio-economic data to document cycling activity. During May and October 2009, 712 participants logged their bicycle trips over a two week period. In total 9,300 trips were analyzed and organized by frequency on heavy routes (p.9), pinch points at bridges and underpasses, bottle necks (p.12), orgins from residential addresses and destinations (p.14) (Centre for Sustainable Transportation, 2009). The study identified twenty major destinations from the travel surveys.

Major Destinations

For this project key destinations from the *Winnipeg 2009 OttoCYCLE Study*and other popular locations identified through the Pedestrian and Cycling Strategies informed route selection (Patterson, 2014).

Figure 25 - Cycling Potential
Source: City of Winnipeg, 2014; Patterson, 2014



Major Destinations

The key destinations include:

- Dowtown: City Hall, the Forks, University of Winnipeg, Red River College (Princess campus), Portage Place Mall
- Post Secondary Institutions: the University of Manitoba, the University of Winnipeg, Red River College (two campuses), the Université de Saint-Boniface
- Hospitals: Health Science Centre, St.Boniface Hospital
- Shopping: Portage Place, Polo Park, Osborne Village
- James Richardson Airport and Centre Port Canada

Access to major destinations from all four directions in the City formed the basis for the "spine" and "hub and spoke" routes identified for a pilot winter cycling network and expansion in future phases.

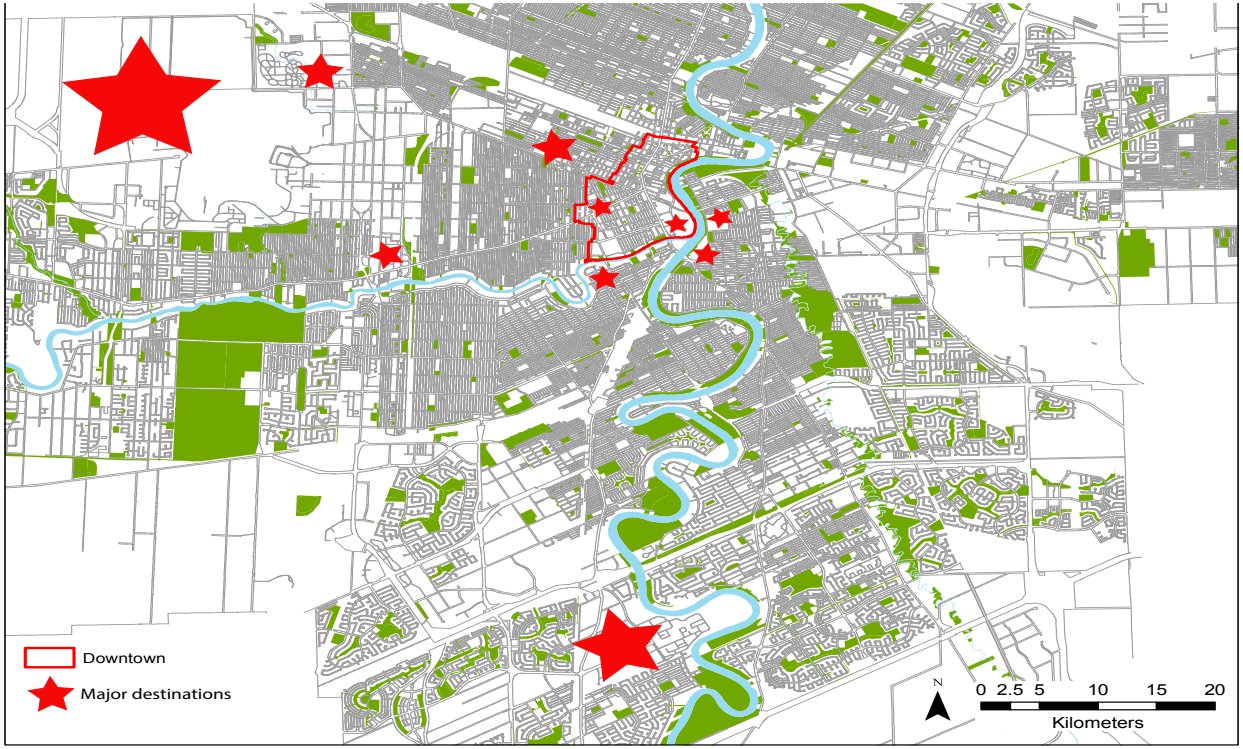


Figure 26- Major Destinations City of Winnipeg

Current Snow Removal and Winter Road Priority

Following the analysis of the local bicycle network, the next step is analysis of the existing road network prioritization for snow removal and maintenance.

The City of Winnipeg prioritizes the entire road network as follows: for major arterials roads (priority 1), collector streets (priority 2) to residential local streets (priority 3) (City of Winnipeg, 2011). **Figure 27** illustrates the road network prioritization: red is priority one (P1), yellow priority two (P 2) and purple priority three (P3). As bicycle facilities are prioritized in developing a winter cycling network changes to the roadway priority may be needed.

Overlaying the snow removal priority network with the bicycle network is necessary to evaluate route selection for a winter cycling network. Major bicycle routes that lead into Downtown from surrounding areas are important corridors to prioritize, as well as, identifying both on-street and off-street bicycle facilities.

Figure 27 - Snow Removal and Maintenance Routes

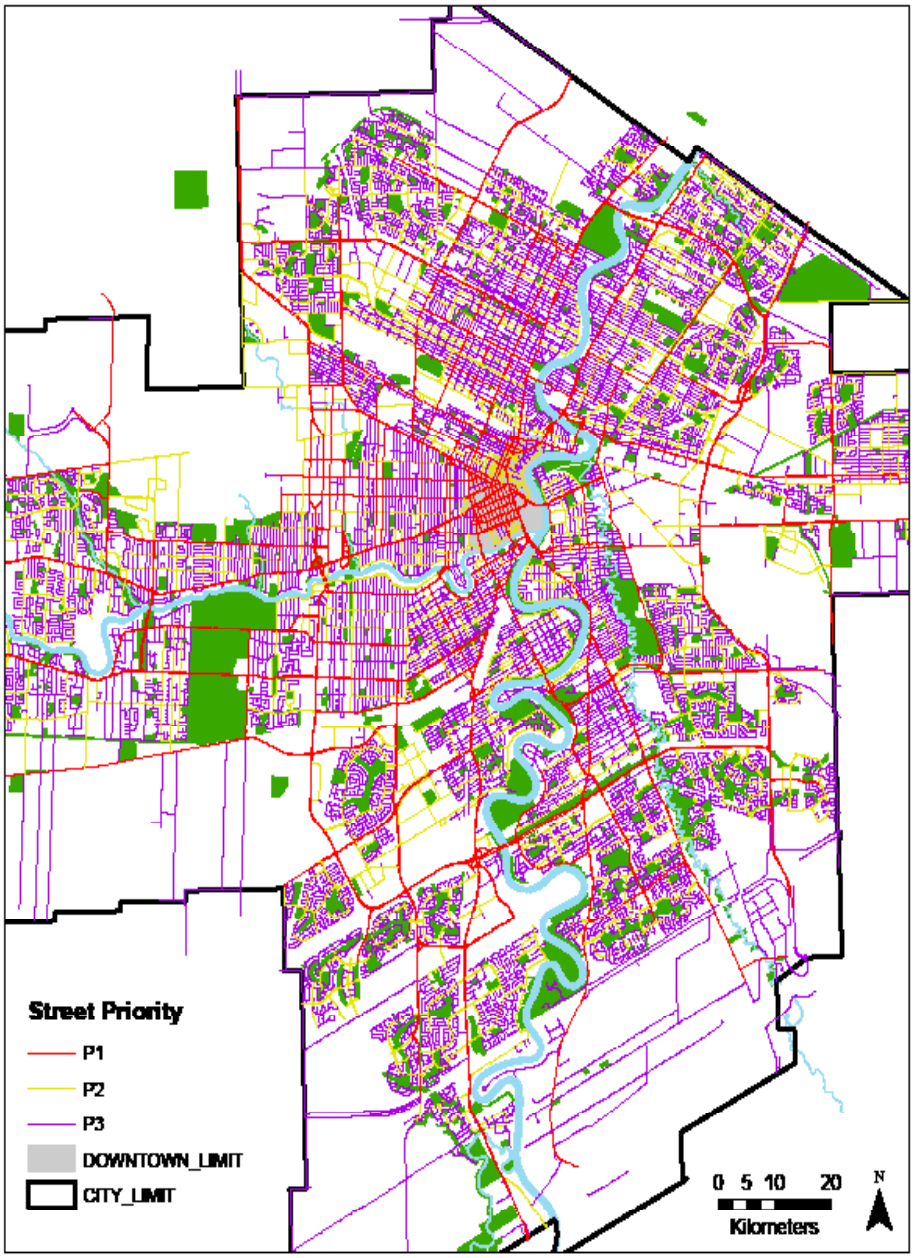
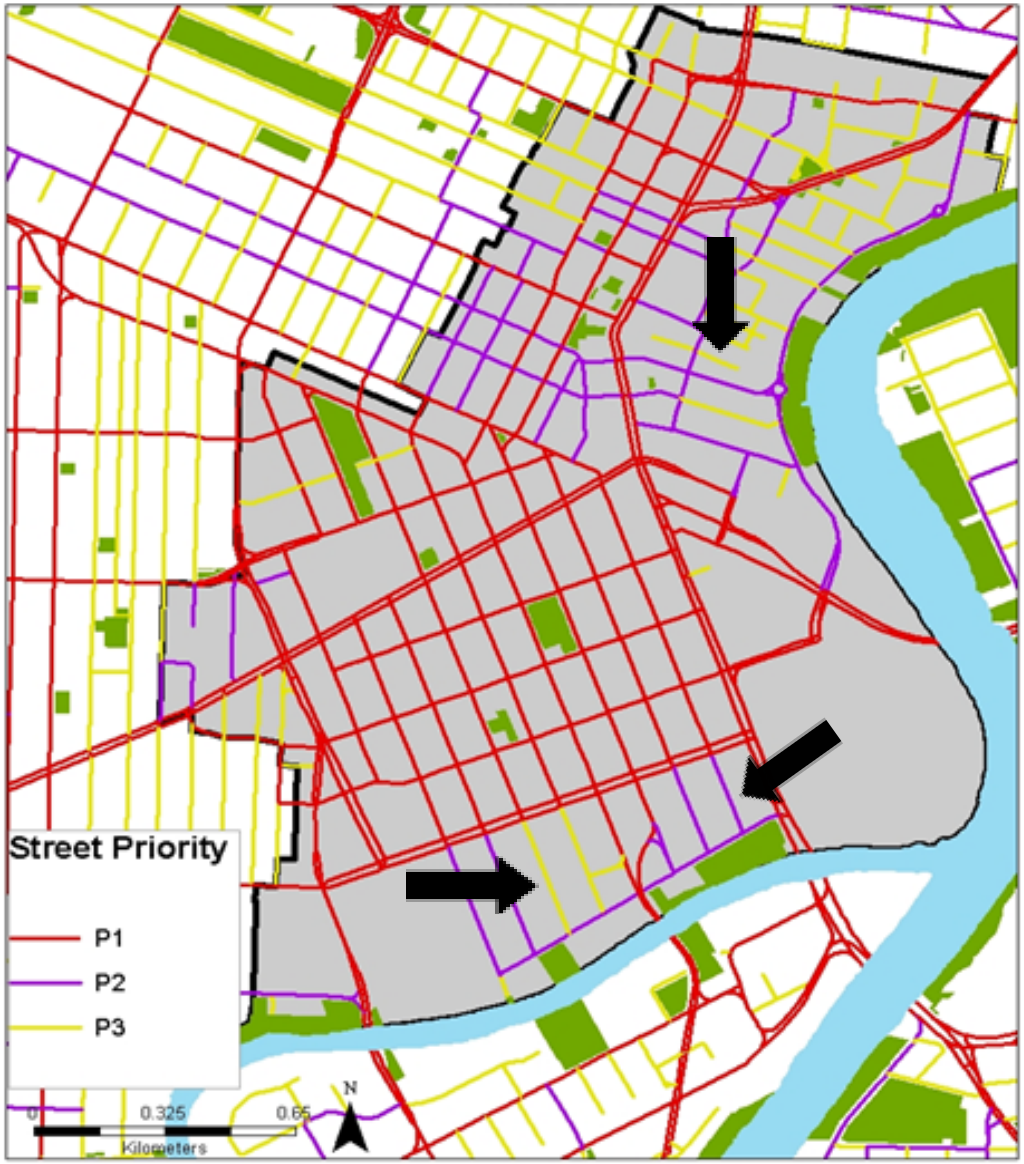


Figure 27 illustrates the City's snow removal and maintenance priority routes, and **figure 28** highlights this priortiy in the Downtown. For example both Hargrave Street and Carlton Street downtown have on-street bike lanes and these streets are a priority one (P1). However each street has a one-city block area that is a priority three (P3) (see black arrow) between Assiniboine Avenue and Broadway. Another section to highlight is Fort Street and Gary Street which both have on-street bike lanes and these are priority one (P1), with one block a designated priority two (P2) between Assiniboine Avenue and Broadway. The bike lanes on Fort Street, Gary Street, Hargrave Street and Carlton Street all connect to the Assiniboine Avenue cycle track and River Trail network.

Identifying these gaps is necessary to create a consistent connected winter cycling network. Assiniboine Avenue cycle track is on a priority two (P2) street yet this important separated facility is a priority as it connects to the south, Downtown and to the east and western routes throughout the city.

Route selection for a winter cycling network must analyze local bicycle counts, origin and destination travel survey information in order to determine popular routes and corridors. This analysis is informed by the existing (and future) bicycle networks and bicycle facilities. Route selection is based on access to major destinations and employment areas across the city. The literature review provided valuable information which contributes to route selection, such as winter cyclists are dedicated, confident individuals traveling

Figure 28 - Downtown
Snow Removal Maintenance Routes



to work or for other utilitarian trips. As well, cyclists are less willing to travel far distances (compared to summer) and they prefer to use dedicated bicycle facilities.

Planning for a winter cycling network needs to address different challenges. Commuter cyclists often prefer to travel routes that are removed from traffic on bicycle facilities. However cyclists change the route they travel in winter, choosing to travel on major arterial or collector roads as they are maintained. Cyclists do not want to mix with motor vehicle traffic due to constrained roadways and real safety concerns, yet there are no other alternatives. Conversely, motorists do not want to mix with cyclists and tensions between road users increase during winter. An additional challenge is that although low volume residential streets are good parallel alternatives, such as bike boulevards, these streets are often a priority three (P3) for snow clearing or winter maintenance.

Once detailed analaysis has been completed and the local context is understood, criteria for selecting a high-quality route along key corridors with improved connectivity between neighbourhoods can be proposed. The criteria for a network in Winnipeg is based on:

- dedicated bicycle facilities; a combination of off-street and separated paths and on-street bike lanes
- origin and destination survey information on major destinations and employment areas
- an east-west, north-south “spine” and “hub and spoke” concept
- existing active transportation paths or multi-use trails (off-street) maintained in winter
- snow removal routes within the road network.

4.5 Plan

This section focuses on recommendations relevant to short and long term planning for a designated winter cycling network, as well as the design of bicycle facilities. The following recommendations are necessary to develop a well thoughout and planned network.

Recommendation 1: Designate a Winter Cycling Network

A winter cycling network is detailed on pages 64 to 69.

Recommendation 2: Engage and involve maintenance workers and operation departments in the planning and implementation of a winter cycling network

Operation and maintenance personnel are experts in winter maintenance and their input is valuable in designing a cost effective and efficient maintenance strategy for the bicycle network. Municipal personnel are also knowledgeable regarding vehicle requirements, scheduling and surface applications.

Highlight: In the City of Hamilton, one Supervisor of Road Operations has been responsible for the pilot area and has recommended further education, training and knowledge exchange between other area Supervisors.

The City of Minneapolis recognized operations and procedural change starts at the top and they sent senior personnel to Finland to learn about winter maintenance practices and procedures.

Recommendation 3: Factor winter maintenance into the design of future bicycle facilities

All future bicycle routes, facilities and roadways should be designed with winter in mind. Different bicycle facilities will require different design considerations and consistent design helps refine the type of vehicles and equipment needed for Spring or Winter maintenance. Additional consideration for runoff and snow melt, particularly at intersections, crosswalks and bridge underpasses is necessary.

Recommendation 4: Refine the timing and order of winter maintenance operations

Common issues include sidewalks that are cleared or plowed into bicycle facilities, and roadways that are cleared or plowed into bicycle facilities. Consider the order of snow clearing procedures to do sidewalks first, bicycle facilities second and roadways third. Match this with possible on-street parking restrictions.

Recommendation 5: Coordinate maintenance schedules between the City and other agencies

Coordinate maintenance schedules with the Parks Department and external organizations like the Forks North Portage Partnership. For example, the Forks is a major destination year round and many high frequency commuter bicycle routes intersect with the Forks area. These areas include: Waterfront Drive, the Assiniboine Avenue cycle track, Provencher Bridge and the Norwood Bridge. Coordination will establish consistent maintenance of these important routes and to major destinations.

Figure 29 - Winter Cycling Network Phase 1

4.5.1 WINTER CYCLING NETWORK

This section details route prioritization for a designated winter cycling network and identifies additional routes for an expanded network. The recommendations are based on popular routes, connectivity, and a combination of on-street bike lanes and off-street paths.

The City's goal within the Pedestrian and Cycling Strategies is to provide a high quality network of pedestrian and cycling facilities that are planned, designed, implemented, and maintained to address year-round access. The recommendations are organized by geographic areas divided by the Assiniboine and Red River - Downtown, Northwest, Northeast, Southwest and Southeast. The recommendations include a phase one (2014/2015), **figure 29**, and future phases (2015-2018), **figure 31**.

Bridges

The City of Winnipeg is formed around both the Red and Assiniboine Rivers and the city has a number of bridges that ensure access throughout the metropolitan region. The following bridges all have a priority one designation on the roadway and this needs to be extended for both the pedestrian and bicycle crossings on each bridge (**figure 29 and 30**). Pedestrians and cyclists should be able to expect a safe, easy to access crossing the same as motor vehicles.

The following bridges need to be prioritized as part of a winter cycling network as they connect to major cycling routes or major destinations across the city.

- Louise Bridge
- Main Street Bridge
- Norwood Bridge
- Osborne Bridge
- Maryland Bridge
- Slaw Rebchuk Bridge (Salter Street Bridge)
- Fort Gary Bridge
- St. Vital Bridge
- Arlington Street overpass

The following bridges are access only bridges for pedestrians, cyclists and other non-motorized users (wheelchair access, strollers, inline skaters, etc). The following bridges run parallel to priority one routes and they need prioritization:

- Disraeli Pedestrian Bridge
- Esplanade Riel (Provencher Bridge)
- Omand Park and Creek Rail Bridge
- (future) University of Manitoba Pedestrian Bridge

The Bridge Operation Branch and Bridge Maintenance and Inspection team should be engaged in the process of prioritizing these crossings. Bridges are a major issue in ensuring an accessible cohesive network. Cyclists continually identify bridges, underpasses and overpasses as major barriers to the transportation system. Consideration needs to be given to road surface conditions, and if cyclists need to travel on the roadway, curb to curb clearing procedures are necessary. Bridges that provide pedestrian only crossing areas or shared path crossings, such as the Main Street and Norwood Bridge, need priority sidewalk maintenance.

Downtown

The following routes for the central city are recommended for phase one:

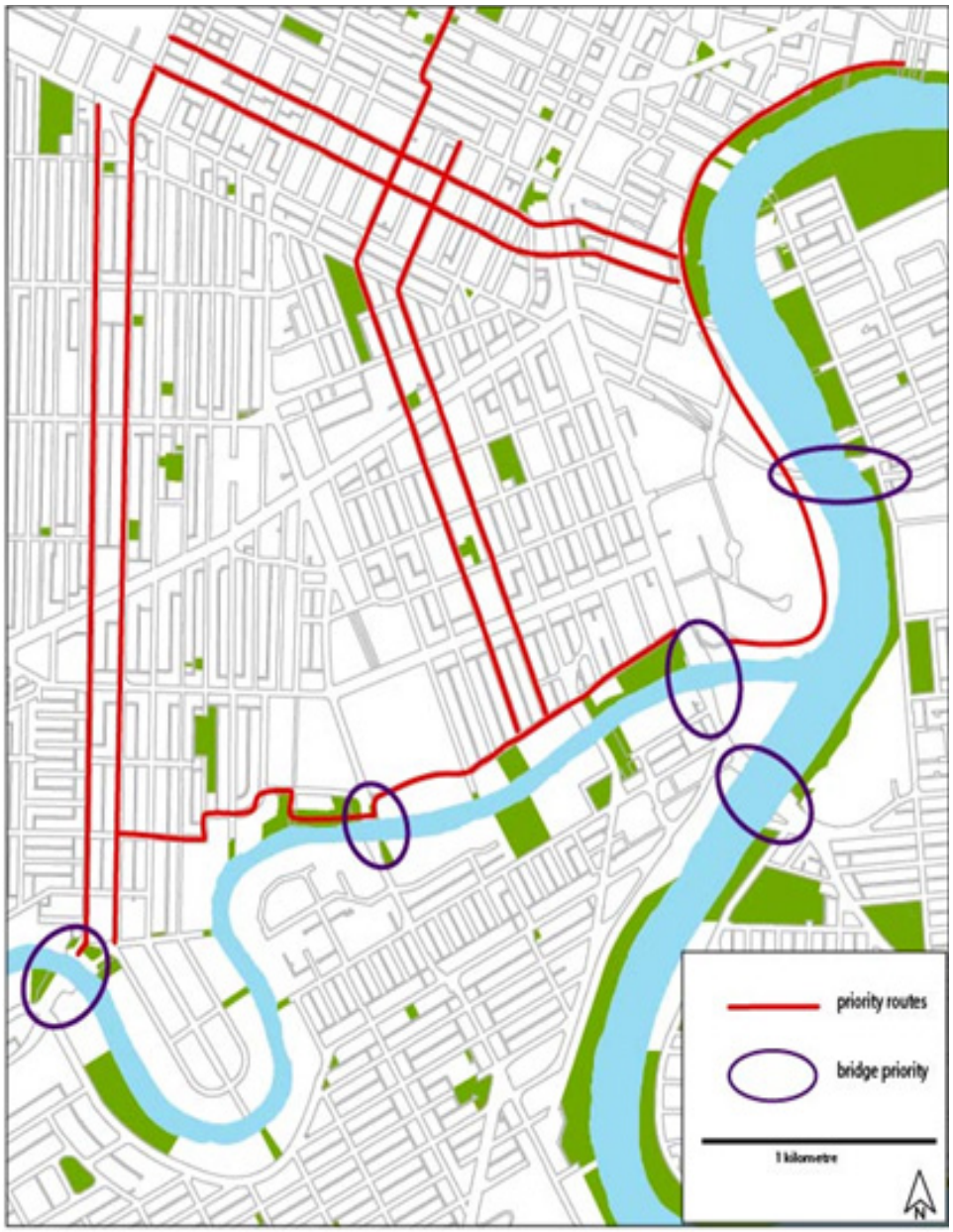
- Maryland Street bike lane
- Sherbrooke Street (future) bike lane
- Assiniboine Avenue cycle track and AT off-street path
- Hargrave Street bike lane
- Carleton Street bike lane
- Bannatyne Avenue bike lane
- McDermot Avenue bike lane
- Waterfront Drive AT path

For a phase one pilot, the City can establish a priority one high level of service for the winter cycling network. The City can further determine if the winter cycling network will have special (independent) priority one level of service designation or if the existing snow removal route bylaw will need to be updated for consistency with recommendations 6 to 8. The recommended routes for Downtown currently have prioritization gaps that will need to be addressed in order to have a coherent winter network.

Figure 30 highlights a section of the recommended route for Downtown. Bridges within the Downtown area that need special attention are:

- Esplanade Riel (Provencher Bridge)
- Main Street Bridge
- Norwood Bridge
- Osborne Bridge
- Maryland Bridge

Figure 30 - Downtown Priority Winter Cycling Network



Downtown continued

The following routes for the central city are recommended for phase two:

- Wolseley Avenue
- Wellington Crescent
- Fort Street bike lane
- Gary Street Avenue bike lane

Both Wolseley Avenue and Wellington Crescent currently have a priority two (P2) roadway designation and these routes connect to important west and southwest routes.

The following routes for the central city are recommended for phase three:

- Alexander Street bike boulevard

Northwest

The following routes for the northwest area are recommended for phase one:

- St. Matthews Avenue
- Berry Street bike lane and off-street path
- Sherwin Road off-street path
- Silver Trail
- Yellow Ribbon Trail ** currently a priority off-street AT Path
- Annabella Street
- Rover Avenue

Bridges within this area that are recommended for prioritization for phase one are highlighted below. The City can evaluate whether the Slaw Rebchuk or the Arlington Street overpass provide a safer crossing for cyclists depending on pedestrian path width and/or vehicle travel lane width.

- Slaw Rebchuk Bridge (Salter Street Bridge)
- Arlington Street overpass
- Omand Park and Creek Rail Bridge
- Louise Bridge
- Disraeli Pedestrian Bridge
- Charleswood Bridge

The only bridge in the above list that is not currently on a priority one route is the Omand Park and Creek Rail Bridge. This bridge is not currently maintained and needs prioritization as it facilitates a major north-south and east-west corridor and connects directly to high frequency cycling routes and destinations. Each of the listed bridges are either on or are adjacent to a priority one route for motor vehicles and this priority needs to be extended to both pedestrians and cyclists. Recommendation 12 suggests establishing a separate winter maintenance contract for the Winter Cycling Network in order to ensure gaps and spot maintenance is complete to ensure a cohesive network and this would apply to the bridge crossings.

The following routes for the northwest area are recommended for phase two:

- Powers Street bike boulevard
- Church Avenue bike lane and Machray Avenue bike boulevard

The routes recommended for phase three in the neighbourhoods of Inkster and Seven Oaks need further consideration. The link between St. Matthews Avenue and the Berry Street and Silver Trail also requires further consideration.

Northeast

The following routes for the northeast area are recommended for phase one:

- Northeast Pioneers Greenway ** currently a priority AT Path
- Transcona Trail ** currently a priority AT Path

Bridges within this area that are recommended for prioritization for phase one are highlighted below.

- Louise Bridge
- Disraeli Pedestrian Bridge

The routes that need further consideration are between Transcona Trail, routes through St. Boniface and routes leading to the Disraeli Pedestrian Bridge.

The following routes for the northeast area are recommended for phase two:

- Grey Street
- Mission Street
- Redwood Bridge
- Kildonan Settlers Bridge (Chief Peguis Trail)

The following routes for the northeast area are recommended for phase three:

- Roch Street bike boulevard
- Kildonan Settlers Bridge (Chief Peguis Trail)

Southwest

The following routes for the southwest area are recommended for phase one:

- Grosvenor Avenue bike lane
- Harrow Street bike lane
- Darcy Street and Sidney-Smith Street underpass
- Harte Trail ** currently a priority AT Path

Grosvenor Avenue and Harrow Street both have bike lanes and are currently on priority two (P2) roadways. It is recommended for an initial pilot that these routes be prioritized. However, as the City determines appropriate procedures and prioritization, alternate routes of Fleet Street and Warsaw Avenue bike boulevard can be considered.

Southeast

The following routes for the southeast area are recommended for phase one:

- Bishop Grandin Trail** currently a priority AT pathway
- Dunkirk / Dakota multi-use path
- Churchill Drive
- Jubliee Avenue

Bridges within this area that are recommended for prioritization for phase one are highlighted below:

- Fort Gary Bridge
- St. Vital Bridge
- (future) University of Manitoba Pedestrian Bridge

The following routes for the southeast area are recommended for phase two:

- Eugenie Street bike boulevard
- South St. Vital Trail
- Niakwa Trail multi-use path

The following routes for the southeast area are recommended for phase three:

- Egerton Street bike boulevard
- Archibald Trail

Other Considerations

In order to ensure a predictable and reliable route for cyclists the City should integrate spot maintenance at problem areas such as underpasses (i.e. Annabelle, Pembina, Osborne, Darcy/ Bishop Grandin), bridges, and access points between different areas of the network. Bike boulevards are a good bicycle route to designate as they provide an alternate route on low volume residential streets and run parallel to major streets. However most bike boulevard streets are currently priority three (P3) as a result this level of service is not suitable for cyclists. It is important for the City to determine if it can improve maintenance procedures on major streets for a safe cycling route (on a priority one street) versus additional procedures for a priority three street.

Figure 31 - Winter Cycling Network Future Phases (2015-2018)

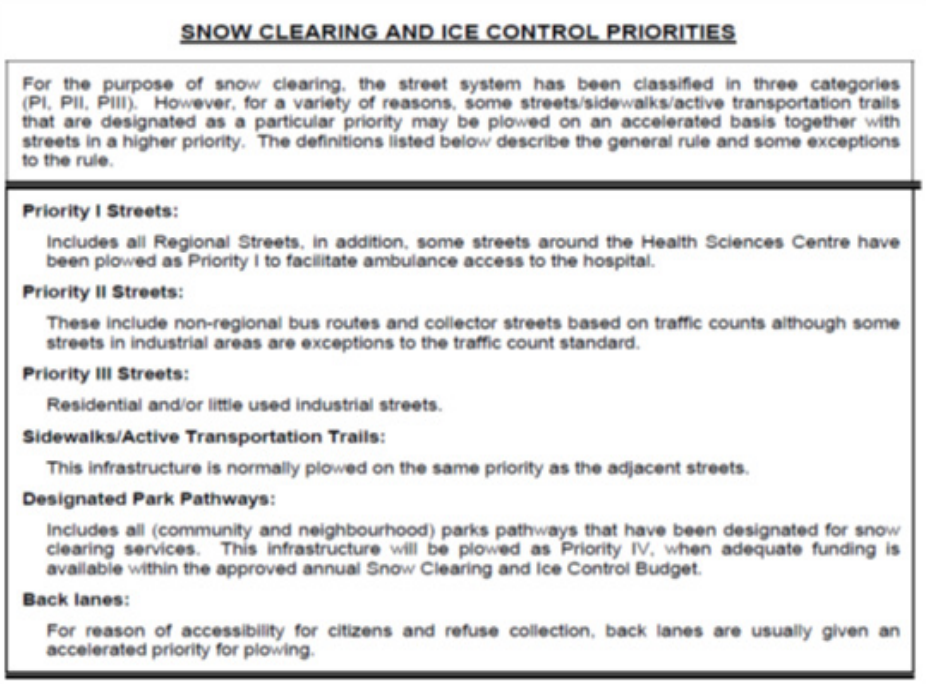
4.6 Implementation

Implementing a winter cycling network and maintenance strategy requires a comprehensive approach to improve supportive policies and programs. This section is organized by policy, procedures, and promotion recommendations.

4.6.1 POLICY

The City indicates its number one winter maintenance goal is to: "provide safe and accessible operating conditions for motorists, cyclists and pedestrians" through the maintenance of roadways, sidewalks, back lanes, active transportation trails and select park pathways (City of Winnipeg, 2011). A first step in establishing a winter cycling strategy is to revise and update the Snow Removal and Ice Control Bylaw to include prioritization for bicycle routes. Bicycle routes and facilities require a priority level of service similar to the road network. Winter cyclists are exclusively commuter cyclists traveling to work or for utilitarian purposes therefore the bicycle network prioritized should match peak travel times and patterns.

Figure 32 - Snow Clearing and Ice Control Priorities
Source: City of Winnipeg, 2011



SNOW CLEARING AND ICE CONTROL PRIORITIES

For the purpose of snow clearing, the street system has been classified in three categories (PI, PII, PIII). However, for a variety of reasons, some streets/sidewalks/active transportation trails that are designated as a particular priority may be plowed on an accelerated basis together with streets in a higher priority. The definitions listed below describe the general rule and some exceptions to the rule.

Priority I Streets:

Includes all Regional Streets, in addition, some streets around the Health Sciences Centre have been plowed as Priority I to facilitate ambulance access to the hospital.

Priority II Streets:

These include non-regional bus routes and collector streets based on traffic counts although some streets in industrial areas are exceptions to the traffic count standard.

Priority III Streets:

Residential and/or little used industrial streets.

Sidewalks/Active Transportation Trails:

This infrastructure is normally plowed on the same priority as the adjacent streets.

Designated Park Pathways:

Includes all (community and neighbourhood) parks pathways that have been designated for snow clearing services. This infrastructure will be plowed as Priority IV, when adequate funding is available within the approved annual Snow Clearing and Ice Control Budget.

Back lanes:

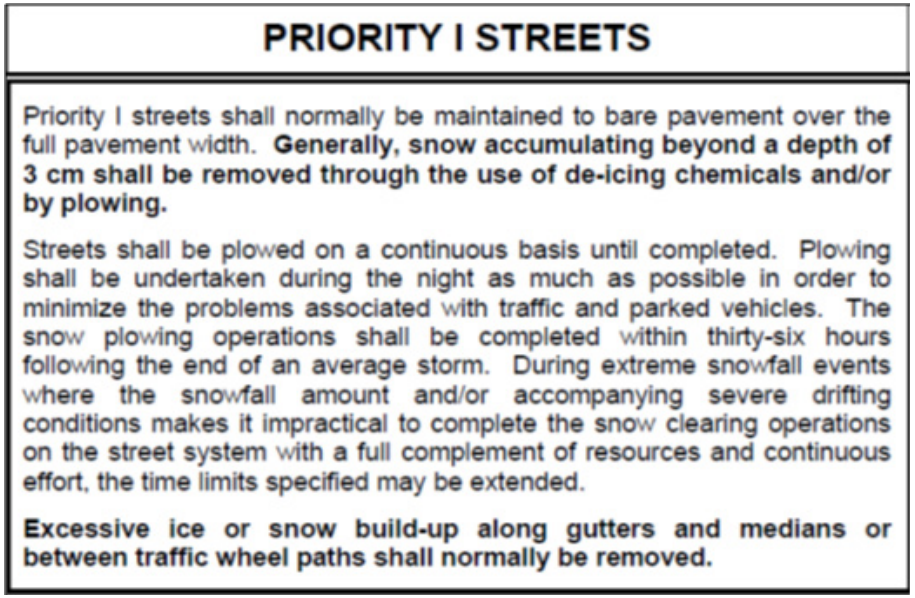
For reason of accessibility for citizens and refuse collection, back lanes are usually given an accelerated priority for plowing.

Recommendation 6: Add a statement to the Priority I Street bylaw defining the maintenance of bicycle facilities and establish an operational procedure indicating the timing of this level of service (figure 33).

The current policy outlines that snow accumulation over 3cm will be removed through de-icing chemicals and plowing. This is a good standard to apply to all on-street bicycle facilities and can include a target of reaching bare pavement on all facilities within a specified period. The time frame of the maintenance schedule needs to meet the travel times for peak commuter traffic of 7am-9am and 4pm-6pm daily. The following addendum in bold is recommended to be added to the policy:

> **Marked and designated on-street bicycle facilities (i.e. bike lanes, protected bike lanes or cycle tracks) will be cleared to the same level of services as the street they are on for peak travel times 7am to 9am and 4pm to 6pm, unless otherwise indicated.**

Figure 33 - Priority I Streets Policy
Source: City of Winnipeg, 2011



PRIORITY I STREETS

Priority I streets shall normally be maintained to bare pavement over the full pavement width. **Generally, snow accumulating beyond a depth of 3 cm shall be removed through the use of de-icing chemicals and/or by plowing.**

Streets shall be plowed on a continuous basis until completed. Plowing shall be undertaken during the night as much as possible in order to minimize the problems associated with traffic and parked vehicles. The snow plowing operations shall be completed within thirty-six hours following the end of an average storm. During extreme snowfall events where the snowfall amount and/or accompanying severe drifting conditions makes it impractical to complete the snow clearing operations on the street system with a full complement of resources and continuous effort, the time limits specified may be extended.

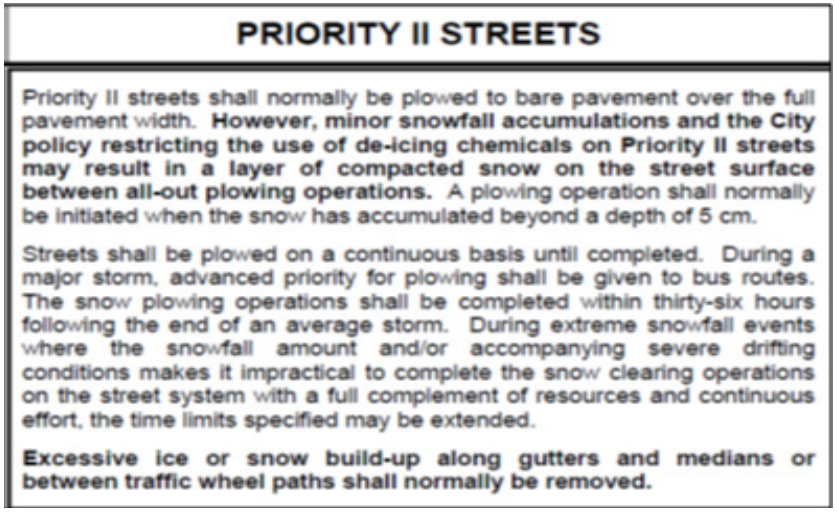
Excessive ice or snow build-up along gutters and medians or between traffic wheel paths shall normally be removed.

Recommendation 7: Add a statement to the Priority II Street bylaw defining the maintenance of bicycle facilities and establish an operational procedure indicating the timing of this level of service (figure 34).

The following addendum in bold is recommended text to be added to the policy:

> **Marked and designated on-street bicycle facilities (i.e, bike lanes, protected bike lanes or cycle tracks) will be cleared to the same level of services as the street they are on for peak travel times 7am to 9am and 4pm to 6pm, unless otherwise indicated.**

Figure 34 - Priority II Streets Policy
Source: City of Winnipeg, 2011



PRIORITY II STREETS

Priority II streets shall normally be plowed to bare pavement over the full pavement width. **However, minor snowfall accumulations and the City policy restricting the use of de-icing chemicals on Priority II streets may result in a layer of compacted snow on the street surface between all-out plowing operations.** A plowing operation shall normally be initiated when the snow has accumulated beyond a depth of 5 cm.

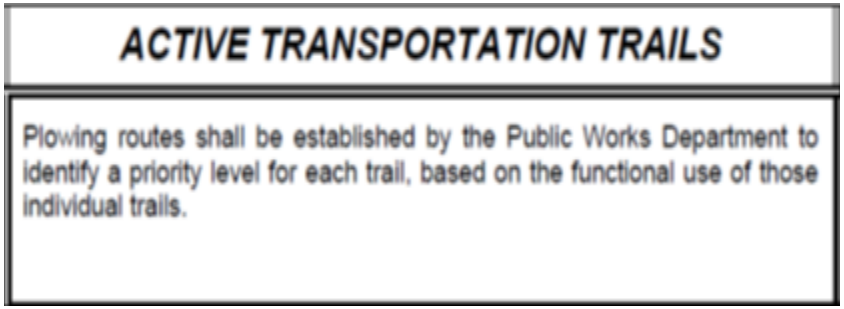
Streets shall be plowed on a continuous basis until completed. During a major storm, advanced priority for plowing shall be given to bus routes. The snow plowing operations shall be completed within thirty-six hours following the end of an average storm. During extreme snowfall events where the snowfall amount and/or accompanying severe drifting conditions makes it impractical to complete the snow clearing operations on the street system with a full complement of resources and continuous effort, the time limits specified may be extended.

Excessive ice or snow build-up along gutters and medians or between traffic wheel paths shall normally be removed.

Recommendation 8: Clarify and strengthen the Active Transportation Trails Policy Statement (figure 35)

Currently, a number of active transportation paths are maintained yet this information is not easily accessible. Define the Active Transportation Trails network similar to how the "Parks Pathways" is defined.

Figure 35 - Active Transportation Trails Policy
Source: City of Winnipeg, 2011



ACTIVE TRANSPORTATION TRAILS

Plowing routes shall be established by the Public Works Department to identify a priority level for each trail, based on the functional use of those individual trails.

Recommendation 9: Update the Sidewalk Snow Removal Bylaw.

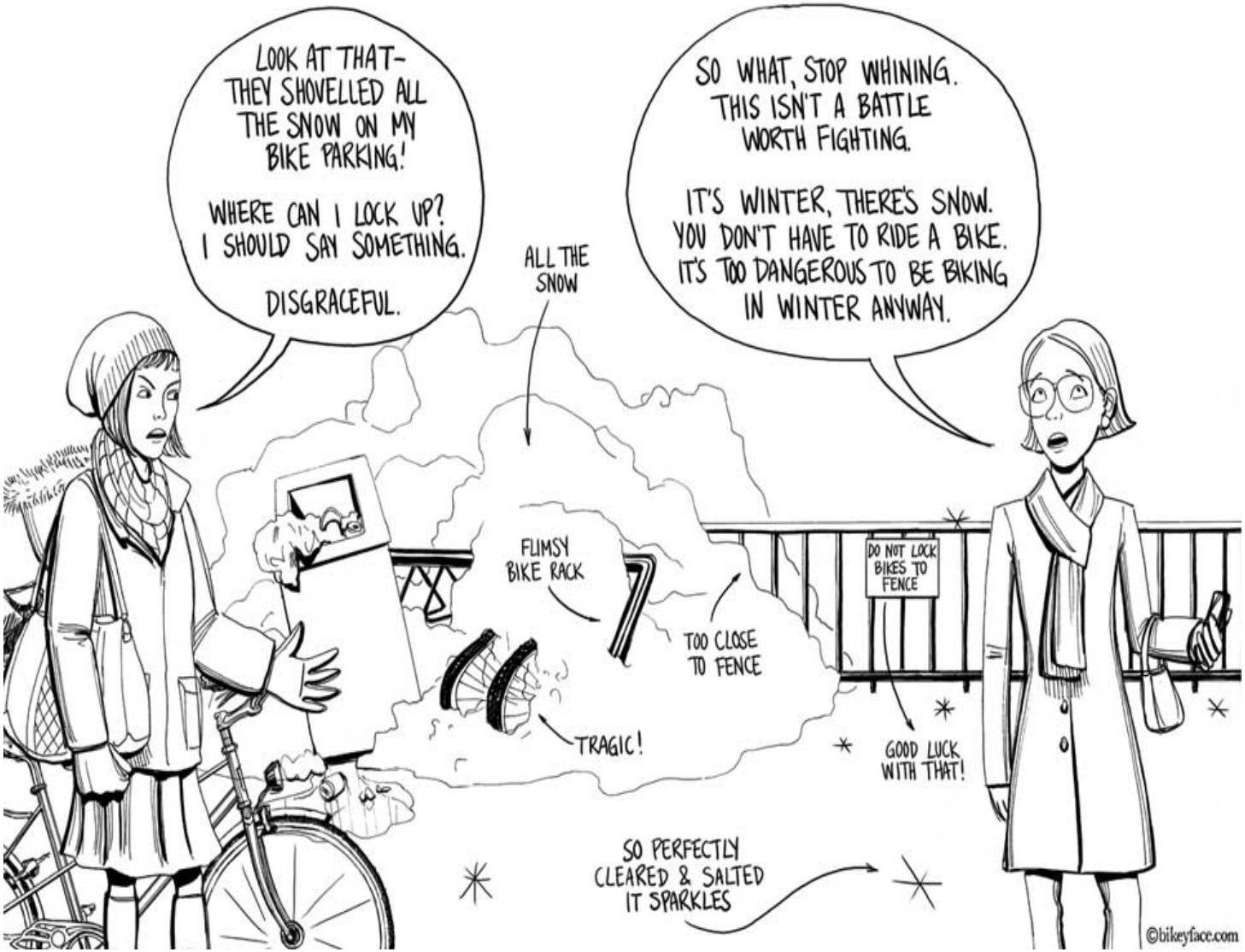
The City of Winnipeg is currently responsible for snow removal on city sidewalks. It is possible for cities to change policy to encourage more property owners to be more responsibile of secondary streets. Cities should be responsible for core areas such as Downtown, all sidewalks adjoining or adjacent to civic buildings, leisure centres, schools, senior's facilities, emergency services, City Parks, City-owned property, and trails.

Highlight: The City's of Edmonton, Regina and Saskatoon have snow removal bylaws that require property owners to help with winter maintenance by clearing adjacent sidewalks. Cities can share the responsibility for secondary residential streets with residents

Recommendation 10: Create a policy that encourages business to clear and maintain around high use bicycle parking

End of trip facilities, such as bicycle racks, require all year maintenance at high frequency destinations, such as major institutions, civic buildings and shopping centres.

Figure 36 – If You Were Me
Source: Bikeyface.com /2014/03/07/if-you-were-me/



4.6.2 PROCEDURES

The coordination of winter maintenance operations is an important step in providing a high level of service for all transportation users. Coordinating efforts and operations between roads, parks, bicycle and pedestrian departments will lead to more efficient operations and costs savings for the City of Winnipeg. Communication and integration between different city departments, agencies or operators will also lead to overall better winter maintenance operations (i.e. Parks, Streets, The Forks, etc.). A pilot approach to the following recommendations is suitable in order to test new procedures and create flexibility in operations.

Recommendation 11: Experiment and test maintenance procedures for each bicycle facility type

Weather conditions in Winnipeg may allow for different maintenance levels on different types of facilities. Engage and work with the local Street and Road Operation (Public Works) crew to determine which methods are possible for each bicycle facility route or type. Different types of facilities require different maintenance procedures, including different equipment or vehicles and different techniques (i.e., plowing, removal, sand). **Table 2** on the next page highlights different level of service options for the bicycle network in Winnipeg.

Recommendation 12: Consider establishing a separate subcontract for the entire bicycle network and Downtown

Ensuring coordination between different agencies and departments is an important component of winter maintenance operations in order to provide a high level of consistent service and ensure predictability. Evaluate the current contracts and flexibility in operations and consider a special contract for the bicycle network to one service provider.

Highlight: The City of Edmonton piloted snow removal on one route in 2013/2014 and the preliminary finding is that they have not reached their goal of keeping 1m clear to bare pavement. Final analysis is not complete, however preliminary observations state it could pertain to more snow this winter, the level of service established was unrealistic or procedures need to be adjusted.

Table 2 – Bicycle Facility Maintenance Procedures

Bicycle Facility	Maintenance Method or Procedure
Off-Street Pathways are separated from the roadway and are generally intended to be shared among multiple users.	Plowing, clearing, compact snow Texturize surface applications/treatments Sidewalk Bobcat plows or Pick-up truck
Cycle tracks are bike lanes which are physically separated from vehicle lanes through a buffer or barrier and located within the road-right-of-way (i.e. Assiniboine Avenue cycle track).	Plowing, clearing, removal Compact snow Sidewalk Bobcat plows, Pick-up truck
Painted bicycle lanes are separate travel lanes designated for bicycles, located beside vehicle travel lanes.	Plowing, clearing, removal Snow plows, Pick-up truck, Bobcats
Bicycle Boulevards are located on local streets with lower traffic volumes and speeds where cyclists and vehicles share the road.	Plowing, clearing, removal Texturize surface applications/treatments Snow plows
Sharrows (or shared lane markings) are pavement stencils places in the middle of a vehicle lane to indicate a cyclist may use the lane.	Maintained the same as roadway

Recommendation 13: Include and encourage flexibility in winter maintenance operations

Winter weather fluctuates and snow clearing policies should take temperature into account. When temperatures warm and there are melting events create mechanisms for City Departments and contractors to clear the build-up of compact snow or ice instead of waiting for a snow event or new minimum accumulation to activate the Bylaw and maintenance operations.

Recommendation 14: Establish a Spring maintenance schedule for the bicycle network

Accumulation of sand or grit on the road surface following the snow melt should be removed in a timely manner as it creates unsafe surface conditions. Communicate the timing of Spring maintenance schedule to the public.

Recommendation 15: Upgrade pavement marking and test thermoplastic pavement markings for bike lanes, stencils etc.

Bicycle facility pavement markings are applied through a variety of methods, most common paint. Painted pavement markings experience abrasion from winter maintenance vehicles, often becoming invisible in the Spring and a more durable method is either Thermo-Sets or recessed Thermoplastic applications.

Recommendation 16: When designing new bicycle infrastructure consider including a budget that factors in a year-round life-cycle to include snow removal.

The City of Winnipeg estimates it costs $1200/km for plowing of roads which can be applied to estimate a budget for winter maintenance of on-street bike lanes. The Pedestrian and Cycling Strategies recommend $500,000 towards the creation and initial pilot of a winter cycling network. See Highlight below for other ideas.

Highlight: The City of Hamilton estimates $1000/km for plowing, salting and sweeping (based on a 10km pilot).

The City of Toronto budget for the maintenance of the Waterfront Trail (15km) is $100,000/yr. The goal is to keep clear to bare pavement for "expressway" level of service. The estimated maintenance budget for the Sherbourne St. cycle track is $104,000/yr.

The City of Oulu maintains 700km of off-street paths for an estimated $1.5 million/year and has a budget up to $2 million.

4.6.3 PROMOTION

Communication is essential to informing existing and new cyclists about all bicycle programs of the City. The City of Winnipeg currently makes information available on the active transportation section of the website. The City can promote a positive attitude towards winter by highlighting its efforts to improving conditions for cycling and non-motorized transportation generally. Embrace and promote Winnipeg as a winter cycling city.

Ensuring residents have transportation options in winter that are reliable, accessible and predictable fulfills the City's sustainability goals and objectives. In addition, the City contributes to normalizing winter bicycle commuting and shifts the public perception that winter cyclists are 'crazy'. This recommendation is in accordance with the Pedestrian and Cycling Strategies vision statement that Winnipeg become recognized as a leading Winter City in promoting walking and cycling throughout the year.

Recommendation 17: Create a dedicated page or area on the city website for winter cycling.

The website will serve as a hub on winter cycling and can include information for all road users on safely sharing constrained roadways, safe cycling tips, and other resources. Highlight the winter maintenance of the bicycle network and provide a map of the network. Engage the local cycling community to create a locally made "Tips for Cold Weather Cycling" brochure for the city website.

Recommendation 18: Establish a "cold line" or encourage reporting on 311

Recommending the public provide feedback on problem areas in the network will help the City maintain a high level of service through winter. Collecting information from regular users is valuable information particularly in regard to maintenance contracts and quality of service.

4.7 Monitor and Evaluate

Transportation mode share data or travel surveys are often conducted during the spring season or early summer therefore it is challenging to know what the mode share of cycling is in winter. Based on research, feedback from the Strategies public consultation and surveys of cyclists, it is estimated that up to to 25% of cyclists continue to cycle all year.

Recommendation 19: Expand the traffic monitoring pilot project and add Eco-Counters to the on-street bicycle network

The City is currently piloting inductive loop Eco-Counters at ten locations on select multi-use off-street paths. Adding monitoring locations to the on-street network will allow the city to evaluate daily commuter traffic removing the responsibility from volunteer manual counts. Automated data counter allow for remote data collection and can be examined for trends and patterns. In the long term this can help evaluate policy measures for improving the cycling network.

Recommendation 20: Establish a winter maintenance committee or advisory group

It is important to evaluate the service of contractors and city operations to ensure the specified level of service is being delivered. Communication between departments, agencies and contractors is important to exchange knowledge, evaluate services and refine operations. Creating the time to do site visits, monitoring and regular updates to overall operations will result in efficiencies and cost savings. Specific attention and monitoring is needed for bridges and access points between the off-street trail systems and on-street bicycle network to remove gaps in maintenance.

Summary

The City of Winnipeg has identified the creation of a winter cycling strategy as a key priority in the Pedestrian and Cycling Strategies. The recommendations for a winter maintenance strategy and cycling network offer the City of Winnipeg implementation steps to create a four-season cycling enviroment. The winter conditions in Winnipeg are unique to the area and recommendations are based on the local climate context and by looking to similar bike-friendly winter cities like Minneapolis and Oulu.

Employing a pilot project model, the City of Winnipeg can establish select routes and test operation procedures. The recommended routes outlined require further consideration and analysis. There may be additional routes, paths or corridors that need to be added to the priority list. Engaging the operations and maintenance department to determine which procedures are best suited to the priority route and bicycle facilities will lead to a higher quality pilot project. The recommended cycling network is on both off-street and on-street facilities. As the on-street facilities may not be visible due to fallen or compact snow, the use of signage can be used to indicate a winter cycling facility is present to both motorists and cyclists. Encourage city personnel to explore innovations from places like Minneapolis and see what can be applied in Winnipeg.

As winter approaches, promote and publicize the steps the City will take through the Winter Cycling Network pilot. In addition, the City can engage local organizations like Bike Winnipeg, the Green Action Centre or the University of Winnipeg Ice Riders to develop a resource on winter cycling, including how to dress, type of bike needed, safe driving and cycling tips. Take the time between the fall and the spring to refine and update supportive policies, such as priority routes for year two, bicycle rack maintenance and general procedures. If temperatures allow, do manual spot counts on select routes during peak commute hours over the winter season. Spend time evaluating the pilot project at the end of the winter season and look to expand the winter strategy for the following winter.

5. Conclusion

This supervised research project has endeavored to present leading plans, policies and practices to support cycling in winter. The lessons learned from the literature review, the Peer City Review and participation at the 2014 Winter Cycling Congress formed the basis for proposing thematic design principles for developing a winter cycling network and maintenance strategy. The four thematic principles are plan, prioritize, procedures, and promote, and this framework was applied and tested by creating a winter cycling strategy for the City of Winnipeg. Winterpeg is a true prairie winter city with a growing cycling population, and planning for winter cycling is a new focus for the city. Determining what practices and policies are best suited is based on political will, local weather conditions and the local cycling environment.

Criteria for establishing a winter cycling network is based on high frequency bicycle corridors, existing on-street and off-street bicycle facilities, access to major destinations, connectivity and existing snow removal priority routes. The overall goal of supporting winter cycling is to ensure cycling continues to be a safe, viable transportation option throughout the winter season. Adopting four-season transportation policies and climate responsive strategies is the next steps for winter cities as they strive to meet climate change targets and sustainability objectives. Cities in northern latitudes experience diverse winter climates and a winter maintenance strategy is shaped by the existing bicycle network and customized maintenance procedures. The literature and peer city review explored a variety of polices, plans and programs that provide ideas and examples for and from winter cities world-wide.

The body of research on winter cycling is limited yet it contributes to a greater understanding of the motivators, deterrents and preferences of year around commuter cyclists. Weather conditions are a significant barrier to cycling throughout the year, especially during winter. Weather conditions are variable and without predictable road surface conditions many cyclists chose not to bicycle. However, individuals who bicycle in winter are dedicated confident commuter cyclists who will cycle regardless of colder temperatures and some snowfall. In Canada and the United States, and even Northern Europe, it is estimated that one-quarter or 20-25% of cyclists continue commuting through the winter season. As cyclist adapt to the local climate more people will continue to cycle therefore the rates of winter cycling have the potential to increase an additional 12% to 24% (Bergström & Magnusson, 2003; Miranda-Moreno & Kho, 2012; Amiri & Sadeghpour, 2013). Cyclists prefer dedicated bicycle facilities but as these are not available in winter, cyclists change their route and travel on arterial and collector roads as they provide a somewhat predictable surface (and they are prioritized for motor vehicles). The key summary of the literature review is that road surface maintenance that prioritizes bicycle facilities and thus creates predictable routes will lead to higher rates of cycling in winter.

The Peer City Review was based on independent research, participation at the Winter Cycling Congress and information gathered through interviews with municipal planners or engineers. The peer city review investigated municipal snow removal bylaws, maintenance of bicycle routes, implementation of comprehensive strategies, design of bicycle facilities, and monitoring and promotion programs relevant to winter cycling. Winter planning and design for the transportation system requires context sensitive application, and knowledge of temperature and snow accumulation is necessary to find suitable winter maintenance solutions. Geographic regions of the world experience very different

types of winter and the peer city review classified cities as mild, moderate or severe based on the average January temperatures as an indicator of seasonal variation. Solutions and procedures for maintenance of bicycle facilities in winter cities need to look at different methods (i.e., surface applications, plowing, removal, etc.) based on temperature and snowfall volume. What works in Montreal will not necessarily work in Calgary, and what works in Winnipeg will not necessarily work in Toronto. Cities that experiences numerous days of above zero degree temperatures, often referred to as a "freeze-thaw" cycle, may focus on surface applications and snow plowing which distributes snow out of the roadway to the edges of the roadway. Cities with a more severe environment of freezing temperatures and snowfall may focus on snow removal.

Planning for a winter cycling network and a complimentary winter maintenance strategy begins with identifying suitable routes or corridors. A prioritized winter cycling network needs to be selected based on the type of bicycle facility relative to popular origins and destinations and the existing maintenance operations, and priority road network. Off-street routes and on-street facilities require different maintenance procedures and often fall under different municipal jurisdictions, therefore coordination is necessary. While cyclists may prefer separated facilities and cycle tracks, they are a new infrastructure type for North American cities. Cities like Montreal who have extensive separated networks prioritize cycle tracks for maintenance which creates predictable routes. The most common bicycle facility in Canada and U.S. cities are on-street painted bike lanes and bike lanes present a variety of challenges in winter.

The Peer City Review was unable to find a best practice for maintaining bike lanes in extreme winter cities. The example from Hamilton provides a good example for a mild to moderate winter city, and this area warrants further research, experimentation and innovation. On-street bike lanes are most often on priority one (P1) streets as they are on major arterial or collector roads, so improving maintenance procedures seems highly possible. Bike lanes are often a hazard to cyclists as operation procedures and attitudes see bike lanes as snow storage facilities. On-street parking further complicates procedures for maintaining bike lanes. More importantly, for severe winter cities like Winnipeg, Montreal and Minneapolis, bike lanes are covered in snow and become invisible. Signage for winter routes with bike lanes is an area for development. Any bicycle facility that relies on pavement marking for use – bike boxes, bike lanes, and contra flow bike lanes – are a major issue and require innovate signage applications to make these facilities visible and safe in winter. Alternately future bike lanes can be retrofitted with bollards (flexible delineators) and painted buffer style bike lanes. The painted buffer area provides additional space for snow storage and bollards provides a visual indicator. Cycle tracks also require winter design consideration, specifically for severe winter cities (i.e. low curb barrier cycle tracks are not appropriate as they become snow covered). Winter cities must integrate winter into the design of bicycle infrastructure and facilities. Planning for cycling in winter requires flexibility or a variety of different approaches and procedures.

In order to be leaders in sustainable transportation, winter cities need a vision for creating four-season year-round accessible bicycle networks and a political will to commit the resources towards this goal. Beyond the support of elected officials and senior management, operations supervisors and managers need to also offer direction, leadership and guidance of snow removal innovations. A major strategy to improving winter

maintenance level of service and delivery in any city is through the engagement and 'buy-in' of operations crew.

Once a portion of the bicycle network is prioritized, the next step is ensuring the routes will be predictable for commuter peak travel times, the procedures and methods for maintenance can be tested and established in partnership with the operations crews. Incremental approaches to enhancing the level of service for bicycle networks is recommended as cities evaluate winter maintenance practices in order to improve efficiency and costs effective operations. A city's commitment to winter cycling needs to be publicized and promoted so the public knows the municipality is dedicated to improving the safety for all road users. As cyclists change their routes in winter to be on streets that are maintained, and in order to move cyclist's to a prioritized winter network, promotion is necessary.

As cities in Canada and the United States look to share best practices in planning for winter cycling, Northern European cities offer a glimpse of what is possible as they have very high winter retention rates (i.e. 9% in Oulu and Copenhagen) and they have similar climates to North American cities. Winter strategies can be integrated into transportation plans, snow removal policies or bylaws, or in bicycle facility design guidelines. Winter cities, especially bike-friendly winter cities with growing mode share, like Minneapolis and Montreal have a responsibility to provide predictable, safe, prioritized winter cycling networks. The proposed winter cycling network and maintenance strategy for the City of Winnipeg offers a comprehensive framework to become recognized as a leading Winter City in promoting cycling throughout the year.

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