Bicycle Commuting: Developing an Effective and Comprehensive Active Transportation Network in Winnipeg, Canada

by

Raymond Yuen

A Thesis submitted to the Faculty of Graduate Studies of

The University of Manitoba

in partial fulfilment of the requirements of the degree of

MASTER OF PUBLIC ADMINISTRATION

Department of Political Studies

University of Manitoba

Winnipeg

ABSTRACT

Winnipeg, Canada received $20.4 million from the three levels of government to augment the city's active transportation infrastructure. Like many North American cities, Winnipeg is an automobile-focused centre that experienced little funding or development towards active transportation until recently. Winnipeg's current active transportation system is insufficient, poorly conceived, and fractured. As cities move towards environmentally friendly initiatives, Winnipeg has an opportunity to build comprehensive and safe access to all parts of the city through active transportation. Concentrating on the bicycle as the primary transportation mode, this study examines the current status of Winnipeg's active transportation network and searches for areas of improvement/development. This study identifies critical areas needing improvement and offers solutions by integrating input from Winnipeg's cycling community, standards established by government/industry bodies, and successes from other jurisdictions. Key issues include bicycle facilities, safety and education and their integration into an effective and comprehensive bicycle transportation network.

EXECUTIVE SUMMARY

Bicycle Commuting: *Developing an Effective and Comprehensive Active Transportation Network in Winnipeg, Canada* is a multifaceted study of the bicycle as a viable transportation option through a primarily automobile-dominated city. The large majority of Winnipeg, Canada's, commuters travel by motor vehicle and many of those people consider active cycling as a recreational activity, rather than a viable means of transportation. Because of the paucity of bicycle commuters, Winnipeg's infrastructure development echoes traffic usage. The design, construction and augmentation of roadway infrastructure cater primarily to motorised vehicles—few people commute cycle because Winnipeg's infrastructure does not facilitate cycling, and the infrastructure does not accommodate commuter cyclists because few people commute cycle. We must break this cycle to entice more people to consider the bicycle as a viable means of transportation.

In 2010, the federal, provincial and municipal governments collaborated to inject $20 million to Winnipeg's active transportation infrastructure; this may prove to be the impetus that promotes the bicycle from a recreational tool to a commuting standard. However, building an effective, functional and comprehensive active transportation network involves more than simply funding. This study examines the parts and construction of a successful active transportation network, the usage of this network, education to its usage, and safety through its usage.

While Winnipeg is still in its infancy in active transportation development, some North American cities have flourishing bicycle commuting communities. We look to those successful centres and apply their best practices to Winnipeg's situation. To determine Winnipeg's unique needs, we conducted a survey gathering information from Winnipeg's cycling community. The results of the survey gave us direction on how to apply best practices to local needs.

Winnipeg's cycling community wants an active transportation network, but they want a network that is well-built and accessible. Cyclists should be able to access the infrastructure without too great of a deviation. The infrastructure should also reach major destination areas, popular points of interest, shopping hubs and the central business district (CBD).

Forming the framework of the active transportation infrastructure, the multi-purpose trails should sit as concentric circles in the city, with multiple radii emanating from the CBD. Presently, Winnipeg's network of multi-purpose trails abut many of the major thoroughfares and rivers but the network has numerous fractures within its frame. This study looks at ways to overcome those deficiencies and build towards a complete skeletal structure.

While the multi-purpose trails make up the major framework of the active transportation network, the framework alone is not enough to reach all the major destination points, residential neighbourhoods and even the CBD. Other cycling facilities act as supporting tendrils to the skeletal network. Along major thoroughfares with no abutting multi-purpose trail, widened shoulders can sometimes act as a temporary alternative, or as a short transition between other, major bicycle facilities. Major arteries with widened shoulders sometimes act as part of the active transportation superstructure, thus it is very important that routes with widened shoulders be properly constructed. This study examines Winnipeg's streets with widened shoulders and provides options for improvement.

Bicycle routes also act as transitional bridges between major bicycle facilities. Winnipeg has numerous signed bicycle routes throughout the city and this study goes into detail describing those routes. Although Winnipeg features a considerable number of bicycle routes, many of them have severe deficiencies. The deficiencies should be overcome to provide safe and adequate passage for cyclists and this study goes into detail on improving the bicycle routes.

To support the active transportation network, Winnipeg uses a combination of bus-bicycle shared lanes (diamond lanes) and motor vehicle-bicycle shared lanes (sharrows). If constructed properly, both diamond lanes and sharrows can provide viable alternatives to multi-purpose trails through high-traffic areas. Winnipeg introduced sharrows a few years ago and continues to designate more locations as diamond uses. This study examines the positive and negative aspects of Winnipeg's diamond lanes and sharrows as an augmentation to the overall network. Since lane sharing between cyclists, motorists and high occupancy vehicles requires direct interaction between the different modes of transportation, properly designing shared lanes and diamond lanes adds critical value to safe, effective and efficient usage.

Bicycle lanes make up another important component to the active transportation network; they can traverse major, high-density areas along heavily trafficked roadways. Bicycle lanes cut through congestion to provide bicycle access to high volume areas, like the CBD. Because bicycle lanes often run alongside or in-between high motor vehicle volumes, they should be constructed properly to promote safety for the cyclist and the motorist. This study goes into explicit detail in examining Winnipeg's bicycle lanes for effectiveness and safety—we continue by providing innovative options in improving bicycle lane structure and placement.

Cyclist, motorist and pedestrian safety should stand paramount in the construction and maintenance of roadways, including cycling facilities and the active transportation network. This study examines the safety features of the bicycle facilities and other street facilities, such as traffic calming. Winnipeg has adopted a number of safety initiatives to protect the bicycle user; the study evaluates these initiatives and compares them to practices used in other cities, as well as industry standards. We present detailed recommendations for improvement to current safety initiatives and potential for expansion.

Bicycle and road facilities must be used properly to achieve the desired outcomes. Traffic regulation and law enforcement contribute to proper road usage and make up a significant part of road safety. We examine the kinds of enforcement that are available, whether they are used and how effective they are. Enforcement strategies in other cities have shown robust effect in reducing dangerous operation and those strategies are available for application in

Winnipeg. Safety is the responsibility of all road users and pedestrians, and should be a fundamental part of active transportation development.

The bicycle helmet is a simple device that can provide personal safety to the cyclist. Opponents to helmet use outline a number of reasons why the helmet may not offer much protection. This study weighs the positives and negatives of helmet use and presents the support behind both arguments. The helmet analyses conclude with policy, usage and education recommendations.

General road use education should also make up a major part of safe road usage. Education can target all children through inclusion in the elementary school curricula. The education process continues to adulthood through reinforcement, drivers' licensing and public campaigns. Cyclists, motorists and pedestrians should know how to use the roads to navigate them safely. The study provides insight into establishing an effective education system that reaches the entire population and maintaining the knowledge through one's lifetime.

Enabling people to embrace the bicycle as a viable transportation vehicle involves numerous factors integrated as a complex network. All of the factors should work in unison to generate a dynamic and adaptable network. Parts of this network include a comprehensive active transportation infrastructure, complete with a solid skeletal structure and peripheral bicycle facilities. People should share this system and know how to use it properly. Governments should provide the education necessary to enable people to use road and bicycle facilities properly and safely. This study looks at all facets of this network and provides insight on how to build, maintain and expand this network.

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ACKNOWLEDGEMENTS

I express sincere appreciation and gratitude to my advisor, Dr. Christopher Leo for exemplary patience, guidance and mentorship he provided to me. Dr. Leo has a genuine interest in making the world a better place to live, and to helping out his fellow persons. Dr. Leo taught me to be a better writer as well as a scholar, and I am truly fortunate to have had the privilege to have worked with him.

I also want to thank the dedicated members of Bike to the Future for their support and assistance. This is a great group comprised of great people who work hard to make Winnipeg a better place for cyclists.

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INTRODUCTION

The large majority of Winnipeg, Canada's commuters travel by motor vehicle. From the 2006 Census, Statistics Canada reports bicycle commuting at a mere 1.6% (2006). The number of people using bicycles as a commuting option does not increase rapidly as the previous Canadian census showed bicycle commuting at 1.4% (2001); in the five years between Census samplings, Winnipeg only added 0.2% to the bicycle commuting population. Many of Winnipeg's citizens consider active cycling as a recreational activity, rather than a viable means of transportation, which contributes to low bicycle commuting. Winnipeg's citizens use motor vehicles and public transportation as means of commuting but few view the bicycle as a viable option.

Since Winnipeg's citizens consider active cycling as a recreational activity, rather than a viable means of transportation, motorists consider on-street cyclists as nuisances and commute cycling as a fringe activity. Winnipeg's infrastructure development echoes traffic usage as road constructions cater primarily to motorised vehicles with little regard for cycling traffic; the automobile dominates the road and the infrastructure caters to this dominance. Infrastructure responds to user demand; however, commuting demand also responds to infrastructure. That is, few people commute cycle because Winnipeg's infrastructure does not facilitate cycling, and the infrastructure does not accommodate commuter cyclists because of a paucity of commuter cyclists. Either of these factors (or both) can initiate an impetus for change to improve commuter cycling numbers. Alternatively, an external stimulus may also play a part in augmenting commuter cycling numbers, or improving cycling infrastructure; public pressure or change in political will also affects infrastructure development.

Increasing commuter cycling provides many advantages to users, the infrastructure and the environment. Numerous health advantages associate with increased physical activity and commuter cycling provides the opportunity to combine exercise with transportation.

Increasing the number of cyclist commuters conjunctively reduces the number of motorist commuters, and number of automobiles used. Automobiles cause significantly more wear-and-tear to road infrastructures than bicycles. The greatest cause of road deterioration in Winnipeg results from seepage of water into pavement crevices, and subsequent freezing of the water, which expands and cracks the pavement. As automobiles travel over compromised pavement, the automobile’s weight crumbles the concrete and degrades the condition of the road. The insignificant weight of the bicycle causes relatively little damage to the concrete.

Reducing the number of active motor vehicles also reduces the emissions caused by internal combustion motors. Hybrid vehicles reduce the amount of fuel usage and electric vehicles produce no hydrocarbons. However, electric vehicles rely on electricity and consume battery cells. Reducing fossil fuel and electricity usage reduces harm to the environment.

The present era of unprecedented environmental awareness, united with constant fuel price increases, propels renewed interest in alternate forms of transportation and a possible turn towards the bicycle as a means of transportation, rather than merely a recreational outlet. Using the bicycle for locomotion eliminates all reliance on external energy sources and only produces carbon dioxide as a result of respiration. As the public's disposition about using the bicycle as an alternative to vehicle transportation changes, government action should follow citizens' demand. Similarly, government initiatives in improving bicycling experiences should impel more people to embrace bicycle commutes. The City of Winnipeg's response to cyclist commuting demands include a major initiative to implement and improve bicycle facilities in Winnipeg; recently, the Manitoba provincial government and the Canadian federal government pledged support for the advancement of active transportation, in conjunction with initiatives from Winnipeg's municipal government. These initiatives represent the greatest investment Winnipeg has seen put into bicycle facilities to date.

Winnipeg's plan in developing and expanding bicycle facilities should examine the current status of bicycle facilities and prior developments leading to the current status. Historical development plays a major role in Winnipeg's current cycling status, structure and attitude. Exploring into Winnipeg's evolution and comparing/contrasting with similar cities' developments provide directions for development in Winnipeg. Because Winnipeg's movement into enhancing bicycle facilities still sits at an early developmental stage, Winnipeg has a great opportunity to embrace the successes of comparable cities and their pro-bicycle travel expansions. Winnipeg's pro-bicycle development has the opportunity to forego a repetition of inadequate, inappropriate or ineffective policies that failed other cities; Winnipeg can proceed with successful initiatives, and adapt them to local needs.

Probing the fundaments of urban design, Winnipeg can view the possible design models and assess their efficiencies and effectiveness with regard to enabling local bicycle usage. The application of those efficiencies provides a template for future neighbourhood and road design with active cycling as a major consideration. The design of Winnipeg's new neighbourhoods should work effectively and efficiently in conjunction with current, existing neighbourhoods. Studies show that neotraditional neighbourhoods encourage bicycle usage (Krizek & Johnson, 2006; Dieleman, Dijst & Burghouwt, 2002); the integration of new neighbourhoods with existing neighbourhoods contributes to a comprehensive, accessible and effective bicycle-friendly infrastructure. This success requires the proper implementation of new neotraditional neighbourhoods with the modification of existing neighbourhoods. In this process, bicycle facilities should become a key component in creating new infrastructure, as well as updating/upgrading existing infrastructure. Winnipeg should develop new neighbourhoods with commute cycling considerations, as well as re-develop existing neighbourhoods to accommodate commute cycling.

Promoting bicycle friendliness in new and existing neighbourhoods often involves the incorporation of bicycle facilities. However, bicycle facilities alone are not sufficient to provide an adequate support to commuter cyclists. Cyclists and motorists must know and understand how to use the facilities properly. Proper bicycle facility usage comes from education, regulation and experience.

Thus, facilitating bicycle transportation can be defined by three key areas of development: the condition of bicycle facilities, education with respect to bicycle usage and bicycle-motor vehicle interactions, and the establishment/execution of bicycle and motor vehicle regulations.

This study examines the various types of bicycle facilities in detail and applies them to Winnipeg's unique geographical and social structures. Examinations include analyses of existing facilities, facilities in progress, and proposed facilities. These analyses counterpose Winnipeg's existing and proposed facilities to the standards established by industry and government bodies, including the Transportation Association of Canada (2007), the American Association of State Highway and Transportation Officials (1999), and The Government of Manitoba (1999).

Cycling facilities that fail to meet established standards create risk and peril to motorists, cyclists, pedestrians and structures. This study provides recommendations for upgrading facilities that fail to reach required industry and government standards. The study further searches for alternatives to upgrade deficiencies in facilities that may conform to industry and government standards, but may not provide the adequate support for users. In conjunction, the study gives options for the future direction of development and expansion. These options arise from research and examples set by cities with successful bicycle facilities. As Winnipeg's bicycle usage increases, Winnipeg should continue to monitor cities with successful bicycle facilities/programs and continue to provide usable models for Winnipeg's future design developments.

Bicycle facilities improve cycling accessibility, movement and safety, but facilities also present unique risks to safety. The study examines the risks associated with each facility and searches for ways to ameliorate those risks. Even though facilities may meet industry/government standards they may also carry elements of risk to cyclists, motorists and pedestrians; the risks may arise from specific situations or unanticipated factors. The study searches for means of reducing risk, within the physical confines of infrastructure, and through designs outside of the physical features. Risks may arise from structural design deficiencies, as well as cyclist/motorist/pedestrian usage (Dill & Carr, 2003; Nguyen & Williams, 2001; Harkey & Stewart, 1997; Kiburz, Jacobs, Reckling & Mason, 1986). In addition to design of the facility, improper (or even proper) use of those facilities can also result in risk. Reducing risk to cyclists, pedestrians and motorists involves action on numerous fronts.

Cycling, driving and pedestrian behaviours play large parts in the safety and risk of transportation. Increasing positive behaviours and decreasing negative behaviours should reduce risk to safety. Improving travel behaviour results primarily from education (Freund, & Martin, 1997). Education should involve programs for both motorists and cyclists in improving on-road practice. Behaviours of both motorists and cyclists affect the situation of their surroundings and other road users. This study looks at the effectiveness of education to both motorists and cyclists, and the resulting reduction in incidents and accidents. The study further examines Winnipeg’s initiatives in providing education, and the potential for greater public coverage. Education should reach all road users to have desired effect; thus, education should play an important part in policies aiming to improve bicycle usage.

The information and policy options presented by most studies derive from a combination of academic research, empirical data and popular best practices. Extending the policy options and insights to Winnipeg's bicycling situation can only infer appropriateness to a unique urban centre. That is, what works for other cities may not work for Winnipeg. Limiting research to cities with similar characteristics eliminates some of the confounding variables; however, true application to Winnipeg's circumstances cannot be assumed beyond inference. To adapt lessons from other cities to Winnipeg's unique culture, infrastructure, design, climate, and cyclist-motorist behaviour, a survey of the local cycling community was undertaken.

The timing of this study fortuitously coincides with growing interest in Winnipeg's dedication of funding and programs concerning cycling infrastructure. The results of the study provide valuable direction for future cycling programs and initiatives. Results from the local survey provide a unique lens to Winnipeg's cycling needs, and an opportunity to address distinct, local cycling issues in Winnipeg. This study moulds general facilities, policies and practices to Winnipeg's specific requirements. Providing solutions that fit the local demands offers best-suited options to improve conditions for all cyclists.

Cyclists may be categorised into three classifications: Type A cyclists have considerable experience and comfort in travelling on most roadways and have extensive familiarity with cycling rules and behaviours. These cyclists use the bicycle as a transportation mode. Type B cyclists are mostly leisure cyclists who confine travel to low traffic areas or recreational areas. These cyclists generally do not use the bicycle as a viable transportation vehicle. Type C cyclists comprise of children and riders not of age to obtain a driver's licence. People with no cycling experience and limited cycling ability also fall into the Type C category. This category of cyclists rarely uses the bicycle for any purpose. The movement to increase commuter cycling includes increasing the frequency of Type A cyclist usage and the conversion of Type B cyclists into Type A cyclists. Because Winnipeg has a very low percentage of bicycle commuter usage, it can be inferred that most of Winnipeg's cyclists fall into Type B or Type C category cyclists. This study looks at numerous factors involved with converting Type B and C cyclists to Type A cyclists. To achieve a comprehensive outlook of Winnipeg's cycling culture and development, the study begins with a look at some of the existing literature and best practices from cities with established and successful active transportation networks.

EXISTING LITERATURE

A considerable body of knowledge exists regarding the development of active transportation. However, because Winnipeg has only recently begun to regard the bicycle as a transportation medium rather than solely as a recreational tool, there is not a wealth of literature specifically studying Winnipeg and bicycle transportation. Thus, developing an applicable and effective background requires integrating established standard and fundamental practices to local, unique needs. As a start, we should assess the available literature and expand on it. There is no need to reinvent the fundaments if a working foundation has already been built. We need to determine what the established standards are and subsequently mould them to apply to Winnipeg's specific needs. This is achieved through examining the best existing practices from the most established bicycle-friendly cities. Simply, how are the cities with successful bicycle transportation built and how can we adopt their best practices to Winnipeg?

In 2005, Winnipeg commissioned the City of Winnipeg Active Transportation Study (2005) and subsequently adopted the report as the authoritative reference in developing and promoting active transportation polices and programs. The Active Transportation Study reviewed Winnipeg's active transportation status as of 2005 and identified the components of the physical network. The study further described the nature of Winnipeg's bicycling facilities identified the need for expansion, and listed the available options; Winnipeg already has a foundation but new developments should include the expansion of the network. The study presents a number of reasons why Winnipeg's citizens support the use of active transportation, and the expansion of the active transportation network. The study argued that citizens believe that good quality of life associates with benefits offered from a comprehensive, well-planned active transportation network; those benefits include convenient access to all parts of the city, maintained infrastructure, and good environmental quality.

Although the Active Transportation Study identifies the need to expand Winnipeg's current active transportation network, the study does not elaborate on which areas need expanding and upgrading or how they should be expanded and upgraded. The report concludes that Winnipeg needs to consult with the interested public, develop action plans, maintain existing infrastructure, improve facilities and improve connectivity. The report falls short of providing specific recommendations for target areas; it does not identify specific areas and what actions need to be taken. Indeed, Winnipeg needs a better active transportation network, but the Active Transportation Study falls short of providing specific requirements and details for infrastructure improvements. For those details, we need to look at research outside of Winnipeg.

In terms of design specifications and minimum requirements for roads and bicycle facilities, the American Association of State Highway and Transportation Officials (AASHTO) provides the most detailed and comprehensive standards for construction. The Guide for the Development of Bicycle Facilities, 4th Edition (2012) presents exact definitions of bicycle facilities, the requirements to design them, and the measurements required for minimum standards. AASHTO also prescribes what bicycle facilities are appropriate according to the conditions and requirements of the location. Winnipeg's bicycle facilities should follow the AASHTO guidelines to meet safety standards; however, AASHTO presents standards as a general guide to universal situations. Demands of the specific sites may require deviations from the AASHTO guides. For example, the minimum requirements set out by AASHTO may not be sufficient to provide safe usage because of the particular circumstances of the specific site. To ensure public safety, Winnipeg should follow industry standards, as well as consider further enhancements to adapt to the local cycling needs.

Using the bicycle as a mode of commute and transportation is not a new concept. Although Winnipeg's adoption of bicycle commuting sits at a relative state of infancy, other North American cities and European cities are much further progressed, decades ahead of Winnipeg in some areas. The evolution of other bicycle-friendly cities provide a vivid history to transition from an exclusively motor vehicle dependent society to a multi-faceted transportation centre. The State of Oregon (2010) details the evolution of Portland from a car-dependent city to the North American prototype of an alternative transportation hub. Transformation is a multi-stepped process, not a simultaneous conversion.

Dieleman, Dijst & Burghouwt (2001) provide insight into what segment of the population is amenable to switching from vehicle-based transportation to bicycle-based. We should focus efforts on people with a propensity to change, and not squander resources on those who are unwilling. Among those willing to adapt the bicycle as a transportation mode, the authors further explore factors that provide the impetus for commuters to abandon the vehicle. Neighbourhoods that are friendly to cyclists invite higher usage; neighbourhoods designed solely for motor vehicle usage will see a paucity of other transportation modes.

Specifically, the neighbourhood should have access to, or be a part of an active transportation network to induce bicycle usage. Krizek & Johnson (2006) found that proximity to bicycle facilities motivates bicycle usage. People are more apt to embrace bicycle usage where bicycle facilities are accessible and nearby. Simply having bicycle facilities is not sufficient to entice usage; the proper facility should be available in the proper situation to enhance usage and safety (Shafizadeh & Niemeier, 1997). These facilities should also be properly maintained. Factors such as pavement quality have a significant effect on commuter usage (Stinson & Bhat, 2002). Dill & Carr (2003) discuss the importance of maintaining industry standards on construction and maintenance of facilities. Substandard facilities impose considerable peril to all users, including cyclists, motorists and pedestrians.

Safety involves more than just maintaining bicycle facilities. Safety involves proper sharing of the roads (DeRobertis & Rae, 2001) and mutual respect among all users. Traffic calming devices reduce motorists' speeds and increase their awareness, thus influencing neighbourhood safety as well (Ewing, 1999). Traffic-calming devices make up a part of neighbourhood design. Designing neighbourhoods to be more bicycle-friendly improves bicycle access and safety, and may including limiting motorised traffic (Pucher & Dijkstra, 2000). To address motorists who do not respect traffic laws, or threaten public safety with aggressive driving practices, cities can assertively apply traffic enforcement to limit dangerous driving and reduce law-breaking (Davis, 2006).

Helmet use also contributes to safety for the cyclist (Osberg & Stiles, 1998) by reducing personal injury. While question exists regarding the effectiveness of helmets, numerous studies show robust effect for improving cyclist safety (Attewell, Glasea & McFadden, 2001), Legislated helmet usage further improves personal safety (LeBlanc, Beattie, & Culligan, 2002), lessens injury (Lee, Schofer, & Koppelman, 2005, Wasserman & Buccini, 1990), and fatalities.

Helmet use should start at youth and be part of the education process (Berg & Westerling, 2001). The public education system has a responsibility to teach safe cycling at an early age, but this education should be augmented by at-home teaching and reinforcement (Rourke, 1994). Education in road usage should also cover all motorists, from training the learning driver to re-educating the experienced driver (McMahon & O'Reilly, 2005).

Many of the initiatives that have worked for other cities should apply to Winnipeg as well. The challenge comes in honing the concepts to adapt to Winnipeg's unique features. Many of the infrastructure issues that face other North American cities also apply to Winnipeg. In some ways, Winnipeg's infrastructure is already friendlier to the cyclist than other centres. For example, Winnipeg's flat landscape does not impose altitude climbing challenges that face many cities. By contrast, Winnipeg has a relatively colder and windier climate than most North American cities; cold climate and winter conditions add unique challenges to the cyclist. Through the existing body of literature, this study attempts to determine the best practices to apply to Winnipeg. As a starting point, we should examine the history of bicycle transportation and the progress made to date.

HISTORY

Similar to most North American cities, Winnipeg's growth featured the automobile as the dominant form of transportation; land development followed with automobile-centered infrastructure models. Consequently, most of Winnipeg's infrastructure has little consideration for other forms of travel, including the bicycle. Because the infrastructure skeleton is exclusively comprised of motor vehicle roadways, creating bicycle facilities requires altering or modifying existing roadways. Since many North American cities have a similar history of development—including Portland, Oregon, which has one of today's best cycling infrastructures in North America—examining the evolutions of North American cities with successful bicycle programs provides insight into possible directions for Winnipeg in developing effective bicycle facilities and policies.

Portland too was part of the ubiquitous expansion of roadway and highway networks until 1971, when The State of Oregon adopted the *Bicycle Bill,* which required the State to allocate 1% of highway funds for the development of bicycle and pedestrian friendly facilities (The State of Oregon, 2010). The Bill required pedestrian and bicycle facilities in all road or highway construction or reconstruction. The *Bicycle Bill* further prompted Portland residents to create the Bicycle Advisory Committee, a citizens' advisory committee, in providing input to bicycle network development. In 1973, a task force comprised of residents developed Portland's first bicycle plan, and subsequently the establishment of the Portland Office of Transportation's Bicycle Program.

In 1996, Portland adopted the *Bicycle Master Plan*, which acted as the guide to city development in promotion of bicycle facilities. The *Bicycle Master Plan* is based on several key objectives focussing on:

- Establishing a complete network of bicycle-friendly routes that connects commercial areas, recreation areas, transit stations;
- Establishing bicycle-friendly routes used for employment commuting;
- Maintaining and improving existing bicycle facilities;
- Providing bicycle parking in areas of frequency;
- Providing showering and changing facilities for commuter cyclists;
- Increasing integrated bicycle-transit usage;
- Providing bicycle education and encouragement; and
- Promotion of the bicycle as a means of transportation to students.

(City of Portland, 1996)

Portland drafted the *Bicycle Master Plan* with input from over 2000 residents, neighbourhood activists, businesses, parents, educators, cyclists and potential cyclists, the Portland Office of Transportation, Portland's transit authority, Portland's port authority, area county officials, the Oregon Department of Transportation, the Portland Bureau of Planning and the Portland Bureau of Parks.

In 2010, Portland adopted the *Portland Bicycle Plan for 2030,* which supersedes the 1996 Plan. The *Portland Bicycle Plan for 2030* updates and improves the former plan by effecting fundamental change to city policy, bicycle facility design, increased bicycle infrastructure network density, and increased programming.

In 1996, Portland saw 2% of travel by bicycle transportation, with 3.3% in the inner city. The *Portland Bicycle Plan for 2030* found bicycle usage increasing to over 25% in 2010. In 1996, Portland's bicycle facilities distance totalled 144 miles (232 kilometres); as of 2008, the directives of the *Bicycle Master Plan* boosted Portland's bikeway total to 274 miles (441 km). The *Portland Bicycle Plan for 2030* aims to further increase the total bikeway facilities distance to 962 miles (1548 km) by 2030. Today, Portland boasts one of North America's most comprehensive bicycle infrastructures and North American cities look to Portland's active transportation models and initiatives for best practices.

Winnipeg shares a similar history with Portland regarding the absence of bicycle travel consideration in early development. Whereas Oregon made a considerable advancement towards active transportation with the *Bicycle Bill* in 1971, Winnipeg only began to adopt active transportation models recently. To date, most of Winnipeg's neighbourhoods developed with a motor vehicle centered approach and had little regard for the cyclist—similarly Winnipeg's policies towards cycling amenities have historically been equally absent. Modern planning recognises the absolute dependence on the automobile and a movement has begun to shift towards building new neighbourhoods that are more pedestrian and bicycle friendly.

Winnipeg's major parks featured recreational trails but outside of the park systems, Winnipeg offered few cycling amenities. Winnipeg had very few cycling trails and on-street cycling lanes were non-existent. Until 1994, Winnipeg infused few initiatives and little funding into bicycle transportation (see Appendix A).

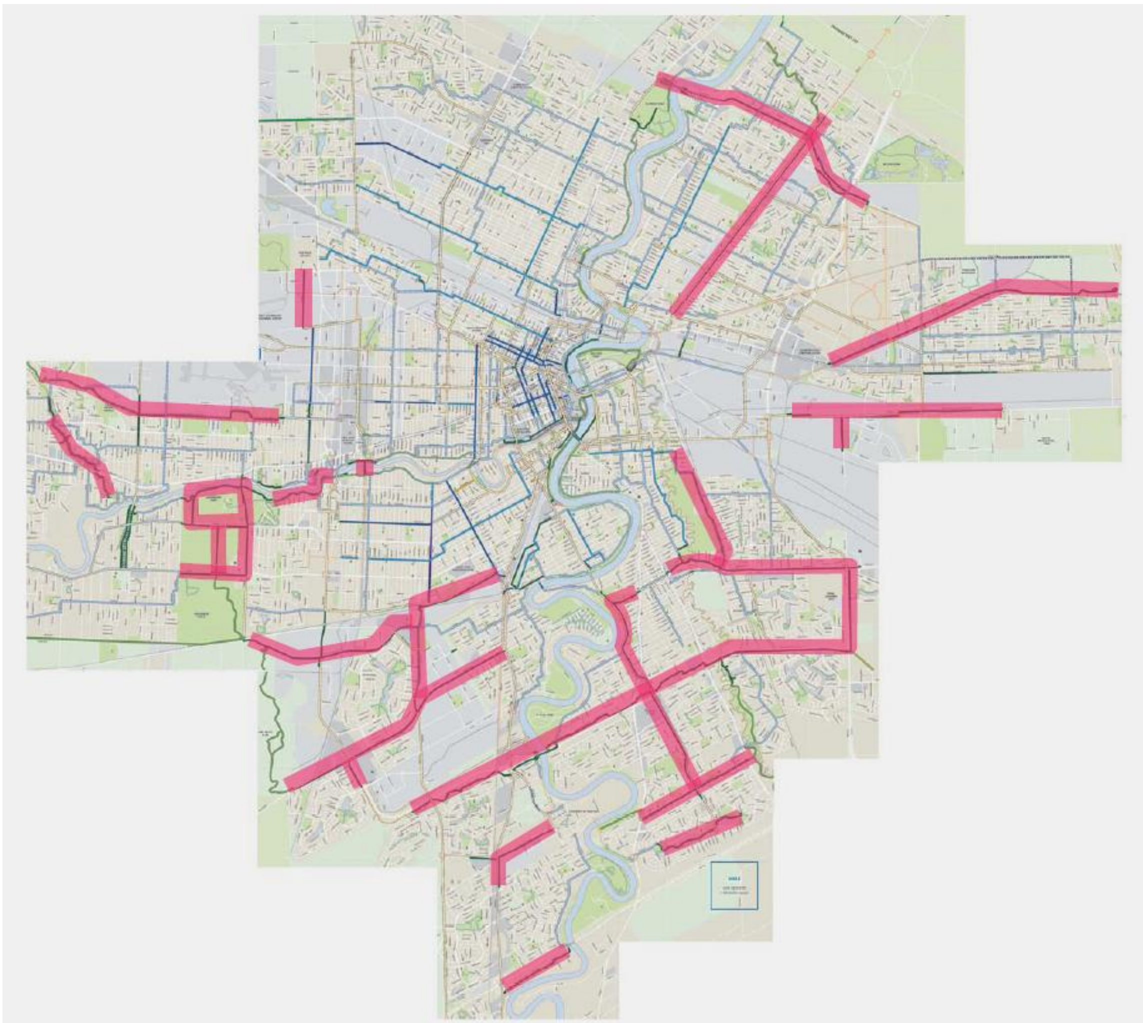
Like many North American cities, Winnipeg invested very little into cycling amenities in the recent past. From 1994 to 2005, Winnipeg's municipal government committed approximately $1 million into cycling facilities. Recently, Winnipeg improved its commitment to cycling facilities with $3.6 million investment from 2006 to 2007. On April 25, 2007, Winnipeg adopted the "Active Transportation Study Implementation Plan," which Winnipeg's municipal government intended to use as a guideline in devising active transportation polices and programs for the city. The Plan calls for Winnipeg to improve cycling facilities by developing a citywide pathway infrastructure that links open spaces and major destinations. Where possible, the bicycle and pedestrian system should be segregated from motorised traffic. The Plan aims to promote cycling as a viable commuting alternative. To implement policies and programs of the Active Transportation Plan, Winnipeg designated an Active Transportation Coordinator and formed an Active Transportation Advisory Committee. The committee consists of members of cycling interest groups as well as various members of Winnipeg's municipal government administration. The committee represents a diverse membership that provides unique and practical input into the development of policies. Key initiatives of the Active Transportation Plan include setting deadlines for action and improving public awareness. In May, 2008, Winnipeg identified an active transportation infrastructure network and adopted a policy to incorporate active transportation facilities into all reconstruction or rehabilitation of components of the network (The City of Winnipeg, 2008a). Winnipeg planned to invest $3 million into the commitment of the Active Transportation Action Plan (ATAP).

The ATAP estimates Winnipeg's active transportation network as of 2008 runs a total of 120 kilometres. The ATAP hopes to increase the total bikeway distance to 450 kilometres by the completion of the action plan. The ATAP's primary initiative intends to establish a north-south spine and an east-west spine that form the skeleton to Winnipeg's active transportation infrastructure, with supporting off-shooting branches.

In December, 2009, Winnipeg adopted an initiative to provide $20.4 million in capital funding to create and improve an extensive active transportation network through Winnipeg. The three levels of government, The City of Winnipeg, The Province of Manitoba, and the Canadian Federal Government provided equal shares of $6.8 million each. This entire active transportation program involved 35 projects that provided bicycle boulevards, trails and bicycle lanes. The program increased the total active transportation network in Winnipeg from 120 km in 2008 up to a projected 375 km upon completion. This includes 149 km of multi-purpose trails, 61 km of neighbourhood paths, 13 km of bicycle lanes, 35 km of sharrows and 16 km of bike boulevards (The City of Winnipeg, 2008a).

Although comprehensive improvements to active transportation initiatives include structural as well as education and promotion, this active transportation endeavour concentrated primarily on physical bicycle facilities. The major components of the active transportation skeletal spines run along the traffic thoroughfares and extend into the suburbs (see Appendix B).

Figure #1: Map of Winnipeg with major multi-purpose trails highlighted



Source: City of Winnipeg Cycling Map

As seen from the map, Winnipeg's newer infrastructure includes off-street trails, which provide comprehensive alternatives to road travel. The south and southeast section of the city features uninterrupted trails that abut the major travel routes. The west and east areas of the city have fragments to the skeletal structure that require connections. Winnipeg's north has few active transportation arteries and has little connection with the skeletal network.

In addition to trails, Winnipeg also includes bicycle lanes and identifies sharrows on a number of streets. These routes mean to augment the major skeleton and provide connections to main destinations.

- Major southwest thoroughfares Roblin Boulevard and Grant Avenue are both identified with cycling sharrows. From south Winnipeg, the Dunkirk Drive-Dakota Street sharrow runs adjacent to the new trail. Regent Avenue identifies sharrows between Panet Road and Plessis Road.
- Winnipeg's north sees an extension of the North Winnipeg Parkway. The North Winnipeg Parkway connects the Chief Peguis Trail to The Forks. The North Winnipeg Parkway includes trails and streets identified as cycling routes.
- Winnipeg also has a bikeway (consisting of a number of different bicycle facilities) connecting the main campus and the downtown campus of the Red River College.

As a hub to the skeleton frame, the city requires good access through the city center and downtown areas. Through Winnipeg's core, a number of bicycle facilities exist, including:

- The Assinboine Bikeway (a cycletrack) runs on Assiniboine Avenue and provides a connection between Osborne Street and Main Street. This connection provides an alternative to the busy east-west streets of Winnipeg's Central Business District (CBD).

- Winnipeg also introduced cycling lanes in its CBD. These cycling lanes run along the one-way streets couplings of Carlton Street and Hargrave Street, as well as Fort Street and Garry Street.
- The WinSmart Pathway connects Osborne Street to a trail system leading to the Norwood Bridge. This important connection provides cyclists with an alternative to the Osborne Street railway underpass, which currently exists as one of the most dangerous cycling access points to downtown Winnipeg.

The Southpoint Pathway further improves connectors to The Forks. The Southpoint Pathway provides an underpass connection from the Riverview and Lord Roberts neighbourhoods to The Forks.

The $20.4 million investment in 2010 added considerable bicycle facilities to the active transportation infrastructure but gaps and areas for improvements remain. The city should connect the gaps between the skeletal frame, as well as improve some of the existing arteries. Different bicycle facilities offer varying levels of benefit and the main skeleton should feature good, solid facilities.

BICYCLE FACILITIES

Bicycle facilities include a number of implementations that are incorporated with motorways to improve travel for the cyclist. Some offer more protection for cyclists while others provide fewer benefits. Bicycle facilities include:

- Off-road trails (or multi-purpose trails), which exist separated and exclusive from the motorway. Trails offer good protection to cyclists since they remove bicycle traffic physically from the presence of motorised traffic.
- Paved, widened shoulders, which normally exist on highways and high-speed travel motorways. Widened shoulders do not separate the cyclist from traffic; they only offer more separation between the travellers.
- Signed bicycle routes are low-traffic streets, recommended and signed for bicycle travel.
- Bikeways are low-traffic streets with modifications to discourage automobile travel and encourage non-motorised modes of transportation.
- Traffic-calming devices, physical inhibitors or barriers mean to slow motorised traffic.
- Shared lanes (sharrows) are wider-than-normal street lanes designed to be shared with bicycles. Signs and on-road symbols indicate the presence of sharrows.
- Dedicated use lanes (diamond lanes), are marked lanes limited to usage for only designated vehicles (bus, bicycle, motorcycle, high occupancy vehicle, etc.).
- Bicycle lanes run parallel to vehicle traffic lanes; they are part of the motorway but dedicated exclusively to bicycle use.

- Bicycle boxes are marked off areas for bicycle occupancy only, meant to allow cyclists to change lane positioning in front of motorised vehicles.
- The Cycletrack (bike boulevard) is a bike lane that is physically separated from motorised traffic lanes and sidewalks. Barriers can include curbs, medians, posts, pylons, or other physical separators.

Bicycle facilities may also include any number of combinations of the cited, incorporated into the same roadway.

Multi-purpose Trails

Trails are paths designed for travel that are physically removed or separated from motor vehicle roadways. Trails permit pedestrian, cyclist, inline skating and other non-motorised travel, but automobiles, motorcycles, mopeds, etc. are prohibited. Trails connect points of interest and often run alongside rivers, major thoroughfares, or through greenways. Trails form the major part of the active transportation skeletal structure and a number of community groups work in conjunction with The City and The Province to cooperate in the continued development and expansion of the backbone. Two off-road trail systems form the skeletal backbone of Winnipeg’s trail system following the city’s two major rivers. The Red River partitions Winnipeg into east and west sections and the Assiniboine River bisects Winnipeg into north and south sections. Winnipeg designed the Riverbank Parkway System to run parallel and on both sides of these rivers; however, the Riverbank Parkway System is not exclusively built on trails; some public roadways connect fragmented segments of the trails. The

Riverbank Parkway System coincides with major sections of the Trans Canada Trail, which covers all provinces and territories of Canada. The Trans Canada Trail runs 81 kilometres through Winnipeg; Winnipeg's trail system totals to 120 kilometres. Recently, Winnipeg made concerted efforts to expand the trail system beyond the confines of the rivers; those developments include trails that run through parks, along major thoroughfares, through residential neighbourhoods and in newly developed neighbourhoods.

Trails preserve open space and make natural landscapes accessible to the public, in addition to facilitating active transportation and providing alternatives to motorways. Cyclists cite off-road trails as the preferred transportation facility (Ortuzar, Iacobelli & Valeze, 2000, p. 356) for a number of reasons. The removal of the presence and influence of vehicular traffic offers the greatest safety and security, and the resultant reduction of risk to the cyclist. Cyclists face fewer distractions and disruptions on trails insomuch as trails circumvent busy thoroughfares and intersections. In addition, cities often build trails along scenic passages that offer scenic alternatives to roadway infrastructures.

As of recent, Winnipeg has experienced a strong movement towards trail-building. Trails form the major component of the active transportation superstructure and are necessarily integral to cycling facilities. However, trails cannot stand alone as conduits for commuter cycling. Because trails avoid major streets and intersections, trails normally add distance between the origin and the destination. Trails weave away from traffic and into scenic zones and areas of interest. Trails appeal to recreational cyclists and fitness cyclists. However, due to commuter cyclists' preferences for shorter distances and less travel times, trails are not as conducive to commuter cyclists' needs (Tilahun, Levinson & Krizek, 2006, p. 88). In fact, most cycling commuters refused to make small deviations from the most direct route. Tilahun, Levinson and Krizek focused on several trail alternatives that ran parallel to the high-traffic, direct routes, and found that cyclists largely preferred the shorter, high-traffic routes. With a common origin and destination, the trail usually has a longer in-between distance than high-traffic roadways, and many commuter cyclists prefer the shortest, most direct route. Consequently, commuter cyclists often disregarded the trail option.

The Distance-tolerance Study

To determine whether Winnipeg's bicycle commuters and Type A cyclists share the preference for shorter distances over the safety offered by multi-purpose trails, we designed a survey for current bicycle users. We also approached Type B cyclists to determine whether the less experienced cyclists also prefer shorter distances over longer but safer routes. For those willing to sacrifice route directness for safety, the study tries to pinpoint the amount of extra distance the two types of cyclists are willing to assume in exchange for safety.

Methodology

We designed the survey to test whether cyclists were willing to add distance to a commute in exchange for a safer route. Since our target participants were Type A and Type B cyclists, the survey partitioned the cyclists according to the self-stated levels of cycling competence. The Type C data was excluded from analyses.

We partnered with Bike to the Future and a number of participating bicycle specialty stores to distribute the survey. Bike to the Future is a bicycle usage advocacy group with a mandate “to make cycling in Winnipeg a safe, enjoyable, accessible and convenient transportation choice year-round,” (Bike to the Future, 2012). Because the desired target audience is experienced cyclists, a bicycle advocacy group is an ideal medium to reach participants. Through Bike to the Future’s membership, we distributed an internet-based survey through their listserv to the members with electronic access. For members without computer access, we distributed paper copies at the membership meetings and the annual general meeting. To further reach experienced cyclists, we enlisted the assistance of local, bicycle specialty shops to distribute the surveys. Experienced cyclists frequent bicycle shops for both bicycles and maintenance reasons.

We intentionally targeted experienced cyclists because we wanted data from participants with an understanding of cycling and distances. Participants responded through paper copies and by electronic/website means. We received 230 responses categorised as Type A cyclists, with 34 responses thrown out. There were 90 Type B cyclists and six were Type C. The Type C responses were not used for this study.

Participants were presented with a starting point and a constant destination in downtown Winnipeg (the MTS Centre at 300 Portage Avenue). We selected several starting points from different extremes of the city. This segment of the survey concentrated on cyclists' tolerance level for additional distances versus traffic volumes. We anticipate that a sizeable percentage of Type A cyclists do not tolerate any additional distances; these cyclists pursue the shortest route absolutely. Of the Type A cyclists who have flexibility in travelling greater distances in exchange for lower traffic volumes and commuting safety, we expect that the results will show a threshold of tolerance for the majority of commuter cyclists. We expect Type B cyclists to have more tolerance to greater distances, and be less rigid in adhering to the shortest route. Some cyclists willingly add distance to their commute in exchange for lower traffic volumes; however, a limit exists in how much extra distance the commuter is willing to take on. The results will also reveal the proportion of cyclists willing to use cycling amenities that Winnipeg implements, if there is a considerable added distance. This information will have direct relevance to the usefulness of Winnipeg's trail system and determine need and placement of future trails. Studies show that commuter cycling increases significantly and positively with increases in cycling facilities; however, the type of facility has considerable effects on commuting habits (Dill & Carr, 2003). Cities have limited budgets, labour and resources and investing in non-optimal facilities squanders those investments. Winnipeg—especially since bicycle facility investment is a newer concept—must invest wisely to maximise encouragement of bicycle usage. Poorly prioritising investments results in wastage and underused outputs. Cities that have a long history of experience in developing cycling facilities have advantages with bicycle facility developments. These cities build on successes and avoid future failures. Winnipeg's entry into cycling facility development relies on best practices of successful cities, and imitative modelling. Many cities that have comprehensively integrated cycling facilities feature different climates, topography, infrastructure and commuting cultures than Winnipeg. How effective cycling facility practices apply to Winnipeg will unfold with local experience. This survey attempts to reveal how Winnipeg cyclists will embrace the recent bicycle facilities improvement initiative. The results will also project direction for future improvements and developments.

The study questions

Respondents were presented with at least two options (up to four options) for routes they would prefer to travel if given an origin and a common destination in the CBD, at the MTS Centre. The survey offered an account of the travel distance, as well as a travel time, based on 20 kilometre/hour bicycle velocity, a comfortable average travel speed for accomplished cyclists. The indicated travel times do not account for stoppages from stop signs, traffic lights or other obstructions. Cyclists have differing habits in obeying traffic laws, including stop signs or traffic control signals. The disparity between a cyclist obeying all traffic controls versus a cyclist disregarding traffic controls, avoiding controls (such as bypassing on sidewalks) or haphazardly obeying controls can vary the estimated time travel greatly. Because of the large number of variables involved with incorporating stoppages to travel times, the question informed respondents that travel time was based on uninterrupted travel. Controlling the stoppage factor standardises time travels for a basis of comparison. The survey question followed with a detailed route description, including a map outline overview of the route (for detailed route descriptions and distances, see appendices 1-6). The maps intentionally showed few details and revealed the shape of the route. Expectedly, the shorter distances appear as straighter lines, and the longer distances appear with zigzags.

Six discrete questions posed options for routes originating from various parts of Winnipeg; the origins covered travel from most major routes from Winnipeg suburbs to the CBD. Winnipeg's major thoroughfares generally provide the shortest link between origin and destination. Designing the study around the major thoroughfares measures cyclists' willingness to depart from the shortest travel route. Each option away from the major thoroughfare represents added distance and time of travel. The plotted options all have a negative relationship between traffic volumes (assumed safety) and distance; that is, the farther the distance, the lower the traffic volumes. Where possible, street traffic volumes were determined according to the *Winnipeg Cycling Map 2009*.

The study intentionally omitted a route originating from central St. Vital to the CBD because of the nature of the neighbourhoods in St. Vital. Being one of the newer neighbourhoods in Winnipeg, the urban design of St. Vital features mostly looped and lollipopped streets. The curvilinear nature of these neighbourhoods offers few alternatives to travel on the major thoroughfares. Where alternatives exist, establishing a lower traffic route involved adding considerable, unrealistic distances. In some areas, finding an alternative route to the major thoroughfare was unreasonable.

The survey also included a check question to determine reliability of answers. All participants were asked the following question: "When you commute cycle, which route do you normally use?"

- The shortest route (regardless of traffic volume)
- The safest route (staying on trails, bike paths and low volume residential streets)
- The most scenic route (detouring through parks and riverbank trails)
- The most convenient route (taking short cuts and jumping onto sidewalks if necessary)

If respondents selected "the shortest route (regardless of traffic volume)" or "the most convenient route (taking short cuts and jumping onto sidewalks if necessary)," and also responded by selecting the longest option in every route question, the data for these questions were omitted. Similarly, if the respondent answered with "the safest route (staying on trails, bike paths and low volume residential street)" and selected the shortest option on every route question, the data from those responses were omitted as well. Not intending deceit, cyclists may have a different ideal of personal cycling practices vis-à-vis de facto cycling practices. Cyclists may perceive safety as a primary concern but concurrently and unintentionally take risks. Similarly, cyclists may value shorter distances but act contrarily when confronted with an example. The check question identifies responses that contradict intention. Where the route questions contrast the check question, reliability of the responses is compromised.

Each route question included a detailed description of the travel route, an overview map, travel time, total distance and description of the traffic volumes. Routes were described according to traffic volumes in the following manner:

- Very high [travel required on main arteries (such as Portage Avenue or Pembina Highway)]
- High [travel required on major streets (such as Henderson Highway or St. Anne's Road)]
- Moderate [travel required on collector streets (such as Talbot Avenue or Sargent Avenue)]
- Low [travel required on residential streets (such as Wellington Crescent or Wolseley Avenue)]
- Minimal (travel required on trails, bike paths, through parks, on riverwalks, etc.)

For all routes, Option 1 was designed to minimise the distance between the origin and the destination. Often, Winnipeg's major streets also represent the most direct route between locations. Option 1 covers routes through high-traffic streets and busy intersections. Option 2 avoids travel on the main thoroughfares if possible but makes use of streets with a considerable amount of traffic. Option 2 attempts to balance a degree of safety without extreme compromise to distance brevity. Option 3 tries to avoid major streets if possible, often by the addition of considerable distances. Option 3 seeks out low traffic residential streets, cycling trails and parks. With a concerted effort to avoid high traffic streets, Option 3 embraces longer distances in exchange for safer travel. Only one origin offered a fourth option. Option 4 takes a deliberate and obvious detour away from the destination to determine how many cyclists are willing to travel away from their destination to use a recreational path (the Northeast Pioneer Greenway).

The six origins included the Royal Canadian Mint, located at 520 boulevard Lagimodière (southeast Winnipeg), Crocus Park, on the corner of Redonda Street and Victoria Avenue East (east Winnipeg), The University of Manitoba, 66 Chancellors Circle (south Winnipeg), The Rural Municipality of East St. Paul, north of Winnipeg from Henderson Highway or boulevard Lagimodière (northeast Winnipeg), Kildonan Park, 2021 Main Street (north Winnipeg), and the Unicity business area, 3635 Portage Avenue (west Winnipeg). These locations connect to most of Winnipeg's major streets that radiate out from the CBD. The planned routes also reach or run through most of Winnipeg's populous residential neighbourhoods.

From southeast Winnipeg to the CBD

The Royal Canadian Mint abuts Fermor Avenue, which acts as Winnipeg's east connection to the TransCanada Highway, and channels traffic from the south St. Boniface and north St. Vital areas to the CBD. The most direct option covers 10.4 km (6.4 miles) and requires all of the travel to be on very high or high traffic streets (although a considerable segment of Fermor Avenue features the

Niakwa Trail). After departing from the multi-purpose trail abutting Fermor Avenue, the remainder of the journey continues on high traffic streets with vehicle parking off rush hours. The second option spans 11.8 km (7.3 miles) and features travel on mostly moderate and low traffic streets. The segments that travel along major routes have separated trails or partitioned cycling paths. The final option includes travel mainly on low traffic, residential streets and runs 13.8 km (8.6 miles). This option follows low traffic routes exclusively but also requires a fair number of right angle turns. The distance increase from Option 1 to Option 2 is 13.5% and from Option 2 to Option 3 is 16.9%. The total distance increase from Option 1 to 3 is 32.7% (see table #1). Respondents were told that travel time for Option 1 was 31 minutes, Option 2 was 36 minutes and Option 3 was 42 minutes.

From east Winnipeg to the CBD

Crocus Park sits in the heart of Transcona and eastern Winnipeg, and abuts Victoria Avenue East. Travelling west, Victoria Avenue splits and one artery marks the beginning of Regent Avenue, which acts as one of the major corridors that channel traffic from east Winnipeg into the CBD. The other major eastern channel runs along rue Goulet, which merges with rue Marion. The options for travel from east Winnipeg to the CBD cover both channels. Option 1 is rated as high traffic and has most of its travel on major roads, including Regent Avenue and Nairn Avenue; the total distanced covered is 14.1 km (8.7 miles). Nairn Avenue also permits vehicle parking off rush hours. The second option rates as moderate-high for traffic volumes and runs along the other major corridor from east Winnipeg, from Dugald Road with an offset to rue Marion. The total distance is 14.7 km (9.1 miles). Dugald Road permits higher speed vehicle travel with sections of unimproved shoulder, which might present extra challenges for cyclists. Option 3 covers 15.8 km (9.8 miles) and rates as a moderate-low traffic route. Most of the travel occurs on residential roads with a segment on Talbot Avenue, which has a moderate amount of traffic. Option 4 takes an intentional initial direction away from the CBD to stay on low traffic streets. A fair portion of the journey runs along a recreational trail (the Northeast Pioneers Greenway) where traffic is minimal. The approach-way to the Louise Bridge is the only section that requires travel on a street with moderate traffic levels. The total distance covers 18.0 km (11.2 miles). Travel times given for Options 1-4 were 42 minutes, 44 minutes, 48 minutes and 54 minutes respectively. The distance increase from Option 1 to Option 2 is 4.3%. The distance increase from Option 2 to Option 3 is 12.1%. The distance increase from Option 3 to Option 4 is 21.7%. The total distance increase from Option 1 to Option 4 is 27.7%.

From south Winnipeg to the CBD

With industrial parks, developed residential neighbourhoods and the University of Manitoba population to feed Pembina Highway, this thoroughfare represents one of the busiest major streets in Winnipeg; Pembina Highway also poses some of the greatest threats to safety for cyclists. Bounded by industrial parks, the Red River and a Canadian National mainline, residents in south Winnipeg – Fort Garry have few options other than Pembina Highway for travelling to the CBD. Moreover, most of the urban grid surrounding Pembina Highway sits diagonally to Pembina Highway, thus offering no parallel alternative. Due to the travel limitations, the survey only offered two options. Option 1 runs along Pembina Highway and rates very high in traffic volumes. The total distance spans 11.6 km (7.2 miles). Option 2 is rated moderate-low for traffic volumes but the route involves some short segments on major streets and intersection crossings. Most of the remaining travel occurs on meandering streets that weave through the residential areas. The total distance covers 14.0 km (8.7 miles). Option 1 was given a travel time of 35 minutes and Option 2 rated 42 minutes. The distance increase between Option 1 and Option 2 is 20.7%.

From north Winnipeg to the CBD

East St. Paul is a rural municipality that lies north of Winnipeg, between the major thoroughfares boulevard Lagimodière and Henderson Highway. Henderson Highway also acts as the major thoroughfare channelling traffic from the entire River East neighbourhood. Option 1 runs directly along Henderson Highway until it merges with Main Street. The traffic volume is high and the travel distance is 10.8 km (6.7 miles). Option 2 takes a small detour away from Henderson Highway and follows the parallel streets in the residential areas. The traffic volume is moderate-low and the distance covers 12.7 km

(7.9 miles). Option 3 takes a considerable detour onto Foxgrove Avenue to take advantage of the Northeast Pioneers Greenway. Travelling along the most of the span of the Greenway, Option 3 provides low traffic influence, until reaching the Louise Bridge landing. The total route covers 13.9 km (8.6 miles) with 6.8 km on the Northeast Pioneers Greenway. The given times to travel are as follows: Option 1 was assessed at 32 minutes; Option 2 was assessed at 38 minutes; and Option 3 was assessed at 42 minutes. The distance increase from Option 1 to Option 2 is 17.6% and the distance increase from Option 2 to Option 3 is 9.4%. The total distance increase from Option 1 to Option 3 is 28.7%.

From northwest Winnipeg to the CBD

Main Street and McPhillips Street are the major thoroughfares channelling traffic from the north Winnipeg – Seven Oaks neighbourhoods. Main Street and McPhillips Street bound a grid development which features predominantly parallel and perpendicular streets. The layout and travel through the areas surrounding Main Street and McPhillips Street have very similar characteristics so the study only focused on travel inbound from Main Street; Kildonan Park exits onto Main Street. Option 1 follows Main Street until it reaches Portage Avenue. The traffic volume is very high and the distance covers 7.0 km (4.3 miles). Option 2 offers a moderate traffic alternative that runs parallel to Main Street. Traffic is low in the residential area around Aikins Street; the street has a few offset breaks. Traffic volume increases with the turn onto Salter Street, which is a narrower street (10 feet width) than generally found in

Winnipeg. Traffic remains moderate after crossing over the Slaw Rebchuk Bridge into the CBD. Option 2 covers 8.2 km (5.1 miles). Option 3 follows Scotia Street along the North Winnipeg Parkway; the route has low traffic volume until reaching Salter Street and the Slaw Rebchuk Bridge. Traffic volume is moderate through the CBD. Travel distance is 9.4 km (5.0 miles). Travel times were assessed at 21 minutes, 25 minutes and 28 minutes respectively from Options 1 to 3. The distance increase from Option 1 to Option 2 is 12.9%. The distance increase from Option 2 to Option 3 is 15.2%. The total distance increase from Option 1 to Option 3 is 30%.

From west Winnipeg to the CBD

West Winnipeg comprises of St. James-Assiniboia and Assiniboia South; St. James-Assiniboia covers territory north of the Assiniboine River and Assiniboia South encompasses territory south of the Assiniboine River. Assiniboia South hosts Assiniboine Park and Assiniboine Forest. Winnipeg features some extensive recreational trails, some abutting the major routes, within this area. Consequently, Assiniboia South was omitted from the study. Concentrating on St. James-Assiniboia, Portage Avenue is the major thoroughfare that channels traffic from west Winnipeg to the CBD. The Unicity Shopping Area abuts Portage Avenue, which carries some of Winnipeg's largest traffic volumes. Option 1 exits Unicity and follows Portage Avenue exclusively to the CBD. Traffic volume is very high and the distance is 12.6 km (7.8 miles). Option 2 avoids Portage Avenue by moving into the residential neighbourhoods. This option has moderate-high traffic volumes as the route passes through Ness Avenue after exiting the residential regions. After crossing the Polo Park area, the route cuts through a low-moderate traffic section until entering into the CBD. The distance covered is 13.8 km (8.6 miles). Option 3 stays in the residential areas and makes use of some riverside trails. Except for a short section of moderate traffic on Ness Avenue and Sturgeon Creek, the route features low-minimal traffic. The distance covers 16.5 km (10.2 miles). The given times of travel for Options 1 to 3 are 38 minutes, 42 minutes and 50 minutes respectively. The distance increase from Option 1 to Option 2 is 12.6%; the distance increase from Option 2 to Option 3 is 19.6%. The total distance increase from Option 1 to Option 3 is 31%. At the time the survey was administered, the Yellow Ribbon Greenway Trail was not yet constructed. Thus, there was no option to include this trail in the study.

Results

Southwest Winnipeg

Measuring the route from southwest Winnipeg (the Mint) to the CBD, 30.4% of Type A cyclists were unwilling to deviate from the shortest route. Of the remaining commuter cyclists, 38.7% were willing to travel an additional 11% of distance. The safest option featured a significant portion along the Trans Canada Trail with most of the travel abutting Winnipeg’s rivers; only 30.9% opted for this option.

Of the Type B cyclists, 22.5% opted for the shortest option, 47.5% opted for Option 2 and 30.0% chose Option 3.

East Winnipeg

Examining the route from east Winnipeg (Transcona) to the CBD, 25.0% of Type A cyclists were unwilling to deviate from the shortest route. Factoring in Option 2, which only added 5% of length to the total distance, 31.7% of commuters were willing to take on the additional travel. The third option added 12% to the journey, which covered 85.7% of total cyclists' tolerances. The final option took a deliberate veer away from the CBD to make use of the Northeast Pioneers Greenway. Only 14.3% of commuter cyclists were willing to follow this route, which added 21.7% of distance from the shortest route to the travel. This was the only journey that offered a fourth option.

Regarding the Type B cyclists, 16.7% of the cyclists chose the shortest route, 30.8% opted for Option 2, 32.1% opted for Option 3 and only 20.5% chose Option 4.

South Winnipeg

From south Winnipeg, with the University of Manitoba as the origin to the CBD, 54.7% of Type A cyclists were unwilling to deviate from the shortest route. Although most cyclists acknowledge Pembina Highway as the most dangerous stretch of road for cyclists, only 45.3% preferred the safer route, which zigzagged on the residential streets adjacent to Pembina Highway. The distance increase of Option 2 was only 20.7%. Even though the option to Pembina Highway only added seven minutes to the travel, 54.7% of cycling commuters opted to travel on Pembina Highway.

Type B cyclists found 35.1% choosing Option 1 and 64.9% choosing Option 2.

North Winnipeg

Detailing the north Winnipeg access from the East St. Paul to the CBD, 42.3% of commuters were unwilling to deviate from the shortest route along Henderson Highway. Option 2 provided a parallel option to Henderson Highway with very few turns; 26.4% of commuters were willing to travel the additional 18% distance associated with this option. The final option offered a convenient ride on the Northeast Pioneers Greenway but only 31.4% of commuter cyclists tolerated the 28.7% distance increase.

For Type B cyclists, 28.6% were unwilling to deviate from the shortest route; 29.9% chose Option 2 and 41.6% chose Option 3.

Northwest Winnipeg

From northwest Winnipeg (Kildonan Park) to the CBD, 43.3% of Type A cyclists were unwilling to deviate from the shortest route along Main Street. Option 2 offered a very straight parallel to Main Street; 22.8% of commuters were willing to travel an additional 17% distance. The final option features a long segment along the Red River as part of the Trans Canada Trail. This option added 34.3% of distance and only 33.9% preferred this route.

Of the Type B cyclists, 25.0% chose the shortest route, 27.5% chose Option 2 and 47.5% opted for Option 3.

West Winnipeg

From west Winnipeg at Unicity shopping locale to the CBD, 48.0% of Type A cyclists were unwilling to deviate from the shortest route along Portage Avenue, one of Winnipeg's busiest streets. Option 2 added 10% to the shortest distance and 22.0% selected this option. The least busy route added a 31% distance increase from the most direct route and 30.0% of commuting cyclists were willing to follow this route.

The Type B cyclists chose the shortest route at 34.2%; 25.3% chose Option 2 and 40.5% chose Option 3.

Discussion

Travelling into the CBD from the various suburbs of Winnipeg offers differing encounters, unique to each suburb. Suburb characteristics varied between suburbs and we expect that this may have been a contributor to the data variations between the suburbs. Winnipeg's expansion focussed on different suburbs during varying time-frames; that is Winnipeg did not grow uniformly out from the CBD. Because of the age differences between the suburbs, the design of the neighbourhoods varies. That is, popular neighbourhood design of the era contributed largely to the look of the neighbourhoods as they emerged. Although much of Winnipeg features the grid design, Winnipeg's newer neighbourhoods have predominant lollipop and curvilinear designs. Neighbourhood design greatly affects real travel distances and perceived travel distances. These differences may impact the cyclist's route choice. As well, because this study was primarily distributed through a bicycle advocacy group, we expect most of the respondents to be active bicycle users. Consequently, there is likely an over-sampling of Type A, which may affect overall totals. Thus, the data includes discrete Type A and Type B analyses.

Of Type A cyclists, we found that 41.0% [with a small standard deviation (SD) of 7.5] were not willing to deviate from the shortest route; however, when offered a fourth option, only 25.0% of the cyclists were not willing to deviate. Similarly, among Type B cyclists, 27.6% were not willing to deviate from the shortest route; however, only 16.7% of cyclists were inflexible with an extra option. Thus, providing more options for cyclists may convince them to move from the busy thoroughfares to bicycle facilities.

Conversely, removing options will more likely propel Type A cyclists onto busy roadways than Type B cyclists. The travel from The University of Manitoba to the CBD only offered two options. Facing only two options, 54.7% (mean = 41.0%) of the Type A cyclists chose the shortest route while only 35.1% of Type B cyclists chose the shortest route (mean = 27.6%).

There exists a population of cyclists that are not willing to add any distance to their shortest possible route, at 41% of Type A cyclists and 28% of

Type B cyclists; for these cyclists, the existence of bicycle facilities would likely have little effect. At the other end of the scale, we also have a population of cyclists who are willing to travel greater distances in exchange for safety. This figure stands at 30.6% for Type A cyclists and 39.7% for Type B cyclists.

Table #1: Travel distances by origin, cyclist type and travel options

	Origin	**Distances (km)**	**Type B Cyclists**			**Type A Cyclists**		
	Mint							
Option	1	10.6	22.5%			30.4%		
Option	2	+11.3%	47.5%	70%		38.7%	69.1%	
Option	3	+30.2%	30.0%			30.9%		
	Crocus Park							
Option	1	14.1	16.7%			25.0%		
Option	2	+4.3%	30.8%	47.5%		31.7%	56.7%	
Option	3	+12.1%	32.1%		79.6%	29.0%		85.7%
Option	4	+21.7%	20.5%			14.3%		
	U of M							
Option	1	11.6	35.1%			54.7%		
Option	2	+20.7%	64.9%			45.3%		
	East St. Paul							
Option	1	10.8	28.6%			42.3%		
Option	2	+17.6%	29.9%	58.5%		26.4%	68.7%	
Option	3	+28.7%	41.6%			31.4%		
	Kildonan Park							
Option	1	7.0	25%			43.3%		
Option	2	+17.1%	27.5%	52.5%		22.8%	66.1%	
Option	3	+34.3%	47.5%			33.9%		
	Unicity							
Option	1	12.6%	34.2%			48%		
Option	2	9.5%	25.3%	59.8%		22%	70%	
Option	3	31%	40.5%			30%		

The location of major bicycle facilities does not matter as much to this population as they are not very sensitive to distance tolerances. For the remainder of the cyclist population, the placement of major bicycle facilities is critical.

Shafizadeh and Niemeier (1997, pp. 86-87) confirm that Type A cyclists have low tolerances for travel to access trails. Cyclists prefer to use off-road trails above all other cycling amenities but accessibility to trails acts as a hindrance to cyclists' usage; off-road trails provide little benefit to cyclists if distance to those trails proves unreachable to cyclists. That is, many commuter riders do not travel on trails because the trails take less direct routes, as well, the cyclists do not want to add the extra distance to travel to reach the trail initially. Shafizadeh and Niemerier concluded that 25% of commuter cyclists used trails where the origin sat within 400 metres of the trail. Within 800 metres, 37% of all commuter cyclists used trails. Over 53% of commuter cyclists found the trail within 1.2 kilometres of the journey's origin acceptable. The authors hypothesised a "bikeshed," of up to 1.2 kilometres within which, commuter cyclists have a tolerance to using the trail.

Our study did not measure necessary distances to access trails; we measured overall distance gains. At 1.2 extra kilometres total, we find an acceptance rate of 68.4% for Type A cyclists and 60.8% for Type B cyclists; that is, 31.6% of Type A and 39.2% of Type B are willing to increase their travel distance by more than 1.2 kilometres in order to use a multi-purpose trail. Because our measurements account for total added distances, while Shafizadeh and Niemeier only account for extra distance to access trails, we expect a greater acceptance rate for our study since the overall distance increases are smaller.

Expectedly, the greater the added distances, the less tolerance the cyclist has for using the trails. Along Winnipeg's south, east and north routes, we lose 20.1% of Type A cyclists per kilometre increased in distance (SD = 1.6). Adding this ratio to the 41% who are unwilling to add any distance, and the 31% who are very tolerant to additional distances, and we account for 92% of the total Type A population. That is, only 8% of the tolerance-sensitive cyclists are willing to add more than 2.2 kilometres of distance to their travel. We lose 23.9% cyclists per extra kilometre (SD = 1.0) of Type B cyclists. Add the 28% unwilling to take on any more distance, and the 40% very tolerant cyclists, and we have a similar 92% value, again leaving only 8% of tolerance-sensitive cyclists willing to add more than 2.2 kilometres of extra distance.

However, Shafizadeh and Niemeier could not find a negative, linear correlation between distance to trail from origin and willingness of usage. The results suggest the influence of other factors upon whether commuter cyclists use trails. Our study finds similar anomalies. Along the western area where the route runs along Assiniboine Park and the Assiniboine River, we only lose 8.1% of cyclists/km. Similarly among Type B cyclists, the western route loses 9.4% cyclists/km, while the remainder of Winnipeg loses 20.1% and 23.9% cyclists per extra kilometre respectively.

We speculate that the cyclists who are willing to deviate from the shortest route, more are willing to deviate in favour of a route through parks and along riverbanks. Some cyclists may travel through parks for a number of reasons, including slower traffic and the presence of green space. Large parks especially can provide an alternative to lengthy roadways. Assiniboine Park dominates a large segment of the travel between western Winnipeg and the Polo Park region. Cyclists preferring to travel through parks over roadways can cover the equivalent of over two kilometres through Assiniboine Park, as opposed to a parallel thoroughfare, such as Portage Avenue or Roblin Boulevard. In addition, the Assiniboine River flows through the entire span from Winnipeg's western boundary to the CBD.

While some cyclists may prefer travel through parks, green space and along rivers, trail construction should keep in consideration that many cyclists are unwilling to take on the extra time required to use recreational trails; the Type A cyclist especially sacrifices the benefits of the trail for the convenience of shorter distances (Krizek, 2006, p. 312). Often, trails that abut major thoroughfares generally do not deviate significantly from the roadway; thus, the added distance is negligible. Consequently, trails that abut major thoroughfares may realise greater usage among experienced cyclists than trails that traverse parks or abut rivers.

The Type B cyclists have a higher preference for trails than the commuter cyclist, aside from the distance factor; Type A cyclists avoid off-road trails for more reasons than simply extra distance. Whereas the Type B cyclist reserves a degree of tolerance for pedestrians, Type A cyclists find pedestrians influence on trails an onerous inclusion (Hunt & Abraham, 2007, p. 463). Insomuch as timely travel stands as the paramount consideration for many Type A cyclists, the presence of pedestrians exposes the speeding cyclist to elements of peril. Indeed, the commuter prefers the isolation of designated bicycle lanes from pedestrians over the isolation of trails from motorised traffic; many Type A cyclists perceive greater risk from pedestrians than motorists. Despite the drawbacks perceived by Type A cyclists with regard to off-road trails, trails remain commuter cyclists' preferred cycling facility. Multi-purpose trails form an important part of the cycling infrastructure but trails alone are not sufficient. The meandering nature of trails imposes additional distances, and for this reason, many cyclists avoid trails. As well, cyclists may incur extra distances to reach a multi-purpose trail.. Although the less experienced cyclist may willingly accept the extra distances, the inexperienced rider eventually becomes the experienced rider, building confidence and comfort on road travel. Those cyclists move away from trail use (Hunt & Abraham, 2007, p. 466). Although cyclists seem to deviate from trail usage as they gain experience, the importance of off-road trails should not be discounted. Trails provide safer alternatives for experienced, inexperienced and novice cyclists, as well as other non-motorised users. In continuing the development of a successful active transportation network, Winnipeg should continue its efforts to build trails along major streets. However, successful active transportation networks include a variety of other bicycle facilities, in addition to multi-purpose trails.

On-street Facilities

Many of Winnipeg's major streets do not have the facility to accommodate abutting trails. To further pro-bicycle infrastructure, street planners may consider on-street cycling facilities. Some options for incorporating facilities onto existing roadways include:

- Paved shoulders
- Designate roadways as cycling routes;
- Bicycle boulevards / prohibit the roadway from all traffic except cyclists and buses;
- Widen curb lanes;
- Designate bicycle lanes with street markings.

Paved Shoulders

Paved shoulders along highways or peripheral city roadways provide a number of benefits to cyclists, motorists and the infrastructure. Many highways experience deterioration through the erosion of the pavement edges; the paved shoulder prevents breakdown of the actual lane surfaces. A considerable amount of breakdown occurs at the side of the roadway and the paved shoulder supports the travelled area. The paved shoulder also provides disabled vehicles a safe area to stop. Disabled vehicles have more stability stopped on paved shoulders, in contrast to gravel shoulders, unfinished shoulders, or roadways with no shoulders. Paved shoulders also offer stability to vehicles that veer off the main road surface. Motorists veering into a gravel shoulder run a greater risk of falling off the road. For cyclists, the attributes of the paved shoulder provides a number of benefits. Travelling on paved surfaces reduces wear on bicycles, and gives the cyclist a smoother ride. Paved surfaces also promote a cleaner ride, free of dust created from gravel shoulders. As well, the paved surface provides better traction and stability for the cyclist. Especially on fast-moving thoroughfares, where large vehicles create considerable wind drafts, the stable traction augments safety for the cyclist. The American Association of State Highway and Transportation Officials (AASHTO) directs that paved shoulders along highways have a width of 1.2 metres (4 feet); this width does not include the measurement of the gutter pan (1999, p. 16). Manitoba's *Transportation Planning Manual* (1998) requires shoulder widths spanning from 0.6 metre (2.6 feet) to 0.8 metre (2.0 feet), depending upon the size or the traffic volumes of the highway. Winnipeg sets no standards to shoulder width requirements. The AASHTO determined that an average cyclist requires one metre (3.3 feet) of width space for safe operation.

Many highways or peripheral roadways have high vehicle speed limits, in excess of 70 kilometres per hour. On the roadways and highways with an abutting trail, gravel shoulders may be adequate to the roadways' construction standards; however, highways and peripheral roadways that have no parallel trail should have adequate paved shoulders to accommodate cyclists. Undeveloped shoulders with high vehicle speeds impose considerable danger to cyclists. Boulevard Lagimodière is the major high-speed north-south corridor in east Winnipeg. The segment from Bishop Grandin Boulevard to Fermor Avenue has an abutting multi-purpose trail, with an extension east to the Sage Creek neighbourhood. This trail was completed in 2011. From the south Perimeter Highway intersection to Fermor Avenue, boulevard Lagimodière was twinned and upgraded in 2008; this segment also includes a paved shoulder. Winnipeg also resurfaced boulevard Lagimodière in 2008 from Fermor Avenue to rue Marion; however, this resurfaced segment continues to have unimproved, granular shoulders. North of rue Marion, on the west side of boulevard Lagimodière, a sidewalk runs adjacent to boulevard Lagimodière, which terminates at Dugald Road; this segment also has gravel shoulders. North of rue Marion, boulevard Lagimodière varies with sections of paved and unfinished shoulders, to the north Perimeter Highway intersection. Currently, no other trail (or other cycling amenity) exists in conjunction with boulevard Lagimodière.

As Winnipeg constructs/improves its major, high-speed arteries, abutting trails often accompany those arteries. Boulevard Lagimodière stands as one of the few high-speed arteries without a continuous, abutting trail, and many segments do not have paved shoulders. As well, a segment of the artery consisting of the boulevard Lagimodière and Kenaston Boulevard transition has no abutting trail; however, this section is currently undergoing major reconstruction and an accompanying trail is anticipated.

Policy implications

All of Winnipeg's major, high-speed arteries should include an abutting multi-purpose trail. Where it is impractical to have an accompanying trail, at minimum, the arteries should feature widened, paved shoulders. The absence of paved shoulders on major roadways encourages sidewalk usage by cyclists. Roadways with one sidewalk increase threat to cyclists and pedestrians by compelling two-directional traffic on sidewalks. Cycling on sidewalks introduces an array of dangers, which will be discussed later. Highways with no sidewalks leave cyclists with only the options of travelling on the road with high-speed traffic or travel on granular surfaces. These travel conditions discourage bicycle travel and increases risk to travellers who wish to cycle. All high-speed (and low-speed) highways and peripheral roadways should have paved shoulders and Winnipeg should act to ensure these roadways have paved shoulders. As stated earlier, AASHTO recommends a paved shoulder width of 1.2 metres but Manitoba's standards vary between only 0.6 and 0.8 metre. Insomuch as the average cyclist requires one metre of width for safe bicycle operation, Winnipeg's highways and peripheral roadways should feature paved shoulders with a minimum of one metre in width.

Signed Bicycle Routes

A number of Winnipeg's streets are designated as bicycle routes, also known as shared roadways. Bicycle routes are purportedly preferred streets for cycling because of design implementations. Signs with a bicycle symbol, and sometimes a direction arrow, signify bicycle routes. Bicycle routes generally have low traffic volumes; these routes connect popular destinations such as parks, shopping districts, businesses or schools. Bicycle routes can also connect fragmented cycling facilities, including trails and lanes.

The AASHTO presents a number of criteria that bicycle routes should follow to ensure safety for cyclists and motorists (2012). Bicycle routes should provide a direct, shortest practical access link between facilities or popular destinations. Similar to trails, if designated bicycle routes deviate excessively from the shortest possible distance, cyclists will avoid using the bicycle routes. Bicycle routes should complement the other cycling facilities where lanes and trails are impractical; bicycle routes should not replace trails or bicycle lanes. Bicycle routes can also work conjunctively with either trails or lanes. Road conditions on designated bicycle routes must have vigilant upkeep; bicycle routes should not have large fissures or potholes and the routes should have smooth and cleared surfaces that are free of debris. Grates and drain/utility covers should be designed to accommodate the narrowest bicycle tire. Road lanes on bicycle routes should be wider than normal street lanes and vehicle parking should be prohibited on bicycle routes. If bicycle routes cross signalised intersections, those traffic signals should have bicycle recognition sensors. Many signalised intersections have pressure sensors that trigger responses in the signal loop as motor vehicles approach. The weight of the vehicle activates the sensor which prompts the signal light to change. Similarly, pedestrian activators on the signal standards trigger the signal loop to change. Cyclists do not have the necessary weight to trigger the road pressure sensors. To activate a signal change, the cyclist needs to move to the sidewalk to reach the pedestrian activator. Bicycle recognition sensors are similar to pedestrian activators, except that the switch sits on a standard that is easily accessible to the cyclist on the roadway.

Winnipeg's current bicycle routes adopted few of the AASHTO's criteria. Winnipeg closes several streets to all motorised (except local) traffic on Sundays and holidays, during sunlit hours, over parts of the spring and autumn seasons, and all of the summer season. These closures include Wellington Crescent, from Sir John Franklin Park to the Maryland Bridge. Winnipeg also closes Wolseley Avenue, from Raglan Road to the Maryland Bridge. The entire length of Lyndale Drive is closed, as well as Scotia Street, from Forrest Avenue to St. Cross Street. However, insomuch as these closures only apply on Sundays and holidays, the street conversions facilitate recreational cycling, rather than commuter cycling. These are the only bicycle routes that close seasonally to most motorised traffic.

In maintaining bicycle routes, Winnipeg purports to take action that improves the cycling experience. Winnipeg's streets are currently undergoing replacement of the utility covers; the new grates are designed to be compatible with bicycle tire travel. An interview with Winnipeg's Public Works Department (personal communication, July 26, 2009), indicated that every new street restoration features bicycle-safe drain grates; however, risk-posing grates are replaced only in conjunction with directly affected street repairs, and large numbers of the risk-posing grates continue to sit on Winnipeg's streets.

Moreover, boulevard Lagimodière underwent complete resurfacing from Marion Street to the southern connection with the Perimeter Highway in 2008; the drain grates used in this resurfacing project are the historically common grates that pose hazards to cyclists. Winnipeg should actively move to replace the remaining threatening grates. More importantly, Winnipeg should obey their own initiatives and install cyclist-friendly grates at all street rehabilitations, as per City directives.

Because a completion date cannot be ascertained to replace all of Winnipeg’s perilous grates, Winnipeg implemented a temporary measure in improving safety at tire-threatening drain grates. Winnipeg’s Water and Waste Department installs bands across the drain grates to prevent bicycle tires from falling into the grate slots.

Figure #2: Banding across traditional drain grates

As evidenced in the photograph, some of these bands are in disrepair. The bands break and no longer act as a viable bridge across the threatening drain grate. The bands may act in other disadvantageous ways. Figure #3 shows bands across a drain grate where both bands are broken and missing across one side of the grate.

Figure #3: Broken banding with accumulated debris

The bands across the other half of the grate function as filters in preventing debris from entering the drainage system. The debris collects on top of the grate and if enough debris accumulates, the debris can become a camouflage, hiding the drain grate underneath. An unsuspecting cyclist travelling over this debris could have the tire fall into the slots and suffer the subsequent consequences. Trapped debris creates an extremely dangerous situation for cyclists. Figure #4 depicts another drain grate with damaged bands.

Figure #4: Broken protruding banding

In this situation, the damaged band protrudes into the air at an inclined angle. In addition to the collected debris, this drain grate has the projecting sharp edge of the broken band adding peril to unsuspecting cyclists. An unaware cyclist could roll over the band and have it puncture a tire. Moreover, a fallen cyclist risks severe injury from impalement due to the protruding band.

Winnipeg should ensure that drain grates do not pose additional threats to cyclists. Drain grates with parallel draining slots pose considerable threat to cyclists but failure to maintain the drain grates and bands exacerbates the existing perils. In an interview with Winnipeg's Water and Waste Department (personal communication, July 26, 2009), we learned that the Department only surveys one particular area, once per year. Most of the damage to the bands result from street cleaning equipment and Water and Waste checks for damage after the spring street cleaning effort. Otherwise, repair to band damage only occurs after public reporting. In addition to the general street cleanings in spring and autumn, Winnipeg should maintain clean curb gutters to allow drain grates to be easily seen. Water and Waste cleans Regional and Priority 1 streets weekly in the summer season but residential—including bicycle routes—are only subject to the general spring and autumn sweep. Winnipeg should maintain clean streets to ensure that the drain grates with bands must be vigilantly maintained to ensure that they minimise risk, not add to it, especially on designated bicycle routes.

The AASHTO recommends wider curb lanes on designated signed bicycle routes; the width should be sufficient to accommodate a cyclist plus a passing vehicle without the vehicle needing to change lanes. If parking is permitted on the street, the curb lane should be wide enough to accommodate the parked car, the door zone, the passing cyclist, and a passing vehicle with no need to change lanes.

Winnipeg makes no provision for wider lanes on bicycle routes. Winnipeg’s residential streets measure either 25 feet (7.6 metres) or 33 feet (10 metres) in width (Winnipeg Public Works Department, 2008). The streets with widths measuring 25 feet accommodate easy passage for two vehicles and narrow passage for three vehicles (two opposing vehicles and a parked vehicle). The AASHTO recommends at least 12 feet (3.6 metres) for the safe passage of a parked car by a cyclist. Winnipeg's residential streets provide adequate space for a cyclist to pass a parked car only if the vehicle parks immediately adjacent to the curb, the vehicle does not have excessively protruding mirrors and the cyclist travels in the middle of the street. Opposing automobile traffic may cause additional risk in reducing space adequacy.

The 33 foot wide streets are designed to accommodate three vehicles, side-by-side, either two parked on both sides of the road or one parked with room for two opposing vehicles to pass easily. Winnipeg does not permit parking on both sides of the road on non-lane demarcated streets. Except where opposing vehicles encounter parked vehicles, these streets provide adequate spacing for cyclists. However, during heavy or congested traffic, a stream of traffic using the middle of the road as a third lane will render the street unsuitable to cycling use at all points with parked vehicles.

A number of Winnipeg's bicycle routes serve adequately as connectors but some of the bicycle routes pose some serious concerns. A specific analysis of Winnipeg's bicycle routes identifies and expands on these deficiencies and concerns.

Empress Street

Winnipeg signed and designated Empress Street as a bicycle route between St. Matthew's Avenue and Saskatchewan Avenue. Empress Street is a two-lane, 33 foot width street that runs north-south, parallel and between St. James Street and Omand's Creek. With St. James Street, Empress Street channels traffic through the busiest retail, commercial district of Winnipeg. Traffic volumes are high throughout the day and considerable congestion occurs during rush hours. Currently, the site of the former Winnipeg Arena abutting Empress Street is under construction; completion of this site is imminent and will increase traffic volumes. Also, the existing stadium faces demolition in 2013, with subsequent retail development expected. Winnipeg prepares major street reconstruction to accommodate the increase in traffic, but details are not yet available.

The shopping complex at Polo Park is the largest and busiest shopping plaza in Winnipeg. St. Matthew's Avenue sits 700 metres from the north end of Polo Park. Prior to the commercial development outside of Polo Park, traffic volumes were likely considerably lower north of St. Matthews on Empress Avenue. The demolition of the former Velodrome on the east side of Empress Avenue coincided with a boom of commercial business developments on Empress Avenue. Currently, commercial operations continue to expand on Empress Street, with a trend to extend northward. In the past, Empress Avenue north of St. Matthew's Road may have been suitable as a preferred cycling route. Presently, Empress Avenue functions as a major access route to the busiest commercial district in Winnipeg and business developments continue to increase. Moreover, Canadian Automotive Association – Manitoba listed Empress Street as the 10th worst road in Manitoba (2012). Because of the poor road condition, and the heavy volume of traffic, Empress Avenue is not suitable as a designated bicycle route.

Policy Implications

As a major street through a very busy commercial district, Empress Street carries heavy traffic through most of the day. Empress Street's widened 33 foot, single lane design permits single file vehicle travel with doubling at major intersections for left turns. Doubled automobile queuing eliminates the safety provided to the cyclist by the widened lane. De jure, the widened lane design provides extra room for cyclists to manoeuvre; de facto, the extra width allows enough space for two motor vehicles to travel side-by-side. Thus, motor vehicles move to the sides of the lane to permit two cars in the widened lane (often to form a turning lane). Instead of a widened lane that affords extra space for cyclists, doubled vehicles leave less room for cyclists. Furthermore, if one of the doubled lanes becomes a turning lane, queues form and wait to turn left, discouraging cyclists from assuming the left turning lane. Consequently, cyclists weave through heavy traffic to bypass the queues.

Traffic volumes and driving configurations produce many challenges for cyclists. Empress Street is not suitable as a signed, preferred cycling route; Empress Avenue should be delisted as a signed, cycling route. Omand's Creek Greenway features a number of fragment trails consisting of segments in various states of development; some of the segments are fully paved and some have gravel surfaces. Between the built trail areas, usage has connected the established trails with worn, dirt surface trails. The establishment of an integrated, developed trail would provide a north-south alternative to travel on Empress Street. Winnipeg should develop and maintain a fully paved trail along

Omand's Creek that carries bicycle traffic through Winnipeg's busiest commercial district. Looking specifically at the Omand's Creek Greenway, a gravel path runs off of the corner of Denson Place and Riddle Avenue. This path crosses over Omand's Creek on a footbridge and connects with a second gravel path that runs parallel to Empress Avenue on the west side of Omand's Creek; the path covers a short distance from Westway Avenue to Rapelje Avenue. A third gravel path connects at the footbridge and runs parallel to Omand's Creek, and terminates northward at St. Matthews Avenue; this path spans the entire length of Alexander Park. No path exists along Omand's Creek in the block bounded by St Matthews Avenue to the south and Ellice Avenue to the north; however, north of Ellice Avenue, another gravel path parallels Omand's Creek and runs to Sargent Avenue to the north. If Winnipeg upgrades this system of gravel paths to paved, multi-use paths, and extends the coverage to include the block bounded by St. Matthews Avenue and Ellice Avenue, cyclists would have segregated path access to the entire business strip along the Polo Park area.

Rue des Meurons

The signed bicycle route on rue des Meurons runs north-south from Rosewarne Avenue to rue Notre Dame. Rue des Meurons is one of three lengthy streets that run through St. Vital north and St. Boniface west, between the Seine River and the Red River. St. Mary's Road and St. Anne's Road are the major thoroughfares running through the district and flank rue des Meurons to the west; residential streets Egerton Road-rue Youville runs parallel to rue des Meurons to the east (along the Seine River). From the Niakwa Trail, a short pathway leads to rue des Meurons's terminus; from there to Marion Street, rue des Meurons is a 33 foot wide bi-directional road. This section of rue des Meurons is a residential street. From Marion Street to boulevard Provencher, rue des Meurons is a four-lane street with no dividing boulevard. This section of rue des Meurons runs through a blend of residential, commercial and light industrial zonings and acts as a transit corridor. Both the undivided section and the divided section of rue des Meurons permit parking, except during rush hours. The parked cars present the usual hazards to passing cyclists.

Because the undivided section becomes a four-lane divided street north of Marion Street, heavier traffic accumulates on the undivided section of rue des Meurons as motorists funnel into the street to continue without having to turn. The four-lane section of rue des Meurons is a moderate traffic street, which becomes heavy during rush hours. Heavy traffic during rush hours and parked cars during off hours renders this section unsuitable as a bicycle route. For the same reasons, the undivided section of rue des Meurons is also unsuitable as a preferred bicycle route.

Policy implications

Starting at its south terminus, Egerton Road runs north and terminates just after Haig Avenue, which provides a connection with rue Youville; Egerton Road and rue Youville run immediately parallel to rue des Meurons, one block to the east. As a deviation from rue des Meurons, this distance difference is marginal. Rue Youville terminates at Gaboury Place. A series of gravel and crushed stone paths originate here and abut the Seine River. These paths continue north to Whittier Park.

Winnipeg should delist rue des Meurons as a marked bicycle route and relocate the bicycle route to Egerton Road – rue Youville. Both these streets have uneven surfaces and deterioration on the road-sides. The road surface conditions should be restored and parking prohibited on these streets. At the rue Youville terminus, the paths should be upgraded to a paved surface and widened to AASHTO standards. A concern lies with the situation of the Seine River path system in that the current paths immediately abut the Seine River. The Seine River meanders considerably through the section bounded by Cabana Place and rue Desautels. This significant detour may dissuade commuter cyclists from following the trails. A connector access can be installed join the trail onto rue Bourgeault at both the north and the south termini, and designating the street into a signed bicycle route (with the accompanying standards of a bicycle route).

Parker Avenue

Parker Avenue is a residential street that is signed as a bicycle route running east-west from Hurst Way to the west, to Daniel Street to the east. This is an important bicycle route insomuch as Hurst Way provides the only access to Waverley Street and the Assiniboine South neighbourhood from River Heights

West, south of the Canadian National Railway (CNR) line. North of Parker Avenue, Taylor Avenue connects Pembina Highway to Waverley Street. However, reaching Taylor Avenue requires traversing the Pembina Highway CNR underpass, which is one of the most perilous chokepoints in Winnipeg. Accessing Taylor Avenue from Waverley Street also presents an obstacle to cyclists: the segment of Waverley Street from Taylor Avenue to Hurst Way is a high-speed corridor that has heavy traffic and no shoulder. South of Parker Avenue, the next access point to Waverley Street is the McGillivray Trail. Insomuch as the McGillivray Trail sits 1.2 kilometres to the south of Parker Avenue (one way), the increase in distance would likely deter commuter cyclists from using this alternative.

Parker Avenue is a 25-foot wide street with no curb, no shoulder and a deteriorating road fall-off. The street surface on Parker Avenue has severe potholes. Deep, lengthy fissures scatter throughout Parker Avenue and the overall surface waves unevenly. The segment of Parker Avenue, west of Planet Street, was resurfaced in 2009 but the rest of Parker Avenue remains unimproved. Stop signs exist at every intersection. The east end of Parker Avenue cuts off at Wynne Street and vehicular traffic cannot reach Pembina Highway. Cyclists travelling east off Parker Avenue need to traverse over a commercial parking lot to access Pembina Highway. Because Parker Avenue sits isolated in a residential neighbourhood—and the east terminus does not reach Pembina Highway—traffic volumes are very low.

Policy implications

Parker Avenue is an ideal location for a signed bicycle route. Isolation within the residential neighbourhood deters vehicular traffic but allows easy access to cyclists. The west terminus of Parker Avenue connects to the Waverley Street Greenway and the Sterling Lyon Parkway. For cyclists, the east terminus of Parker Avenue can access Pembina Highway, which forms a linkage to Jubilee Avenue.

Currently, Parker Avenue is only signed as a bicycle route from Hurst Way to Daniel Street, to the east. Winnipeg should extend the bicycle route to Pembina Highway and build a corridor enabling cyclists and pedestrians to access Parker Street. The all-directional stop signs should be converted to give priority to Parker Avenue. Current maintenance of Parker Avenue only involves patching. Parker Avenue is overdue for reconstruction. Winnipeg should reconstruct Parker Avenue to AASHTO standards for cycling routes, including the prohibition of vehicle parking.

Evaluation

Despite the shortcomings of Winnipeg's bicycle routes, Winnipeg's cyclists express satisfaction with their existence. When asked if cyclists **feel** safer while cycling on signed cycling routes, 67.8% of recreational cyclists replied positively; only 60.6% of commuter cyclists believed that signed cycling routes actually increase safety on the road. Providing reasons behind the perceived added safety enabled by signed bicycle routes, the most common answer found that bicycle sign designations bring attention to motorists' perception that bicycles have a right to use the signed road, and that the road is not exclusively for automobile usage. Consequently, motorists respect the cyclist, allow more room in passing and operate at slower velocities. Although cyclists indicate a level of satisfaction with Winnipeg's signed bicycle routes, Winnipeg should not neglect the deficiencies that these routes have. However, respondents were not asked to differentiate between individual signed bicycle routes. It is expected that cyclists would indicate considerable variance in preferences between cycling routes.

The hitherto cited bicycle routes should receive immediate attention insomuch as they pose risks to cyclists and/or pedestrians. The remainder of Winnipeg's signed bicycle routes have potential to be satisfactory preferred cycling routes; however, comprehensive improvements should occur to bring them to acceptable standards. All of Winnipeg's designated bicycle routes should conform to AASHTO standards. In upgrading Winnipeg's bicycle routes, Winnipeg should replace all hazardous grates, improve surface conditions and prohibit parking on all signed bicycle routes as a first step towards betterment of on-street bicycle facilities and bringing the bicycle routes to AASHTO standards.

Bus-bicycle Shared Lanes

Planners design dedicated high occupancy lanes fundamentally for vehicles of mass transport, primarily buses; these lanes prohibit through automobile passage, although vehicles are permitted a next-intersection turn on the bus-bicycle shared lane. Emergency vehicles are also permitted travel on dedicated lanes. High occupancy lanes may include or prohibit bicycle sharing and they generally sit on the curb side of the street. Bus-bicycle shared lanes have street markings and signs designating their usage; Winnipeg permits bicycle sharing on most dedicated lanes and marks them with a diamond symbol (diamond lanes). The diamond marking appears exclusively on the pavement but posted signs include bicycle images.

High occupancy lanes provide several advantages to bus traffic and sharing these lanes with bicycles purportedly extends the advantages to cyclists. The shared diamond lanes exist in urban high-traffic areas, such as retail hubs and CBDs. Winnipeg's diamond lanes traverse some bridges and some major arteries; Winnipeg has one transit mall, which prohibits all traffic save buses and bicycles. Diamond lanes permit users to pass automobile traffic congestion and expedite travel. Diamond lanes provide priority access to popular destinations that normally experience high levels of vehicular traffic. When properly constructed, cyclists and bus operators express positive outlook on the restricted lane efficiencies (Reid & Guthrie, 2004).

A diamond lane width of 4.5 metres (14.8 feet) provides safe and easy passage of a bus by a cyclist, or a cyclist by a bus, without lateral movement. Diamond lanes should not be less than 4 metres (13.1 feet) in width; diamond lanes that are narrower than 4 metres require a bus to leave the diamond lane in passing a cyclist (Cycling England, 2007). Moreover, as the width of the lane increases, the cyclist travels farther removed from the curb (Harkey & Stewart, 1997, 118); this greater separation provides the cyclist with space to travel clear of curb side debris and drain grates, and offers manoeuvrability from cross traffic encroachment or pedestrian encroachment. The minimum lane width allotment for all streets is 3 metres (9.8 feet). A generally accepted high-occupancy lane width in North American measures 3.6 metres (11.8 feet) in width; a widened curb lane provides a width of 4.5 metres (14.8 feet) (Clark & Page, 2000, p. 79). Winnipeg's diamond lanes have 10 feet widths; Winnipeg's buses measure 8 feet (2.4 metres) wide, with a slight variation between fleet models (Winnipeg Transit, 2008). Whereas a cyclist requires one metre (3.3 feet) of width to travel safely and comfortably, Winnipeg's diamond lanes do not provide adequate facility for either the bus to pass the cyclist or the cyclist to pass the bus, without encroachment into the adjacent or oncoming lane.

Challenges

The standard 10 feet lane functions adequately as a shared diamond lane only if cyclists and buses travel at equal velocities with little need to pass. Studies show that cyclists and buses have comparable average, overall speeds but the speed distribution varies considerably. Whereas cyclists maintain a moderately constant velocity, buses' velocities fluctuate greatly between stops and cruising speeds. Thus the cyclist impedes the bus during the bus's cruising speed while the bus impedes the cyclist during passenger embarking and disembarking. The velocity variation conduces "leapfrogging," where the bus and the cyclist exchange passes at opposing opportunities (DeRobertis & Rae, 2001).

Leapfrogging creates animosity and frustration among bus operators, cyclists and motorists in the adjacent or oncoming lane; bus operators and cyclists build negative views on the other's behaviour (Reid &Guthrie, 2004). If the bus operator runs on schedule or ahead of schedule, the operator will often follow the cyclist contentedly. However, if the bus operator runs behind schedule—a common expectation during rush hour traffic—the inclination is to pass cyclists to make up time. By contrast, the bus that runs well ahead of schedule may opt to idle on the street until the bus resumes proper scheduling. The idling bus leaves the following cyclist with the options of passing in the adjacent lane, passing between the bus and the curb, leaving the street and passing on the sidewalk or waiting behind the bus until it resumes its journey. Cyclists using the shared bicycle lanes often move into the adjacent lane to pass, thus encroaching on the adjacent vehicular lane. As soon as the bus resumes operation, a possible leapfrog situation may result.

From the cyclists' perspective, leapfrogging presents several challenges and risks to safety. As a bus prepares to pass the cyclist, the bus must encroach into the adjacent or opposing lane. Safe cycling practices instruct cyclists to maintain a bicycle position one metre from the street curb. If a cyclist follows the practice of cycling one metre from the curb, the bus operator must encroach considerably into the adjacent lane to overcome the cyclist. If opportunities do not arise for the bus to change lanes, the bus operator has two options. The operator may elect to follow the cyclist, or wedge through between the cyclist and adjacent traffic; this option is only available if the cyclist travels near the curb, well within the suggested one metre separation. Because Winnipeg's ten-foot lane widths do not permit adequate passing space, the bus encroaches on the safety zone of the cyclist. The cyclist faces similar challenges in passing the bus. As the bus stops to load or unload passengers, the cyclist cannot pass the bus on the curb-side because of passenger traffic. The cyclist has the options of waiting behind the stopped bus or passing the bus on the left. Repeated searches for lane-change opportunities negate the advantage of the diamond lane and frustrate both the bus operator and the cyclist.

Cyclists who do not pass buses and wait for the buses until they accelerate, and stop for passenger who embark/disembark, inhale excess emissions generated by the lead transit vehicle, in addition to the normal vehicle emissions. While trailing the bus, the cyclist inhales pollutants from the internal combustion engines continually as they envelop the cyclist who follows. A number of toxins make up the bus pollutants, including volatile organic compounds, carbon monoxide, nitrogen oxides and other particulate matter. A number of factors determine the volume and quality of the pollutants; engine age acts as a significant variable in the make-up of the pollutants. Later generation engines generally produce fewer pollutants while older generation engines were built with less consideration for pollution. In addition to quantity, engine age also determines the quality of pollutants emitted; as the engine ages, the emissions become greater and more noxious. Buses in Winnipeg's transit fleet run an average of 400 000 kilometres before retirement (Winnipeg Transit, 2008). Consequently, much of Winnipeg's current fleet continues to have older generation engines, and those engines continue to age with the associated emission degradation.

The type of driving in which internal combustion engines engage also influences the amount and quality of pollutant emissions. Accelerating from a stop—typical and frequent for a bus travelling during rush hour or in the CBD—drastically increases the amount of pollutants produced (Frank & Engelke, 2005, pp. 202-203). The differing types of pollutants vary with the speed of the vehicle; however, most pollutants show greatest concentrations during initial accelerations. A number of reasons impel people to opt for cycling as a commuting option; many cite improved personal health as motivator to regular bicycle usage. Constant inhalation of bus pollutants at its highest emission presents obvious detriments to the goal of greater health.

In addition to pollutants emitted by buses, cyclists encounter and inhale pollutants emitted by private and commercial vehicles as well. Although the diamond lane permits through traffic for only buses and bicycles, all vehicles are permitted to enter the diamond lanes to make an immediate right turn. Because motorists normally travel at higher speeds than cyclists, motorists often attempt to veer into the diamond lane in front of travelling cyclists. Heavy pedestrian traffic along diamond lanes requires right-turning vehicles to stop fully. The motorist slows or stops to complete the right turn and once again presents the cyclist with the options of slowing, stopping or changing into the adjacent lane. Frequent right-turning traffic conflicts with bus and bicycle through usage, which consequently eliminates the usefulness of the dedicated lane (DeRobertis & Rae, 2001).

Policy implications

Winnipeg first implemented diamond lanes in 1995, and in 2009, expanded the diamond lane program considerably. Primarily during rush hours, diamond lane regulations now exist at the following locations:

- Portage Avenue, from Colony Street to Strathcona Street.
- Main Street, from Jarvis Avenue to Smithfield Avenue.
- Goulet Avenue from rue Tache to rue Youville.
- McPhillips Street from William Avenue to Hillock Avenue.

The new additions bring the total distance to 30 kilometres of diamond lanes in Winnipeg. Shorter segments of diamond lanes also exist, including some across busier intersections and bridges. With Winnipeg's continued efforts to bring more diamond lanes into existence to attempt to expedite transit travel, Winnipeg should also consider cyclists' needs when implementing these dedicated lanes. Prior to dedicating diamond lanes, Winnipeg should ensure that all potential lanes have a minimum of four metres width, to meet safe, mixed vehicle use standards. Creating new diamond lanes that have less than the required criteria exacerbates the existing problems associated with diamond lanes. New diamond lanes should follow established standards and the existing designated lanes that do not meet safe criteria should be adjusted to conform to standards.

Shared Lanes (Sharrows)

Shared lanes are widened lanes designed for vehicles and bicycles to share the lane and permit mutual passing without any interference by either the motorist or the cyclist. Sharrows are identified by road-side signs as well as on-street markings. The markings feature a bicycle symbol, as well as a direction arrow. The center of the arrow acts as an indicator to bicycle tire positioning. Sharrows are designed to provide an on-street facility to cyclists where there is not enough room for a full bicycle lane. The sharrow is normally intended to act as a transitional segment or a connector between facilities. Sharrows are not intended to cover long distances and act as a substitute for bicycle lanes or multi-purpose trails.

Sharrow standards

To design a shared lane, the AASHTO prescribes a minimum of 4.2 metres (13 feet, nine inches) of usable lane width from the edge of the lane marking to the edge marking; usable lane does not include the gutter pan. The AASHTO also prescribes that widened lanes not exceed 4.5 metres (14.75 feet) in width; lanes in excess of 4.5 metres promote side-by-side motor vehicle travel in one lane. In modifying existing lanes, an option lies in the repositioning and narrowing of adjacent traffic lanes to widen the curb lane sufficiently. Narrowing lanes must consider the feasibility and impact to traffic along the narrowed lanes.

If lanes cannot be widened, the Transportation Association of Canada (p. 24) directs shared lane markings (sharrows) be placed in the middle of the lane to signify exclusive, non side-by-side lane sharing in this section; this usage normally runs for short distances and applies to transitional areas (such as the termination of a bicycle lane or the narrowing of a widened lane).

Local applications

Winnipeg has several sharrows that span various parts of the city. Southwest Winnipeg finds a significant stretch of sharrows along Roblin Boulevard and Grant Avenue; both sets of sharrows have an eastern terminus at Chalfont Road. The Grant Avenue sharrow has a total lane width of 12½ feet and the Roblin Boulevard has a width of 13 feet. Grant Avenue and Roblin Boulevard merge at Coventry Road. The merged roadway continues westward as Roblin Boulevard and maintains the 13 feet sharrow to its terminus at Dale Boulevard. The entire length of the Roblin Boulevard sharrow runs 5.3 kilometres and the Roblin Boulevard-Grant Avenue sharrow runs 4.6 kilometres.

Higgins Avenue has a sharrow with a western terminus at Main Street and an eastern terminus at Sutherland Avenue, near the Louise Bridge. The sharrow measures 13 feet in width and runs 1.7 kilometres.

The Regent Avenue sharrow has a western terminus at boulevard Lagimodière and an eastern terminus at Plessis Road. A sharrow on Plessis Road starts at this intersection and runs northward to Kildare Avenue West. The Plessis Road sharrow runs a half kilometre and measures 13 feet in width. The Regent Avenue sharrow totals 3.3 kilometres in distance and varies between 12 feet and 13 feet in width. Over a 2.4 kilometre stretch, the sharrow is also a bicycle-bus only diamond lane during designated rush hours.

Winnipeg's other significant sharrow spans Dunkirk Drive and Dakota Street. The northern terminus sits at the Fermor Avenue and Dunkirk Drive intersection. Southward, Dunkirk Drive becomes Dakota Street and the sharrow terminates at the intersection of Dakota Street and Warde Avenue. The majority of the sharrow measures 14 feet in width, with a short segment north and south of Bishop Grandin Boulevard that measures 12 feet in width.

Bannatyne Avenue, a one-way west street, has a bike lane from Waterfront Drive to Main Street. Crossing Main Street westward, the street no longer has room for a bike lane until after Arthur Street. At this bottleneck, there is a sharrow placed in the middle of the lane, indicated a bicycle use in the middle of the traffic lane. The complementary one-way east street, McDermot Avenue, has similar sharrows placed in the middle of the lane in this block.

Figure #5: Lane middle sharrow

The sharrow in the middle of the vehicular lane indicates a shared lane where the cyclist positions in the middle of the lane. The bicycle waits and travels in the lane with no passing between motorist or cyclist in this lane.

Policy implications

The AASHTO recommends that sharrows measure a minimum of 13 feet, nine inches in width. Except for the Dunkirk Drive-Dakota Street sharrow (at 14 feet), all of Winnipeg's sharrows fall short of AASHTO's recommended specifications. Moreover, the AASHTO recommends that sharrows only be used as connectors and bridges between other bicycle facilities, not as a sustained facility in itself. Some of Winnipeg’s sharrows cover considerable distances and act as a major bicycle facility, rather than a connector or bridge. To address these deficits, Winnipeg should reconfigure the sharrows to ensure that they meet the AASHTO minimum requirements. Where possible, the sharrows should be converted to a more suitable bicycle facility form (trail or bicycle lane) and the sharrow should only be used as connectors where other facility placements are not feasible.

Where sharrows sit in the middle of the lane, motorists and cyclists are not supposed to pass each other. In reality, many cyclists ride to the side of the lane, near the adjacent curb lane with parked cars. Cars pass the cyclists or cyclists weave through stopped cars. The cyclists faces increased danger by moving into the door space of the parked vehicles, and by weaving through traffic. The motorist faces increased risk by passing on narrow lanes, and in heavy traffic. To reduce mutual passing, Winnipeg should introduce signs to accompany the middle of the lane sharrows. The signs direct cyclists to hold the middle of the land, and direct motorists not to pass the cyclists.

Figure #6: Sharrow usage sign

Once past the bottleneck, both motorist and cyclist can assume their dedicated lanes.

Bicycle Lanes

With respect to safety, cyclists prefer to travel on separated trails or paths. The isolation of the trail or path from motor roadways provides the greatest protection to the cyclist from the motorist. In the absence of trails, cyclists prefer travel on residential roads over major and minor arterial routes. Larger roadways carry greater motor vehicle traffic, and often higher speed travel. If compelled to travel on major arteries, cyclists cite segregated bicycle lanes, integrated among motor vehicle lanes, over all other cycling facilities within motor roadways (Stinson & Bhat, 2002, p. 10). Bicycle lanes exist within motor vehicle roadways and prohibit motor vehicle travel, except in marked areas, certain crossings (e.g. to access curb side parking), and transitions. Surface markings act as separations, otherwise, no physical barrier exists between the motor lanes and bicycle lanes; demarcation occurs through a variety of street lines and sometimes differing pavement colouring. Bicycle lanes run parallel to motor vehicle lanes and normally run in the same direction as motorised traffic; however, contra-flow bicycle lanes allow cyclists to travel against motorised traffic. While parallel to the motor lanes, the bicycle lane(s) can be placed in several areas with respect to motorised travel lanes. Bicycle lanes can exist as follows:

- Adjacent to the curb, as the curb lane to the roadway;
- Inside the curb lane, where the curb lane often acts as either a parking lane or a turning lane (or both);
- In the middle of the roadway, as a median to the motorised travel lanes;
- Adjacent to the curb lane, or against the curb, on the left side of the roadway on unidirectional streets.

Each placement has advantages and drawbacks. Bicycle lanes placed adjacent to right curbs allow easy right-turning for the cyclist wanting to move into an intersecting street. However, placing the bicycle lane adjacent to the curb causes conflicts with motorised vehicles wanting to make right turns into intersecting streets. The right-turning vehicle cuts off the straight-through travelling cyclist.

Placing the bicycle lane inside the curb lane (as either a turning or a parking lane) decreases the conflict with turning vehicles, but conflict increases with vehicles or bicycle changing lanes to approach a turn onto an intersecting street. Vehicles turning right must cross over the bicycle lane to access the turning lane, conflicting with the through cyclist. If both cyclist and motorist want to turn right, the cyclist must turn outside the vehicle if maintaining the bike lane. The cyclist must veer beside the curb to turn inside the vehicle. The moment of uncertainty where the bicycle and vehicle re-position causes conflict and risk.

Placing the bicycle lane in the median of the roadway permits easy left turns, but to commit a right turn, the cyclist must change over multiple lanes to approach the curb/turning lane. Moreover, gaining access to the center bicycle lanes requires the cyclist to cross multiple motor vehicle lanes. Also, if both a cyclist and a motorist intend to turn left, the cyclist would end up on the wrong side of the street, unless the intersecting street has a left bicycle lane as well. If a cyclist wants to move to the right side of the street, the same conflict would occur as with both cyclist and motorist turning right.

On-street bicycle lanes require road-sharing and interactions between motorists and cyclists. Although bicycle lanes impose risks to both motorists and cyclists, the lanes also offer numerous advantages.

Bicycle Lane Influences on Behaviour

Bicycle lanes improve travel safety and reduce the potential for conflict between cyclists, and between cyclists and motorists. Road lanes direct the placement of motorised traffic and cycling traffic. Bicycle lanes have the same influence but additionally, bicycle lanes direct placement of motorised and bicycle traffic discretely. Because of the bicycle lane's influence, motorists commit fewer erratic movements, thus causing fewer infringements on adjacent cyclists using the bicycle lane (Hunter, Stewart & Stutts, 1999, p. 72). Motorists veer less often away from cyclists, while passing cyclists. If a motorist veers away from a cyclist to pass, the motorist often encroaches on the adjacent lane opposite to the cyclist. This encroachment may infringe upon another motorist in the parallel lane, or possibly cause a collision with an adjacent vehicle. The veering action may also initiate a cascading series of veers in the succeeding adjacent lanes. A bicycle lane allocates space to the cyclist and provides adequate space for motorists to pass without having to veer in passing cyclists; the motorist does not encroach on the lane opposite to the bicycle lane. Similarly, cyclists maintain travel within the demarcation lines and swerve less frequently. Vehicle widths and parking distances from curbs vary. Consequently, the amount of encroachment a parked vehicle imposes on the adjacent lane also varies. Dependent on how much room a cyclist gives to parked vehicles, the amount of lateral movement by a cyclist will also vary when there is no bicycle lane. The bicycle lane provides a riding zone for the cyclist without having to vary laterally; the bicycle lane provides safe distance removal from parked vehicles. In addition, cyclists travel farther from adjacent parked cars within the confines of a bicycle lane. The extra distance that cyclists give between themselves and parked cars reduces the potential for collisions with car door openings.

Van Houten and Seiderman (2005) conducted a study examining several impacts to the implementation of a bicycle lane; these impacts include vehicle parking habits, cyclists' positions and motorists' positions while travelling.

In examining parked car positioning, the authors determined a baseline of mean distances from parked vehicles to the curbs, using an unmarked road as the basic condition. The study focused on a newly repaved road that bore no markings except the centre line. The study took another set of measurements after an initial line was painted (this would later form the outer line of the bicycle lane). Next, the bicycle symbols and arrows were painted onto the road surface. The study again took measurements. Finally, full bicycle lanes were completed on the roadway and the study took a final set of data. The study found that 85% of car doors open to 9 feet 6 inches from the curb. Allowing for a minimum of six inches of passing room for the cyclist, the door infringement zone established at 10 feet.

With respect to parking positioning, the study found that parked vehicles averaged 6.88 inches (17.48 cm) from the curb on the eastbound side of the street and 7.62 inches (19.35 cm) from the curb on the westbound side. After the initial line was drawn, essentially establishing a widened curb lane, parked vehicles increased curb removal by 3.19 inches (8.10 cm) on the eastbound side and 1.86 inches (4.72 cm) on the westbound side. The addition of the bicycle symbols and arrow symbols caused motorists to park 0.57 inch (1.45 cm) closer to the curb on the east side and 0.58 inch (1.47 cm) closer on the west side. After the bicycle lane was completed, motorists again parked closer to the curb.

The final curb distances showed no significant differences from initial the baseline positioning (p. 17).

Without pavement markings, motorists parked closer to curbs to leave maximal space for travelling traffic. With the outside bicycle lane drawn, the motorists considered curb lane to be a widened curb land and positioned their cars to take up more of the available room in a widened lane; that is, the widened lane becomes a standard parking lane, thus providing more room for the parked vehicle. Motorists take up more room because there is more room available. The bicycle symbol and arrows made motorists aware that cyclists share the lane with parked vehicles and resulted in a reduction in curb distance separation. The full bicycle lane established a limitation to the motorist by creating a smaller parking boundary; this prompted the motorists to give appropriate room to the adjacent bicycle lane or cycling facility.

Van Houten and Seiderman also observed the behaviour of cyclists before and after the painting of markings on the road. Whereas the type of pavement marking influenced motorists in parking removal against curb, the markings showed little effect regarding cyclists' positioning and curb removal; that is, pavement markings did not significantly affect cyclist distance from the street curbs (p. 7). Cyclist positioning relied on the placement of parked vehicles; regardless of the markings on the road, the cyclist left a fixed amount of room between themselves and the parked vehicle. Thus, the positioning of the parked vehicle dictated the position of the cyclist. Although street markings had no direct effect on cyclists, the indirect effect influenced cyclists' distances from the curbs and consequently, distances from the adjacent traffic lane. The closer that the cyclist must ride to moving traffic, the greater is the risk that is imposed to both the cyclist and motorist. Thus, the bicycle lane prompts motorists to park closer to curbs, thus allowing more room for cyclists to ride farther from moving traffic.

Although the parked cars showed no difference in the amount of space between the vehicle and curb, before and after bicycle lane, the presence of the lane reduces the movement of the bicycle. The bicycle also acts as an alert sign to the parking motorists that bicycle traffic may be present.

Van Houten and Seiderman continued their study with a survey of cyclists and motorists. The authors asked the cyclists which facility they preferred and 90% of respondents indicated the full bicycle lane (p. 10). The authors further surveyed motorists and asked what draws their attention to the presence of cyclists. Prior to the road markings, 68% of motorists responded with “nothing.” After the completion of the bicycle lanes, the authors repeated the survey and 42% (the most frequent response) indicated “bike lanes.” Awareness of cyclists impels motorists to use more care and caution while operating vehicles. In addition to moving vehicles, parked motorists also exercise more caution when aware of the presence of cyclists. Motorists exiting vehicles check for the possibility of approaching cyclists prior to opening driver-side doors. The study concluded that bicycle lanes have the dual benefit of imposing safer behaviours and actions on both cyclists and motorists, and improved visibility and awareness of cyclists by motorists.

The Transportation Association of Canada (2007) recommends that bicycle lanes stretch a minimum of 1.5 metres wide on all urban motorways, with adjustments according to catch basin or gutter presences. Both bicycle symbols and diamond lane indicators should appear on the bicycle lane 10 metres from the beginning of the bicycle lane. The bicycle symbol should be one metre in width and the diamond indicator should be one-half metre in width; these symbols should appear every 75 metres (or as conditions require). The bicycle lane demarcation line should measure 100 millimetres in width minimum and run as a solid line. The line should be dashed in areas of transition or high-volume crossing. The dashed line should measure between 100 to 200 millimetres in width, depending on the visibility of the transition. All markings should appear in white, except the contra-directional lines, which should appear in yellow. Contra-directional lines, like dividing lines, indicate traffic travel in the opposite direction; thus, the yellow-coloured paint conforms to the presence of opposite traffic flow. The two common marking materials include paint and thermoplastic pavement markings. Because the lane markings run parallel with cyclist travel, and whereas cyclists potentially spend a considerable amount of time crossing or riding on the markings, both paint and thermoplastic plastic applications should include anti-skid compounds.

Hunter, Harkey, Stewart and Birk (2000) further studied the effect of bicycle lane visibility and cyclist behaviour against safety. The study focused on intersections and the approach to intersections since overwhelmingly, intersections cause the most conflicts and incidents between cyclists and motorists. Thirty-two percent of fatal accidents and 64% of all bicycle-motorist accidents occur at intersections (Wang & Nihan, 2004, p. 2004). Hunter et al. believed that increasing visibility of bicycle facilities in intersections would improve safety and subsequently decrease the number of conflicts; their study involved the introduction of coloured pavement to bicycle lanes approaching and at intersections. Potential conflict sites included areas where motorists and cyclists must interact, either through turning or weaving (lane changing). The bicycle lanes were filled in blue to highlight the bicycle as it interacts near and at the intersection. Blue was chosen because of its effectiveness in other jurisdictions, because of familiarity as a special use area (as with disabled parking), because of detectability by colour-blind individuals, and because of public approval. The study used both paint and thermoplastic applications and neither were found to compromise bicycle traction; because the entire cycling surface was covered with the colour application, road adhesion was critical.

All of the bicycle lanes that approached and entered intersections were painted blue, indicating the path cyclists should follow. Prior to the blue pavement application, 85% of cyclists adhered to the marked bicycle facility through the conflict zone; after the blue pavement treatment, facility adherence increased significantly to 93% (p. 111). The most common deviation from the designated path was a corner-cutting straight travel across the intersection. Prior to treatment, 11% of cyclists slowed or stopped as they approached the conflict zone; after treatment, only 4% of cyclists slowed or stopped. The authors attributed the decline to an increased level of cyclist comfort as they approached the conflict zone. By contrast, 71% of motorists slowed or stopped as they entered the conflict zone prior to treatment; after treatment, 87% of motorists slowed or stopped, approaching or entering the conflict zone, a significant difference. The authors attributed the behaviour to an increase in motorist caution while entering the conflict zone. Furthermore, 72% of motorists yielded to cyclists prior to blue pavement treatment; this number grew to 92% after treatment, another significant change. In measuring actual conflicts—defined as an acute change in direction or speed by either a motorist or a cyclist—the recorded number of incidents was too few to consider significant. Six incidents were recorded prior to treatment, and four incidents were recorded after treatment (pp. 111-112). In interviewing the cyclists after treatment, 58% believed that motorists yielded more to cyclists while 0% believed that motorists yielded less to cyclists; 76% of cyclists felt safer through intersections with blue pavement and 1% felt less safe (p. 113). From interviews with motorists, 70% noticed the blue pavement, and of those, 38% interpreted the coloured pavement to mean “yield to bicyclists” while 43% interpreted the coloured pavement to mean “be careful.”

This study appears to reveal robust advantages to the implementation of blue pavement on cycling lanes; however, it must be noted that the study introduced the blue pavement in conjunction with three novel signs instructing motorists to yield to cyclists. One sign instructed motorists to yield to cyclists while making a right turn across a bicycle lane; one sign instructed motorists to yield to cyclists while changing lanes across a bicycle lane; and the final sign instructed motorists to yield while crossing a perpendicular bicycle lane. The inclusion of these signs definitely confounds the effect of the blue pavement treatment, but the authors have few results isolating the pavement colour treatment versus the signs treatment.

The treatment saw significantly fewer cyclists signal while entering the conflict zone. Although few cyclists signalled prior to treatment (11%), the treatment further reduced those numbers to 5%. As well, significantly fewer cyclists turned their heads and watched for traffic while entering the conflict zone (p. 111). Forty-three percent of cyclists turned their heads prior to treatment and only 26% turned their heads after treatment—another significant reduction. These omissions in action show both an augmented sense of comfort while entering the conflict zones, as well as overconfidence in personal security.

Local applications

Winnipeg's first endeavour towards imposing shared-road symbols and bicycle lanes ended abruptly and unsuccessfully as the pavement markings wore off in a month after their implementation. Winnipeg admitted to experimenting with a water-based paint which could not withstand the erosive nature of traffic on the roadways ("Bike lanes," 2008). In subsequent years, Winnipeg reverted to traditional pavement paints, although traditional pavement paints do not carry much greater longevity, with an expected duration between two to three months. Thermoplastic applications carry much greater lasting power, showing little deterioration a year after application (Hunter, Harkey, Stewart & Birk, 2000,

p. 110). However, the thermoplastic application duration was measured in Portland Oregon and the thermoplastic resiliency may not have the same resistant qualities in Winnipeg's climate. Moreover, the thermoplastic markings carry a considerably higher cost, at approximately 15 fold over the cost of traditional paint application. Regardless of the road marking materials, it is imperative that the markings remain clearly visible on the pavement. Road markings direct traffic flow and in the absence of markings, the bicycle lanes or shared lanes essentially disappear. Especially since Winnipeg's integration with shared lanes and bicycle lanes is relatively novel, motorists may not be familiar with certain streets being established as having bicycle facilities. Although the shared lanes have accompanying signs instructing motorists to "share the road," signs provide instruction on how to interpret street markings; signs cannot act in place of road markings in directing traffic. Signs contribute to motorist awareness of bicycling facility and thus ameliorate the possibility of cyclist-motorist conflict. Portland introduced a series of novel road signs instructing motorists to yield to cyclists, in conjunction with unique street markings, especially in potential bicycle lane conflict areas; the instances of conflict reduced from 0.95% to 0.59% per 100 passing cyclists. Portland also concluded that without the street markings, the signs alone would have caused confusion to both motorists and cyclists (Hunter, Harkey, Stewart & Birk, 2000, p. 115).

Policy implications

Winnipeg has used textured and coloured pavement bands that border pedestrian crossings for many years. Primarily, the coloured bands exist in Winnipeg's CBD, with some limited exceptions. Winnipeg targets high pedestrian volume areas, transit hubs and areas with concentrations of visually-impaired people with coloured and textured pavement. The colour contrast aids people with poor vision and the textured contrast assists people who use canes in feeling and hearing the canes against the edges. Winnipeg has no plans to expand the usage of coloured pavement outside of its present locations or functions, although feature locations of new developments may be considered. The coloured and textured pavement adds considerable initial costs (from $100 to $150 per square metre) and high maintenance costs, which prohibits its ubiquitous usage (The City of Winnipeg, 2008b).

It is neither necessary nor desirable to use textured pavement for bicycle lanes, although textured lane markers at intersections may better direct travel for cyclists, and cause motorists to slow travel. So long as the paint or thermoplastic applications remain visible, users can see the presence of bicycle lanes, although implementing pre-coloured pavement adds a degree of visibility. Moreover, Winnipeg's present bicycle lanes do not cross many difficult-to-navigate intersections. The intersections that cross at right angles do not need special pavement markings to indicate path of travel to the cyclist. The only problematic intersections occur with the northbound connection from Fort Street to Notre Dame Avenue, and the subsequent connection to Albert Street. At the same confluence, confusion arises southbound, arriving from Princess Street, turning eastward onto McDermot Avenue, resuming south at Arthur Street to Notre Dame Avenue, connecting to Garry Street. In both directions, this intersection has challenging connections for both vehicles and bicycles. Moreover, McDermot Avenue and Bannatyne Avenue both carry high traffic volumes over the rush-hours. Establishing continuous bicycle lanes through these areas with blue pavement would provide direction and safety for the cyclist, as well as alert motorists to bicycle traffic through the area. Coloured pavement can provide an added measure of visibility to bicycle lanes, especially in difficult transition areas and should remain a constant consideration when implementing bicycle lanes; however, Winnipeg's primary bicycle lane focus should lie with maintaining the integrity of the bicycle lanes. The road markings should be re-applied before fading to ensure their visibility as bicycle lane markers. Combinations of pavement colouring, road markings and signs should be used in areas of confusion and difficult transitions.

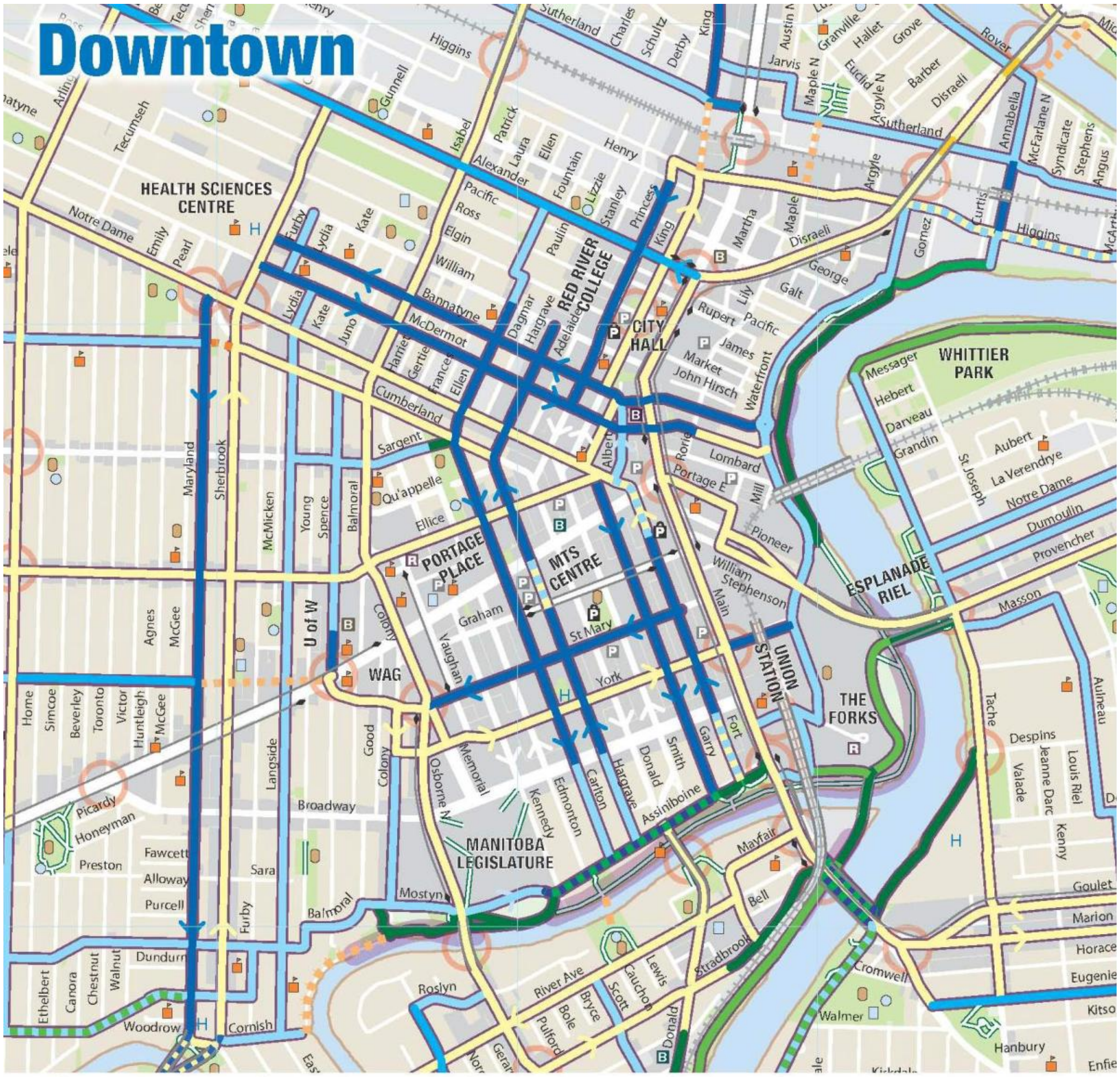
Local applications

In 2008, Winnipeg installed its first set of bicycle lanes, all in the central business district. The majority of the bicycle lines exist on four streets, all of which run north-south on one-way streets. Bicycle lanes on Fort Street and Hargrave Street run from south to north and bicycle lanes on Garry Street and Carlton Street run from north to south. An additional set of complementing bicycle lanes were installed in 2009 on Bannatyne Avenue heading west, from

Princess Street to Sherbrook Street, and on McDermot Avenue, heading east from Sherbrook Street to Princess Street. These bicycle lanes connect The University of Manitoba Children's Hospital and The University of Manitoba Bannatyne Campus to the Exchange District.

The *2008 Active Transportation Action Plan* calls for complete bicycle lanes on the four north-south roadways from Assiniboine Avenue to the south, to Alexander Avenue to the north, except for Hargrave Street, which terminates at William Avenue. The bicycle lanes are complete and intact from Broadway (south) to Portage Avenue (north), except for Hargrave Street, which turns into a sharrow north of Graham Avenue Mall, adjacent to the MTS Centre. From Broadway (north) to Assiniboine Avenue (south), some of the streets maintain as a bicycle lane while some turn into sharrows. North of Portage Avenue, the bicycle facilities are sporadic, some with continued bicycle lanes, some changing to sharrows, and some terminating outright. The *Action Plan* calls for bicycle lanes to run along King Street (one-way northward) and Princess Street (one-way southward).

Figure 7: Winnipeg CBD with bicycle lanes in dark blue



Map Source: City of Winnipeg

Winnipeg's bicycle lanes vary in distance from the curb to the curb-side line of the bicycle lane; this is the area allowed for parking on the curb lane. Van Houten and Seiderman (2005, p. 4) cited a 10 feet minimum for the distance between the curb to the inner bicycle lane marking to provide for adequate room for cyclists to remain outside of the door zone of parked vehicles. Most of

Winnipeg's bicycle lanes comply with the 10 feet curb removal but variability exists in some areas.

Specifically looking at Winnipeg's CBD bicycle lanes, the Fort Street bicycle lane starts at Assiniboine Avenue as a sharrow and remains as such until Broadway. After the Broadway intersection, the bicycle lane begins and provides a 10 foot separation from the curb. The 10 foot separation remains consistent until after the Graham Avenue intersection. In the middle of the block between Graham Avenue and Portage Avenue, the bicycle lane ceases and becomes a sharrow. After the Portage Avenue intersection, Fort Street changes to Notre Dame Avenue and the sharrow continues as a 12 feet widened curb lane until the next block at Albert Street. After the Albert Street intersection, the sharrow discontinues and the cycling facility terminates.

The coupled southbound bicycle lane starts at the Albert Street-Ellice Avenue-Notre Dame Avenue-Garry Street confluence, and extends southward on Garry Street. The bicycle lane on the Garry Street block gives a 10 foot separation. After the Portage Avenue intersection, the Portage Avenue-Graham Avenue bound block gives a nine foot separation. Passing the next intersection into the Graham Avenue-St. Mary Avenue bound block, the separation reduces to eight feet. The next block, bound by St. Mary Avenue and York Avenue, the lane increases in separation back to 10 feet. After the York Avenue intersection, the separation returns to nine feet and remains constant until the termination point at Assiniboine Avenue.

The northbound Hargrave Street bicycle lane commences at Assiniboine Avenue and consistently gives a 10 foot separation until after St. Mary Avenue, where the separation grows to 12 feet. Towards the Graham Avenue intersection, the bicycle lane discontinues and sharrow indicators appear. The block bounded by Graham Avenue and Portage Avenue (along the MTS Centre) exists as a sharrow on a 12 foot shared lane. The bicycle lane re-establishes after the Portage Avenue intersection and leaves an 11 foot curb separation through the blocks bound by Portage Avenue and Ellice Avenue, and Cumberland Avenue and Ellice Avenue. The curb lane then reduces to a 10 foot separation in the block bound by Cumberland Avenue and Notre Dame Avenue. After the Notre Dame intersection, the bicycle lane terminates and a sharrow runs until the termination of Hargrave Street at William Avenue.

The complementary southward bicycle lane starts at the Elgin Avenue intersection and continues on Ellen Street with an 11 foot separation. After the William Avenue intersection, the curb separation reduces to 10 feet and continues with a 10 foot separation. Ellen Street becomes Carlton Street after the Notre Dame Avenue intersection and holds a 10 foot separation until the St. Mary Avenue intersection. The curb lane terminates after St. Mary Avenue and the bicycle lane abuts the curb until the York Avenue intersection. The curb lane re-emerges and leaves an 11 foot separation between the bicycle lane and the curb. The bicycle lane terminates at Broadway.

The bicycle lanes on Bannatyne Avenue and McDermot Avenue run east to west and connect the Health Sciences Centre with Exchange District; both components of the complementary lanes run on one-way streets. The Bannatyne Avenue bicycle lane runs towards the west and commences at Waterfront Drive as its east terminus. The bicycle lane gives a 10 foot curb lane until Main Street, where the bicycle lane terminates, abutting the right curb. The motor vehicle lane to the left of the bicycle lane is a must-turn right lane. West of Main Street, a middle of the lane sharrow exists up to Albert Street. The bicycle lane resumes at Arthur Street and extends to King Street within the block bound by King Street to the east and Princess Street to the west; the bicycle lane leaves an eight and one-half foot, curb lane separation. After Princess Street, the curb lane extends to 12 feet from the curb to Adelaide Street; after Adelaide Street, the separation grows to 12½ feet from the curb to the Hargrave Street intersection. After Hargrave Street, the curb lane contracts to 10 feet in the next block, and further reduces to nine and one-half feet from Dagmar Street to Ellen Street. From Ellen Street, the curb lane returns to a 10 foot separation for two blocks, until Gertie Street, where the separation expands to 11 feet for one block. After Harriet Street, the separation again reduces to 10 feet until Juno Street, where the curb lane further reduces to nine and one-half feet. This separation holds for three blocks until the Furby Street intersection, where the curb lane grows to 10½ feet. The bicycle lane terminates at the next intersection, at Sherbrook Street.

The complementary bicycle lane on McDermot Avenue commences at Sherbrook Street and runs eastward. The entire lane abuts the curb until the Hargrave Street intersection, where a 10 foot wide curb lane begins. The bicycle lane continues for two blocks and terminates at Princess Street, to be replaced by a center lane sharrow.

Outside the CBD, Winnipeg has a number of bicycle lanes, including:

- Church Avenue, from Fife Street to the east, to Keewatin Street to the west;
- Berry Street, from St Matthew's Avenue to the south, to Saskatchewan Avenue to the north;
- Harrow Street, from Pembina Highway to the east, to Wellington Crescent to the west;
- Maryland Street from Notre Dame Avenue to the north, to the Maryland Street Bridge, to the south;
- Cambridge Street, from Taylor Avenue to the south, to Kingsway Avenue to the north; and
- St Matthew's Avenue, from Stadacona Street to Clifton Street, and from Goulding Street, to Banning Street.

Some of Winnipeg's new bridges are built with bicycle lanes or separate active transportation paths, but many of the new bridges and underpasses only feature a shy lane. A shy lane means to give the nearest motor vehicle lane a safe distance from the barrier; it is not intended to be used as a bicycle lane (Manitoba Public Insurance, 2012). Bicycle lanes sometimes lead to bridges or underpasses, and the shy lane can either act as a connector or a termination point. Cyclists should beware to stay at least one metre away from the barrier of the shy lane for safe riding.

Bicycle Facility Discontinuities

Bicycle lanes provide a safer (or perceived safer) means of travel in heavy traffic roadways. Only 10% of cyclists fall into the category of advanced cyclists (or Type A cyclists), who have accomplished skills and experience in cycling, and comfort with cycling on all bicycle facilities and roadways. About 40% of cyclists belong in the casual or inexperienced cyclist (Type B) category (Allen, Rouphail, Hummer & Milazzo II, 1998, p. 29). Many Type B cyclists would not consider cycling on major or busy thoroughfares; however, the presence of a bicycle lane may provide the impetus to travel on an otherwise prohibitive street. Especially for these cyclists, bicycle lanes impose considerable peril if they are incomplete, interrupted, or improperly established.

Krizek and Roland (2004) conducted a study into the impact of discontinuities and best options for the termination of bicycle lanes. The study surveyed Type A and Type B cyclists, and determined the level of comfort or hazard they experienced after traversing a bicycle lane discontinuity; the study did not include input from Type C cyclists. Various factors were tested for significance to determine what caused the cyclist to experience hazard through a bicycle lane discontinuity.

Most bicycle lanes exist on one-way streets, thus providing planners with the options of locating the bicycle lanes on either the left or right side of the street (or both). As well, contra-flow bicycle lanes can also form part of a one-way traffic street. Regardless of the location of the bicycle lane, eventually, the bicycle lane must terminate and the study evaluates three types of bicycle lane terminations, *left side losers, intersection inconsistencies* and *lapsing lanes*.

Left side losers

On streets with bicycle lanes on the left side of the street, the termination of the bicycle lane poses little threat if the street continues to run with one-way traffic and cyclists continue to ride on the left side of the street. However, if the left side bicycle lane terminates in conjunction with the street becoming a two-way traffic street, cyclists must cross all lanes of traffic to continue travel on the right side of the roadway. Similarly, if a cyclist wants to travel on the right side of the road after termination of the left side bicycle lane (because of habitual travel, comfort on the right roadside, or need to make an upcoming right turn), the cyclist must cross all lanes to relocate on the right side of the street.

Although left side placement of bicycle lanes has disadvantages, it also provides several considerable positives. Placing the bicycle lane on the left side of the road removes conflict with transit vehicles. Transit buses always pick up and unload from the right side of the road and left side placement entirely removes the bicycle-bus conflict. Leapfrogging or mutual bus-bicycle delays do not apply inasmuch as the bicycle lane enables either the transit vehicle or the bicycle to pass freely on opposite sides of the street. With right roadside bicycle lanes, conflict arises with the size of transit vehicles where the bus may encroach upon the bicycle lane. Transit passengers as well produce a conflict where unloaded or pre-boarded passengers block bicycle lanes departing from, or en route to the transit vehicle. In addition to bus conflict reduction, left side lane placement also reduces conflict with parked vehicles and the door zone peril. Whereas every vehicle has a driver posing a door zone threat, relatively few vehicles have the same passenger door zone threat; many motorists do not carry a passenger. From the motor vehicle driver's perspective, the cyclist is more visible on the left side of the road insomuch as the driver has a better view of the cyclist and there is no passenger side blind spot to impair vision. Finally, most trucks and other larger vehicles often occupy the right side lanes and encroach less often on cyclist travel (p. 60).

Although left side bicycle lanes provide several bicycle travelling advantages, Krizek and Roland found that the left side loser posed the greatest perceived threat to cyclists as they approached bicycle lane terminations. However, in all save one of the bicycle lane terminations, the left side bicycle lane terminated with a one-way traffic street connecting to a two-way traffic street. In the one exception, the bicycle lane runs as a two-way contra-flow bicycle lane on a one-way traffic street, with contra-flow transit traffic permitted. In all instances, bicycle traffic must cross several lanes to assume a right side curb position after termination of the bicycle lane.

Policy implications

All of Winnipeg's CBD bicycle lanes run on one-way roadways and all flow with vehicular traffic, with two exceptions. First, Ellen Street, between William Avenue and Bannatyne Avenue runs one-way from the north to the south with an 11 foot curb lane on the west side of the street which permits parking. The 5 foot bicycle lane runs parallel to the curb lane and the motorist lane runs in the middle of the road. A second bicycle lane runs on the east-side curb lane and permits contra-flow bicycle traffic travel from the south to the north. The contra-flow bicycle lane terminates at William Avenue, where Ellen Street starts as a two-way traffic street. Bicycle traffic on the contra-flow bicycle lane continues on the right side of the street after two-way traffic begins. Although the bicycle lane ends, bicycle traffic does not cross any lanes to continue travel northward into the two-way section of Ellen Street.

Princess Street's second left (east) side bicycle lane travels southward, starting from Alexander Avenue and terminating at McDermot Avenue, allowing for parked traffic along the eastern curb. This bicycle lane terminates at a one-way to one-way street intersection because Winnipeg's Active Transportation Action Plan (p. 15) (WATAP) hopes to divert southbound bicycle traffic from Princess Street onto McDermot Avenue, subsequently turning south on Arthur Street, and continuing southward on the Garry Street bicycle lane. The intersection with the termination of the bicycle lane on Princess Street shows no indication that the WATAP links the Princess Street bicycle facility with the Garry Street facility through McDermot Avenue and Arthur Street. Without appropriate signage and street marking indicators, cyclists novel to the route will not forecast continuity of the bicycle facility through alternate streets. Those cyclists would continue through Princess Street, unaware that the Transportation Plan intends for bicycle traffic to divert to an alternate route. Moreover, cyclists have a threshold of acceptance for gap size between facilities and forgo the facility if the gap is considered too great (Taylor & Davis, 1999, p. 104). To keep cyclists and motorists aware that a planned bicycle facility exists through McDermot Avenue and Arthur Street, Winnipeg should implement street markings and accompanying signage as indicators.

Excepting the above, Winnipeg's bicycle lanes terminate on the right side of the street, Winnipeg has no left side loser bicycle lanes; consequently, none of Winnipeg's bicycle lanes impose peril on the cyclist in crossing from a left-side bicycle lane at a lane termination, to right side traffic continuance. However, Hargrave Street northbound, Carlton Street, and Garry Street southbound all terminate at an intersection and consequently the bicycle lanes end as well. Whereas these streets do not continue into two-way traffic roadways, relocating the bicycle lanes outside the left curb lane, rather than outside the right curb lane would provide the cyclist with the added protection of the left side lane, without the peril of the left lane losers. Winnipeg should consider relocating the bicycle lane from the right side of the street to the left side of the street.

Intersection inconsistencies

Krizek and Roland categorise the second discontinuity as *intersection inconsistencies*, where bicycle lanes run from the roadway, normally on the right side, and approach a major intersection. The intersection may pose several factors that disrupt a cyclist's movement or cause bicycle and motorist conflict. Examples include (but are not limited to): the termination of a bicycle lane at a major intersection; transition from a bicycle lane to an alternate form of bicycle facility after the intersection; parking introduction after an intersection; or non-standard intersections. In all circumstances, a cyclist unfamiliar with the bicycle facility does not have a clear sense of where, how, or if the bicycle facility continues after the intersection.

The termination of a bicycle lane compels the cyclist to assume lane-sharing after the intersection. If a cyclist turns into a roadway without a dedicated bicycle lane, the cyclist understands and accepts the dynamics of lane-sharing with motorists; however, a Type B cyclist may opt to travel on a given roadway because of the presence of a bicycle lane. The abrupt termination of a bicycle lane after an intersection leaves the cyclist with a sense of being funnelled into traffic and may be compelled into an undesirable cycling situation.

Similarly, if a bicycle facility enters a major intersection as a bicycle lane and emerges after the intersection as an alternate form of bicycle facility (such as a widened curb lane or a shared lane), the cyclist experiences lessened comfort levels insomuch as cyclists view the bicycle lane as the preferred on-street bicycle facility (Stinson & Bhat, 2002, p. 10). Cities use the widened curb lane or the shared lane where the available space for a bicycle lane is inadequate on the roadway (Transportation Association of Canada, 2007, p. 18). Downgrading a bicycle facility reduces the amount of space allocated to cyclists, and subsequently reduces cyclists' comfort levels on the roadway.

While the introduction of vehicle parking does not necessarily reduce measurable cyclist road space, the parked car door zone de facto takes cycling space away from the cyclist. Whereas the Type A cyclist may be familiar with door zone hazards, Type B cyclists may face more peril in a bicycle lane adjacent to parked cars over moving cars.

Policy implications

Winnipeg's curb lanes inside of bicycle lanes vary from eight feet to 12 feet in width. Whereas the distance requirement from the curb to the limits of the car zone is 10 feet, the curb lanes that are less than 10 feet in width are not sufficient to provide adequate safe passing distance for cyclists travelling within the adjacent bicycle lanes. Winnipeg's curb lanes adjacent to bicycle lanes should be reconfigured to 10 feet to provide safe passing distance. Too little room from the curb places the cyclist into the door zone, and too much room gives vehicles the opportunity to squeeze through at congested areas. The bicycle lane section on Garry Street from Portage Avenue to Assiniboine Avenue varies frequently in curb lane width. The width of the curb lane in the block from Portage Avenue to Graham Avenue measures nine feet; the curb lane width of the next block, Graham Avenue to St. Mary Avenue, measures eight feet. The ensuing block from St. Mary Avenue to York Avenue measures 10 feet; the following block from York Avenue to Broadway measures nine feet, which continues at nine feet to Assiniboine Avenue, the termination point. Constantly changing the separation means changing the degree of safety afforded the cyclist, likely without the cyclist's knowledge. Because the cyclist is moved in and out of door zones after each block, the cyclist may not maintain the same degree of vigilance to doors. Those aware of the change in distance may situate in different areas within the bicycle lane, or swerve out of the bicycle lane to avoid the door zone.

Most mid-block conflicts between cyclists and motorists—as a result of cyclist actions—occur because of cyclist swerving (Hunter, Stewart & Stutts, 1999, p. 73). Cyclists swerve for a number of reasons, including lane change in preparation to turn, swerving to avoid unexpected pedestrians, swerving to avoid exiting drivers, or other unexpected intrusions. One of the most dangerous encounters that can befall a cyclist involves a collision with an unexpected car door opening (p. 73). Cyclists establish a sense of comfort (or discomfort) and expectation with travelling on a bicycle lane; changing the parking enabled curb lane width after an intersection changes context for the cyclist and requires a re-adjustment of cycling practice and expectation. Downsizing the curb lane imposes risk to the cyclist, especially if the curb lane changes from 10 feet (such as the St. Mary Avenue to York Avenue block) to 9 feet (the York Avenue block to Broadway). At 10 feet, the cyclist has sufficient clearance from the door zone but reducing the curb lane width after the intersection eliminates the safe door zone buffer and the cyclist may not be aware of the change. Whereas the cyclist on a shared roadway may be alert to potential car door openings, the same cyclist on the bicycle lane may not be alert for door intrusions.

Winnipeg should ensure that all curb lanes inside of bicycle lanes provide a minimum of 10 feet in width to provide adequate door zone clearance to the bicycle lanes. Curb lanes inside of bicycle lanes should also maintain a constant width on the same roadway to maintain consistency for the cyclists and their expectations. Changing the parking lane width creates an unexpected intersection inconsistency for cyclists. As discussed earlier, Winnipeg's curb lanes vary frequently in width, and they should not.

Winnipeg's bicycle lanes also face a number of other intersection inconsistencies. Specifically, the bicycle lane along Hargrave Street between St. Mary Avenue and Graham Avenue features a 12 feet curb lane inside the bicycle lane. As this lane approaches Graham Avenue, the bicycle lane terminates and becomes a shared-lane. The shared-lane measures 12 feet in width and continues through the entire block between Graham Avenue and Portage Avenue; after Portage Avenue, the bicycle lane re-emerges. The 12 feet width does not provide enough manoeuvre room for a motor vehicle and a bicycle to travel side-by-side. The Transportation Association of Canada (2007, p. 18) requires that a shared lane must have a minimum width of four metres (13.12 feet); establishing a shared lane with less width than the minimum requirement jeopardises motorists and cyclists.

Winnipeg has a number of additional intersection inconsistencies, mainly centered around the Portage Avenue and Notre Dame Avenue intersection (including areas surrounding Old Market Square), forming the nexus of Garry Street, Fort Street, Princess Street and King Street bicycle facilities. Pursuant to WATAP, the Fort Street bicycle lane travels northbound through the Portage Avenue intersection and crosses through Old Market Square to connect to the King Street bicycle lane. In detail, a northbound cyclist on the Fort Street bicycle lane would encounter the bicycle lane becoming a shared lane as it approaches Portage Avenue. As the cyclist traverses Portage Avenue, a shared lane symbol appears on North Dame Avenue in a 12 foot wide curb lane. WATAP intends for cyclists to follow Notre Dame Avenue west briefly and subsequently to turn north on Albert Street; however, Albert Street has neither street markings nor signs indicating that it forms part of a larger cycling facility. Moreover, segments of Albert Street are constructed with cobblestones, creating additional difficulty and hazard for cyclists. At Letinsky Place, approaching Old Market Square, the bicycle facility continues for one block along Bannatyne Avenue. This segment of Bannatyne Avenue has a four foot wide bicycle lane. According to WATAP, the bicycle facility on Bannatyne Avenue concludes at King Street, where a bicycle lane begins, to facilitate northbound travel on King Street. To date, no street markings nor bicycle related signage exist on King Street.

In the opposite direction, WATAP recommends that cyclists follow the Princess Street bicycle lane as it runs southbound. At McDermot Avenue, cyclists turn east to reach Arthur Street. As a one-way street, Arthur Street concludes near Garry Street, where cyclists embark on the bicycle lane southbound. No signage nor street markings indicate that McDermot Avenue is a bicycle facility; similarly, Arthur Street shows no indicators. To establish clear and easy-to-follow bicycle facilities as north-south conduits through Winnipeg's downtown, adequate street markings and signage should exist on all bicycle facility routes.

Perhaps Winnipeg's most troubled intersection inconsistency, the bicycle lane at Bannatyne Avenue abuts the curb; left of the bicycle lane, the motor vehicle lane is a must-turn right lane. This merging of straight-through cyclists with right-turning motor vehicles over criss-crossing lanes places both motorist and cyclist into unavoidable conflicts.

Lapsing lanes

Bicycle lane terminations that end with minimal confusion or contrast are called *lapsing lanes*. Lapsing lanes include well-buffered transitions, low traffic roadways; lapsing lanes generally occur in residential neighbourhoods. These lane terminations may include warning signs, advance lane striping, and other indicators alerting cyclists and motorists to the lane termination approach. Cyclists found lapsing lanes a significantly less hazardous lane termination than inconsistent intersections, which was significantly less hazardous than left side losers.

Policy implications

Winnipeg's bicycle lanes have a number of deficiencies. While some of Winnipeg's bicycle lanes terminate benignly as lapsing lanes, a number of intersection inconsistencies have the potential to cause confusion and peril to cyclists and motorists. These lane terminations should be redesigned to have the safety and clarity features of lapsing lanes. At intersections where lapsing lanes are not possible, Winnipeg needs to explore alternate options in ensuring a safe transition from a bicycle lane termination into integrated traffic travel. Where confusing intersections occur, signage, clear road markings, and perhaps coloured pavement can act in conjunction to provide instruction for travel to both cyclists and motorists.

Other bicycle lane termination irregularities

Winnipeg has two cycletracks, one running along Assiniboine Avenue, from the Legislative Grounds at the west, to Main Street at the east. The other cycletrack runs along the southern span of Queen Elizabeth Way, connecting the termini of Main Street and St. Mary's Road, with spur access to Marion Street. A cycletrack runs on both the west and east sides of the bridge. This overpass traverses Assiniboine River at its northern span, and the Red River at its southern span; the overpass forms a major intersection at Stradbrook Avenue between its two spans. The barriered bicycle lanes span the Red River but no bicycle facility exists on the span traversing the Assiniboine River. Both east and west bicycle lanes terminate at Stradbrook Avenue to the north and St. Mary Avenue to the south.

The cycletracks, at all of their termini, merge with the sidewalks as they approach the intersection. The configuration at the merger of the segregated bicycle lanes compels cyclists to embark onto sidewalks at their terminations.

Figures #8 & #9: Cycletrack - sidewalk merger

Both cyclists and pedestrians are expected to queue together at the sidewalk curb while waiting for traffic lights. Northbound cyclists on the east-side cycletrack must wait with pedestrians and cross as pedestrians in order to assume travel on Stradbrook Avenue if the cyclist intends to go westbound on Stradbrook Avenue. Cyclists travelling northbound on the west-side cycletrack must also cross the overpass as a pedestrian to pursue east bound to South Point Park towards The Forks. Because the cycletrack has an unbreaking barrier, the cyclist cannot change lanes through traffic to assume a left-turning lane at the intersection. A similar situation exists at the Main Street, St Mary’s Road bicycle lane termini where cyclists must integrate with pedestrians to access Marion Street eastbound. A four foot width separation flanks both curb side motor vehicle lanes, demarcated with a solid white line.

Policy implications

Cycletracks are one of the safest bicycle facilities available; they completely remove motorised traffic, as well as pedestrian use. However, bicycle lanes should not merge with pedestrian sidewalks as they approach intersections. The 4 foot separation from the motor vehicle lane to the barrier provides adequate space to form an un-barriered bicycle lane. The barrier should terminate with enough room to provide the cyclist opportunity to assume a position on an on-street bicycle lane and manoeuvre into traffic, to the left turning lane if so desired. The northbound bicycle lane termination approaching the Stradbrook Avenue intersection, should have the barrier removed with enough space for the northbound cyclist to shift to the left turning lane, if attempting a westward turn.

The 4 foot curb lane separation exists on both east and west sides of the northern span of the overpass but no bicycle lane exists, barriered or integrated. Northbound cyclists disembarking from the southern span of the overpass must exit the cycletrack and continue northbound on either the sidewalk, the 4 foot curb separation, or the bicycle-transit shared lane. A 4 foot separation already exists between the curb lane (bicycle-transit shared) and the sidewalk barrier. If the transit lane moves to curb and leaves no separation, and the remaining motor vehicle lanes shrink slightly, the 4 feet separation can expand to a 5 feet demarcated bicycle lane (without a barrier). Placing this bicycle lane outside of the dedicated transit lane would eliminate bus-cyclist conflict and leapfrogging.

Other bicycle facility termination irregularities

The Niakwa Trail runs from its east termination point at Niakwa Road East to St. Anne's Road. The trail terminates at St. Anne's Road and a frontage road runs parallel to the Fermor Avenue from St. Anne's Road to St. Mary's Road. West of St. Mary's Road, no bicycle facility exists for 250 metres, after which the trail begins again at St. Vital Memorial Park. Over the 250 metres stretch where no bicycle facility exists, Winnipeg encourages cyclists to share the sidewalk with pedestrians.

Figure #10: Pedestrian / Cyclist sidewalk share

The portion of the sidewalk that encourages shared bicycle usage fronts the Glenlawn Collegiate Institute and the YMCA-YWCA of Winnipeg. At its narrowest point, the sidewalk edge of the tree well to the street curb only provides 1.9 metres (76 inches) of width.

Figure #11: Sidewalk in front of school

Policy implications

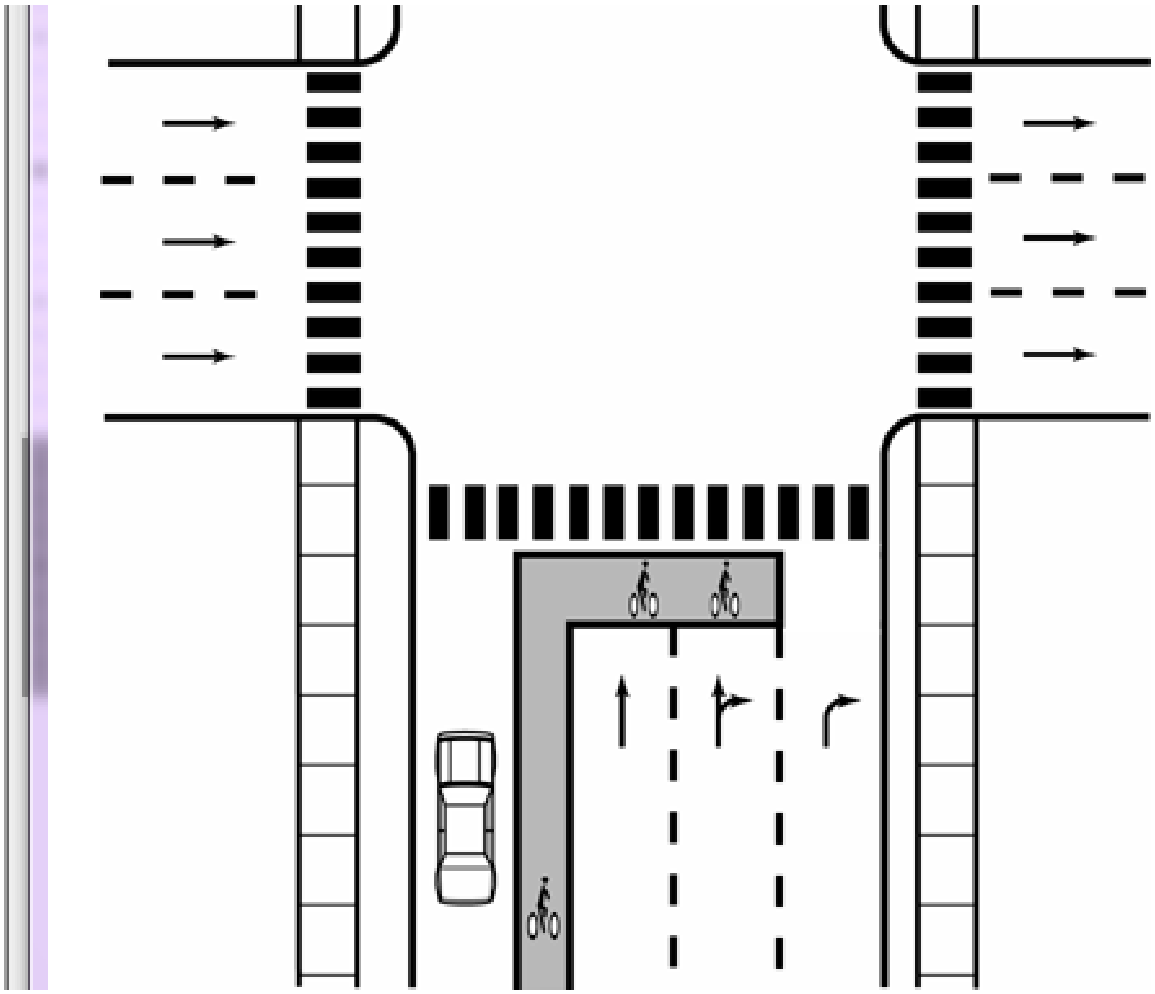
Cyclists should not share sidewalks with pedestrians. For multi-purpose trails, AASHTO requires a minimal width of 3.05 metres (10 feet). The sidewalk at this transition only provides 1.9 metres width. There is not enough for bicycle-shared use. Encouraging cyclists to use sidewalks imperils both the cyclists and the pedestrians. Especially since the sidewalk fronts two institutions with high occupancies, and populations of all ages, cyclists impose dangers to pedestrians, and pedestrians impose risk to cyclists. This is a very dangerous transition. Alternatives should be found to connect the fragmented trail. Insomuch as Fermor Avenue provides a cut-in curb lane for passenger drop-off and pick-up, establishing a bicycle lane through this area may impose frequent conflicts. Narrowing the sidewalk and establishing a cycletrack through the fragmented portion of the Niakwa Trail would provide a conduit that is safe for cyclists, pedestrians and area building occupants.

Bicycle Boxes

One of the major challenges facing cyclists travelling on a right side bicycle lane trying to execute a left turn is crossing over several lanes of traffic to assume a left-turn lane. Similarly, a cyclist travelling on a left side bicycle lane must cross several lanes of traffic to perform a right turn. Left side lane cyclists must also cross lanes of traffic when confronting a left-side loser. Eugene, Oregon devised a solution that addresses these bicycle lane deficiencies in 1998. Bicycle boxes exist at intersections in between the intersection stop line and the motor vehicle stop line. Bicycle boxes provide opportunity for cyclists to manoeuvre, change lanes or position in front of motorised traffic that waits at a traffic light.

Bicycle boxes eliminate the need for cyclists to cross though heavy traffic in order to change street positioning.

Figure #12: Bicycle box design



(Hunter, 2000)

This diagram shows a one-way street with the bicycle lane positioned on the left side of the road, outside the parking lane. This configuration is similar to the bicycle lane on Princess Street, southbound, approaching Bannatyne Avenue. The bicycle box provides the cyclist free movement to the right side of the street to execute a right turn. If the Princess Street intersection supported a bicycle box, cyclists would be able to freely manoeuvre from the Princess Street Bicycle lane to the right of the street, then onto the

Bannatyne Avenue bicycle lane, to proceed westward. Figure #11 shows a bicycle box overlaid to the corner of Portage Avenue and Main Street.

Figure #13: Bicycle box overlay on Portage Avenue and Main Street

Without a bicycle box, an eastbound cyclist wanting to make a left turn northward onto Main Street from the right lane on Portage Avenue needs to cross three lanes of right turning and through lanes to access the left turning lane. A bicycle box enables the cyclist to reposition to the left turning lane in front of stopped traffic. The cyclist then proceeds to Main Street northward on the rightmost bus/bicycle shared lane.

The Transportation Association of Canada (2007, p. 59) recommends that bicycle boxes have a depth of four metres, and greater depth where high volumes of cyclists exist; four metres provides enough space for one bicycle row plus adequate separation from cross traffic and queued traffic. The increased width size also augments cyclist visibility to motorists. The bicycle box should span all lanes of traffic and have a stencilled bicycle lane marking in front of each lane of traffic. Motor vehicles turning right at a red signal light interfere with bicycle box operation and thus, no-right-turn-on-red limitations should exist at all bicycle boxes. Moreover, to avoid left lane obstruction (especially if there is no dedicated left turn lane), an advance left turn signal should also exist. Signs should clearly indicate a stop line to motorists and additional wording, such as “except bicycles” should be added to indicate an advanced stopping line for cyclists. A public education system should exist to alert cyclists that the bicycle box functions in facilitating lane changing and position. The education initiative should also alert motorists that cyclists have a right to occupy these spaces and move in front of motorised traffic.

Hunter (2000) studied the effects of bicycle boxes after their initial implementation in Eugene, Oregon. The study observed behaviour prior to, and after the implementation of bicycle boxes, as well as administered a survey to cyclists using the bicycle boxes. Because the authors conducted this study when bicycle boxes were a novel introduction, some of the basic designs and configurations of the boxes may vary slightly from present, refined designs. The authors do not believe that design refinements and modifications during the study affected the results in any meaningful manner.

Results showed a number of advantages enabled by the bicycle boxes, the primary advantage being the improvement to cyclist safety in changing lanes.

Prior to the bicycle box introduction, many cyclists weaved through traffic to cross over lanes. Some cyclists aggressively exercised their lane crossings while other cyclists crossed the intersection while the traffic light remains red to change lanes ahead of motorists. Cyclists also timed traffic light changes to out-accelerate motor vehicles. Timid cyclists stopped completely in the bicycle lane and waited for an opportunity to cross through traffic, which either impedes other cyclists or causes cyclists to leave the bicycle lane to pass. Passing outside of the bicycle lane caused the passing cyclist to either encroach on traffic in the turning lane, or through traffic on the motor vehicle lanes. Cyclists also passed in front of traffic that queued behind the red traffic light. This movement often puts cyclists into the path of pedestrians crossing at the perpendicular. The bicycle box provides a safe and legal access to the far lane across from the lanes of traffic (p. 99) and suppresses the cited, less safe manoeuvres used to cross lanes. Motorised traffic faces little impediment from the bicycle box since cyclists generally accelerate at a fairly rapid rate to clear the bicycle box.

Although bicycle boxes provide greater safety and buffering for cyclist-motorist interaction, both motorists and cyclists have complaints about bicycle boxes (p. 103). While many cyclists accelerate quickly, some at a comparable initial pace to motorists, many cyclists may not exercise a rapid acceleration across the intersection and onto the continuing lane to move out of motorists' travel path. Slow-accelerating cyclists cause frustration to following motorists. Another motorist complaint about bicycle boxes involves the removal of legal turns on red signal lights (primarily right turns, since one-way to one-way left turn on red permissible intersections will likely not require a bicycle box). Prohibiting red signal light turning is essential to the function of bicycle boxes insofar as cyclists must have uninhibited freedom to move between the curb lanes to allow for proper lane changes. Motorists perceive restrictions to red signal light turns as inconvenient and delaying, especially at intersections where previously legal red light turns are outlawed to install a bicycle box.

Cyclists' complaints about motorists' actions involve improper intrusion into the bicycle box (p. 103). Motorists may not recognise the requirement to stop before the intersection and observe the bicycle stop line as an all-traffic stop line. Other motorists may intentionally infringe into the bicycle box because the motorists do not want cyclists to position in front of them at the traffic queue. Motorists may also ignore the prohibition of red signal light turns and proceed illegally. This dangerous manoeuvre puts cyclists in peril as cyclists expect freedom of movement within the bicycle box without interference of automobile traffic, until a green traffic light releases movement. Experienced and especially aggressive cyclists will move freely within the bicycle box, often without checking for the presence of moving motor vehicles. Bicycle boxes may also present problems for timid cyclists insomuch as timid cyclists may be apprehensive or unwilling to manoeuvre in front of motor vehicles in the traffic queue. If timid cyclists do not use the bicycle boxes, they continue to face the challenge of moving from one side of the street to the opposite side. While bicycle boxes improve travel and safety through intersection transitions, room exists for improvement.

Bicycle boxes can be further improved with multi-advancing traffic signals. Similar to existing transit-priority signals, dedicated bicycle signals permit cyclists to clear intersections while motorised traffic holds behind the stop line. Staggered signal release permits cyclists to free access in negotiating desired positioning and lanes without the need to jostle with motor vehicles. After the second signal releases motorised traffic, bicycle traffic has already assumed travel beyond the perils of the intersection. Although bicycle boxes can introduce some unique challenges to cyclist and motorist movement, the overall effect of bicycle boxes provides enhanced safety for cyclist movement.

Summation

Bicycle facilities can be used to provide safe cyclist access to most urban destinations. Cities with well-developed bicycle facilities have good integration and access to the roadway infrastructure, as well as destination points. Winnipeg is very young in its bicycle facility development. The active transportation skeletal structure has a sound foundation but more effort needs to be made to connect fragmented parts and complete the whole skeleton. Other bicycle facilities should be expanded and developed to properly augment the skeletal superstructure. Cyclists should be able to access most parts of the city without facing unreasonable risk. Bringing all of the bicycle facilities to established standards is crucial before continuing to develop. Furthermore, all future developments should conform to industry standards; substandard facilities should not be built. Facilities need to conform to standards to provide adequate safety to all users.

CYCLIST SAFETY

Traffic safety for all public roadways users should stand paramount in the design, development and implementation of transportation conduits. The physical construction of roadways, the traffic laws that regulate their usage, as well as the behaviour of the roadway users, contribute to affect roadway safety. Planners and engineers should design roadways to allow for safe travel; legislators must ensure that travellers use the roadways in a safe manner; and users must assume responsibility for safe operation and travel. As vehicle volumes increase, infrastructure development responds by increasing vehicular travel efficiency, capacity and increasing permitted travel speeds. As traffic volume and speed increases, the risk to roadway safety also increases. Enhancing roadway safety for cyclists and pedestrians often go neglected in the expansion of infrastructure (Environmental Working Group, 1997, p. 14). While many new roadway, and existing infrastructure retrofits include provisions for active transportation travel, many roadways remain incompatible for shared motor vehicle and bicycle usage. Bicycle usage and roadway incompatibility creates hazardous situations to the motorist, and often dangerous situations to the cyclist (VTT, 2001, p. 7). Planners and engineers should design future roadway projects with continued regard for safety to all users, but emphasise more safety for vulnerable users.

Roadway safety programs purport to protect a variety of users, including pedestrians, cyclists, motorists and public transportation vehicles. For a number of reasons, pedestrians and cyclists encounter greater travelling risk on roadways than motorised vehicles. The obvious factor lies with the physical size of the vehicles. Motor vehicles carry much more mass than either pedestrians or cyclists. The momentum generated by vehicle motion can easily cause serious or fatal damage in collisions against pedestrians or cyclists. Car companies design and construct vehicles with concerted consideration for driver and passenger safety. Modern vehicles act as protective shields that envelop the occupants and protect them from impact. Modern vehicles are also designed to enhance well-being outside of the vehicle in case of accident. Despite improvements in safety design, cyclists and pedestrians face considerable disadvantage if involved in collisions with motor vehicles.

Improved vehicle safety measures decrease occupant injury and fatality rates. On the surface, this trend appears to have many positive implications; however, unanticipated negative implications also arise from enhanced vehicle safety. As motorists perceive greater personal safety, some motorists execute more jeopardous driving manoeuvres; the driver’s heightened perception of personal safety and invulnerability encourages greater risk-taking (Freund & Martin, 1997, p. 174). While increased vehicular protection provides better safety for vehicle occupants, pedestrians and cyclists encounter greater vehicular hazards on the shared roadways when motorists engage in riskier driving. Whereas pedestrians normally interact with motorist traffic only at intersections and crossings, cyclists share the entire road with motorists. Cyclists face greater risk to injury on the roadways than all other road users, including motorcyclists (Schramm, Rakotonirainy & Haworth, 2008, p. 115).

Despite reporting the greatest rate of injury per capita among road travel, the number of actual motorist-cyclist accidents remains under-represented (OECD, 1997). Most accident data comes from reported accidents and injury calls for service; the accidents that cause no motor vehicle damage and have no injury call for service, often go unreported. Automotive insurance companies also record incidents involving bicycles; again, if a vehicle sustains no damage, or minor damage where the driver does not report a claim, records reflect no accident occurring. Accident data can also be gathered through hospital admittance—similarly, minor accidents requiring no hospitalisation will not appear in the tracking of accidents. Looking at incidents that go unreported, an OECD study shows that accident reporting occurs 100% of the time when a cyclist fatality occurs. The rate of reporting drops to an average of 33% when a cyclist encounters a serious accident. The study defined a serious accident as one that involves a hospitalisation involving fractures, concussions, serious cuts or lacerations. Rates of reporting drop to 21% when dealing with slight injuries. A slight injury involves minor cuts, bruises and other injuries not reported under serious injuries. The study concludes that bicycle accident statistics only account for 22%–34% of all cyclist injuries (p. 88). We need better tracking methods to provide a true indication into the number of accidents that befall cyclists; accurate accident reporting may result towards improving the safety levels for bicycles on the road. If accident levels appear low, planners believe the roadways are safe.

At present, design has little regard for the needs of the cyclist. Most North American planners and engineers give first consideration to the motorist, second consideration to the pedestrian and little if any consideration to the cyclist. By contrast, European planners and legislators give primary priority to the pedestrian, secondary priority to the cyclist, tertiary priority to mass public transportation and residual priority to the motor vehicle (Osberg & Stiles, 1998, pp. 62-63). Transportation systems are designed primarily to promote the safety of the pedestrian. Then the design considers the safety of the cyclist before considering the efficiency of motorised traffic movement.

As a transportation medium, planners designed much of North America's road infrastructure based on vehicular travel. The automobile industry boom spurred roadway development and consequently, roadway development catered to automobile travel. From the earliest development of roadways to present constructions, most of the roadway infrastructure continues to support automobile-centric travel (OECD, 1997, p. 168). Vehicular need stands primary to roadway planning and development; mass transportation and alternative methods sit as lower priorities. Consequently, much existing roadway design and development contribute little consideration to the safety of cyclist travel on roadways. Safety measures focusing on the well-being of cyclists reduce cyclist accidents and fatalities considerably (Pucher & Dijkstra, 2000, p. 7). Measures that directly reduce cyclist accidents include: better cycling facilities, traffic-calming in residential neighbourhoods, urban design with a focus on people and cyclists, vehicle travel restrictions, enhanced traffic law enforcement, and greater education/training programs.

Better Cycling Facilities

A number of bicycle facilities exist in the promotion of bicycle travel. These facilities not only facilitate cyclist usage, they also provide safety to the cyclist and the motorist. Trails offer an alternative to cyclists in removing them entirely from the presence of the road and vehicular traffic. As discussed earlier, well-designed multi-purpose trails, bicycle lanes, cycletracks and bicycle-designated routes contribute to cyclist safety. In addition other facilities can add to safer bicycle commutes (Pucher & Dijkstra, 2003, p. 1513). Extensive automobile prohibited zones—especially in densely populated, popular areas such as downtowns and high recreational areas—provide a haven from heavy traffic areas, and areas with dense vehicle parking. Cyclists face multiple hazards while interacting with motorist traffic, moving or stationary. Accidents occur frequently between cyclists and sudden door opening from parked vehicles. Cyclists encounter heightened threat in popular areas; high vehicle volumes impose high demand for parking spaces, which saturate the streets with parked vehicles. Increased roadway traffic leads to congestion where cyclists have the propensity to circumvent traffic by weaving through waiting vehicles. This action directs cyclists to move closer to parked vehicles and thus within the radii of parked car doors. The automobile-free zone permits cyclists and pedestrians leisurely access to otherwise congested sites.

A variation in the automobile-prohibited zone exists in the form of “bicycle streets,” where vehicles and cyclists share the road but cyclist has the absolute right-of-way (p. 1513). On bicycle streets, the cyclist has free usage of lane positioning and travel. The cyclist determines the speed of travel on the road; if the motorists use the bicycle street, the motorist must abide by the pace and conditions set by the cyclists. Being aware that the cyclist has the absolute right-of-way, the motorist must assume a greater onus of responsibility in avoiding collisions; the motorist should drive more safely and be more aware of surroundings and other forms of traffic.

Policy implications

With respect to automobile-prohibited streets and bicycle streets, Winnipeg has several policies that adopt aspects of these concepts. Winnipeg closes a number of streets from sunrise to sunset on Sundays and holidays seasonally, as discussed earlier. During the closures, temporary barricades sit at all intersections along the affected route. These barricades provide limited vehicular access, specifically to permit local traffic to access area residences. From Monday to Saturday (except on holidays), these streets allow free vehicle access.

With the exception of the Lyndale Drive closure, the remaining closures have direct influence on providing bicycle-friendly conduits between major areas of Winnipeg. While Lyndale Drive provides an alternative route to the traffic-heavy St Mary’s Road, the travel distance doubles versus the St Mary’s Road direct route; most cyclists regard this added distance unacceptable and would not use this as a transportation route. The remaining closures provide viable alternatives for cyclists to avoid main thoroughfares. Both closures along Wellington Crescent (2.5 km) and Wolseley Avenue (2.2 km) provide usable alternatives to Academy Road and Portage Avenue, respectively. These routes are in proximity to the Polo Park Commercial zone and access the outer reaches of the CBD. The Scotia Street closure provides cyclists with a safe alternative from the Kildonan Park – Kildonan Golf Course recreational area to the North End (2.5 km) neighbourhoods. Permanently closing these streets to automobiles would establish major connections to an integrated cycling network and lessen the infrastructure fractures. These closures would place minimal disruptions on vehicular traffic insomuch as arterial thoroughfares designed to accommodate heavy traffic run parallel to each of these routes. Winnipeg should close Wellington Crescent, Wolseley Avenue and Scotia Street from spring to autumn every day of the week. Although the intent is to close the streets to all motorised traffic, these streets remain open to local traffic. Thus, these streets are not closed to all traffic; de facto, these streets act as bicycle streets, where traffic is permitted to access local residences but bicycles and pedestrians have the right-of-way.

Dedicated zones, such as pedestrian malls, with permanent barriers to prevent all vehicle access (although emergency vehicles can sometimes override the barriers) represent true automobile-free areas. Many vibrant city centers have vehicle congestion; this congestion poses considerable risk to cyclist safety. Many cities with advanced cycling infrastructures provide ample automobile-free zones to provide cyclists with safe downtown access and provide pedestrians with interaction space (Pucher & Dijkstra, 2003, p. 1513). Winnipeg's CBD experiences traffic congestion, especially during the rush hours and during special events. Winnipeg has the opportunity to develop pedestrian malls and prohibit vehicular traffic use. In 2007, local businesses approached the City of Winnipeg with a proposal to close Albert Street from Bannatyne Avenue to McDermot Avenue and declare the block a pedestrian mall. The petition held the support of 70% of the street businesses and the backing of a Winnipeg Committee of Council, yet The City dismissed the proposal (City of Winnipeg, 2007).

Historically and world-wide, pedestrian malls have been vibrant and successful but North American pedestrian malls have seen some successes and some failures (Robertson, 1992), although the current trend finds North American pedestrian malls gaining success. Early North American pedestrianisation imitated European models but many of those efforts did not have some of the key factors necessary to produce a successful pedestrian mall; simply converting a street to a pedestrian mall will not ensure success. Rather than converting a downtown street and hoping that businesses will entrench vibrancy, today's pedestrianisation involves a comprehensive collaboration between area businesses, government cooperation and public/resident input. Employing comprehensive input into pedestrianisation efforts solidifies rates of success (Antupit, Gray & Woods, 1996, p. 121). The government can initiate the process of pedestrianising a dedicated area by banning motor vehicles. Subsequently, businesses have the opportunity to expand their operations into the street. Certain merchandise sales and restaurants/bars are ideal pedestrian mall occupants insomuch as they have the mobility to expand into streets and withdraw with minimal effort and time. Outdoor business presence draws pedestrian traffic and vibrancy to the neighbourhood. Winnipeg already experiences some of these successes with temporary, occasional closings of Albert Street, Osborne Street (and others) for festivals and events.

Winnipeg should re-table consideration of the pedestrian mall conversion. Albert Street sits in the middle of the most vibrant area of the Exchange District. The businesses express support and the area is ideal. The block in question only runs 87 metres and conversion involves minimal cost. Consequently, if the pedestrian mall proves unsuccessful, re-conversion will not impose a financial hardship. From a cyclist's perspective, a pedestrian mall on Albert Street provides a safe corridor through one of the CBD's most congested areas during rush hours, being adjacent to a Main Street approach. As a one-way street heading towards a dead-end, Albert Street cannot act as an effective motor traffic access street, but as a pedestrian corridor, cyclists have easy access bearing in either direction. Located at the northern terminus of Albert Street, Old Market Square—as a major meeting-point to many of Winnipeg's outdoor events and concerts—sees much pedestrian and cyclist traffic crossing

Bannatyne Avenue and into Albert Street. This Albert Street pedestrian corridor would also relieve cyclists from this hazardous blind corner, which intersects with Bannatyne Avenue. Associatively, a pedestrian mall increases foot traffic, further raising motorist awareness to surroundings. Annually, Winnipeg closes Albert Street to motorised traffic during the Fringe Festival, almost two weeks. During the closure, the area sees vibrant foot and bicycle traffic.

Traffic-calming

If motorists must give more attention to the surrounding areas and less to strict driving requirements, motorists would be more aware of hazards that can arise; this is the fundamental principle behind traffic-calming measures. Many driving commuters become very familiar with the route between home and the workplace. This familiarity evokes complacency and sometimes overconfidence—motorists may enter into a state of "autopilot" while navigating through neighbourhood streets. The relaxed driving increases risk to surrounding road users insomuch as reaction times increase if unexpected occurrences arise. Traffic-calming measures reduce driver complacency and augment alertness to other road users. Many European jurisdictions use traffic-calming measures successfully; however, North American jurisdictions do not primarily emphasise traffic-calming initiatives (Sarkar, Nederveen & Pols, 1997, p. 12). Over the last two decades, some North American localities started to incorporate traffic-calming measures, which have seen marked success in reducing traffic accidents. In traffic-calmed residential areas, planners intentionally develop neighbourhoods designed to deter high vehicle speeds. Traffic-calming measures include (but are not limited to): winding (rather than straight) roads, obstacles in the road (including forced-turn islands, build-outs and roundabouts), road narrowing, partial road closures (coupled with one-way conversions), raised crosswalks, half-signal crossings, and dead-ends. The basic intents of traffic-calming measures lie in the effort to slow motorised traffic and reduce the volume of neighbourhood traffic. Because of the increased difficulty and time in traversing these neighbourhoods, non-local traffic and traffic using neighbourhoods as conduits (commuter short-cutting) search for alternate routes—traffic-calming reduces the amount of traffic on residential streets, and reduces the speed of neighbourhood traffic, while channelling traffic back to the major roads. Whereas traffic laws provide incentives (or disincentives) in traffic speed regulation, traffic-calming measures physically control traffic speeds. Motorists cannot exceed prescribed, traffic-calmed speeds without engaging in reckless or dangerous driving manoeuvres. Average drivers have less apprehension about exceeding posted speed limits than executing dangerous driving exercises. As well as imposing slower traffic speeds, traffic-calming reduces conflicting traffic incidents, including incidents between motorists and cyclists. A frequent motorist-cyclist conflict occurs with a motorist passing a cyclist because of a large speed disparity. In traffic-calmed neighbourhoods, the disparity between motorised traffic speed and cyclist speed narrows considerably, and the subsequent conflict frequency diminishes. Moreover, because of the lower traffic speeds, accidents that occur between motorists and cyclists/pedestrians result in fewer and less severe injuries (Ewing, 1999, p. 10).

As expected, reductions in vehicle speed greatly reduce accidents resulting in fatalities among pedestrians. In conducting a post-accidents study, The British Department of Transport discovered that a vehicle travelling at 20 km/h imposes a 5% fatality risk to the pedestrian; a vehicle travelling at 30 km/h imposes a 45% fatality risk; and a vehicle travelling at 50 km/h imposes an 85% fatality risk. Injury reduction spans all levels of severity; serious injuries dropped as much as 56% and overall injuries dropped by up to 70% in traffic-calmed neighbourhoods (Pucher & Dijkstra, 2003, p. 1513). In addition to reduced speeds, traffic-calming measures contribute to reduced traffic volumes. Traffic-calming alone is not enough persuasion to impel most North American motorists to seek alternative forms of transportation; however, traffic-calming may influence motorists to seek alternative routes. Of course, the local traffic will continue to travel through traffic-calmed neighbourhoods; however, traffic-calming dissuades motorists who use neighbourhood streets as transportation conduits. Depending on the type of traffic-calming measure, traffic volumes drop from 5% to 44% (Ewing, 1999, p. 3). Insomuch as little of the volume reduction attributes to lessened vehicle usage, the traffic avoiding calmed neighbourhoods must displace to alternate routes. Consequently, city officials must necessarily impose comprehensive neighbourhood traffic-calming. Selectively targeting specific streets simply displaces traffic to nearby or adjacent streets. The nearby non-traffic calmed streets must bear their normal traffic volumes in addition to the displaced traffic volumes. Cities must impose traffic calming in an area-wide manner to comprehensively augment safety to the entire neighbourhood. A comprehensively imposed traffic-calming neighbourhood ensures that motorists either reduce their speeds or displace to arterial routes, designed for higher speed travel and greater traffic volumes.

Policy implications

Some of Winnipeg's newest neighbourhood developments, including Sage Creek and Waverley West, feature traffic calming measures. These measures include forming the neighbourhoods around winding and interconnected roads, and having obstacles in the road (traffic circles or roundabouts). However, Winnipeg does not have a comprehensive plan to address existing neighbourhoods in traffic-calming implementation. Some streets in older neighbourhoods that sit not far from the CBD have received some traffic-calming measures; however, Winnipeg has no comprehensive plan to provide traffic-calming in a widespread fashion. Winnipeg's recent *Active Transportation Action Plan* converted selected roadways into bicycle boulevards, which include extensive use of traffic-calming measures. However, traffic-calming will be limited specifically to the bicycle boulevards and generally not apply to surrounding streets. Again, this may provide a safer calmed route for cyclists but it also displaces traffic to neighbouring streets, and increases risk and congestion on those streets. Winnipeg also implements traffic-calming measures according to neighbourhood demand, upon the impetus of the neighbourhood residents; that is, Winnipeg only provides traffic calming measures on a subject street if a significant number of residents on the street request it (The City of Winnipeg, 2008b). The traffic-calming measures that Winnipeg makes available on neighbourhood demand include the Speed Watch Program and speed hump installations.

The Speed Watch Program consists of two components, variable message signs and speed reader boards. Both implements run on the same concept where a portable radar speed indicator displays the velocity of the passing motorist. The variable message sign sits on a trailer and can be positioned along target areas on roads. The variable message sign's intended use lies in high-speed, regional streets. By contrast, the smaller and more portable speed board reader focuses on residential streets. The speed board reader requires two volunteers to attend the reader at all times and it often measures motorists' speeds in school zones and community zones. Both of the speed capturing devices work on the same principle: the speed display brings awareness to the motorist of their current speed. If the travelling speed exceeds the posted speed limit, the motorist is expected to conform to the legal limits on a volunteer basis. Motorists also experience self-consciousness when the boards post speeds for other people within the vicinity to see. Motorists unfamiliar with the program may also have concerns about law enforcement monitoring associated with the message board. With the speed board reader, the volunteers attending the board have the opportunity to indicate visually to the motorist if their speed exceeds posted limits. The volunteers may also draw drivers' attention to their speeds and indicate that they exceed the posted limits. The drawback to the speed board reader is the requirement of community volunteers to operate the equipment; communities without activists would not have the usage of this equipment. Moreover, when motorists become aware that these signs pose no legally punitive threat, offenders may disregard the posting and the volunteers' admonishments entirely. In 2010, Winnipeg established, on an experimental basis, the installation of several, mounted, speed board readers that do not require volunteers to monitor them. Vehicle speeds are displayed on the board as the vehicle approaches. The mounted speed boards have the same purpose as the volunteer-operated boards.

Winnipeg's established communities have another option in traffic-calming implementations—speed humps. Winnipeg installs speed humps according to the Transportation Association of Canada's guidelines where the humps measure 4 metres wide and 8 cm high, which is considerably larger than speed bumps that motorists encounter in many shopping mall parking surfaces (The City of Winnipeg, 2008b). The speed humps are designed to impose significant discomfort to motorists who exceed the recommended speed (30 km/h). The gradual inclination and declination of the speed humps impose discomfort to motorists but have little effect on cyclists travelling over them.

Residential streets that want speed hump installation must fulfill several criteria, outlined as follows:

A. The Street is a Local Residential Street with an Urban Cross-Section (curb and gutter) and is not a Transit Route, Snow Route or a Residential Collector Street.

B. Submission of a Petition Representing a Minimum of 70% of the Residents in the block on both sides of the street supporting the Installation of Speed Humps.

C. At least one of the following speed criteria is met:

   (i) Average Speed exceeds the speed limit (50 km/hour); or

   (ii) At least 15% of vehicles exceed the speed limit by 5 km/hour or more (55 km/hour); or

   (iii) At least 10% of vehicles exceed the speed limit by 10 km/hour or more (60 km/hour);

(The City of Winnipeg, 2003, Council Minute 166).

The street residents bear the onus of satisfying the criteria and approaching the City of Winnipeg for speed humps. If The City grants the petition and approves speed humps, only the street affected receives speed hump installation; adjacent and proximal neighbourhood streets must submit individual, discrete petitions. As with other traffic calming devices, the street with the humps would likely displace traffic to nearby streets. Street hump installation limits to only the block applying for the installation; adjacent blocks remain unchanged.

As discussed earlier, traffic-calming practices should extend comprehensively throughout a neighbourhood. Selectively applying traffic-calming measures imposes a greater traffic burden on surrounding streets. In improving traffic-calming measures in neighbourhoods holistically, Winnipeg should include traffic-calming programs to all applicable residential streets within the neighbourhood.

Zein, Geddes, Hemsing and Johnson (1997) conducted a study into the benefits of traffic calming measures by comparing pre-calming and post-calming in four neighbourhoods in the census metropolitan area of Vancouver, Canada. The data collected covered a minimum of one-year prior to traffic-calming installation and one-year after implementation. The areas of study include the West End area of downtown Vancouver, the suburban residential area of Mount Pleasant, and exurban neighbourhoods in Burnaby and New Westminster.

The medium/high-density West End neighbourhood installed traffic-calming measures, which included forced-turn islands, street closings, diagonal diversions (which cut through traffic on streets), roundabouts, one-way street conversions, and street narrowings. The area covers 70 city blocks and the traffic-calming measures cost $7.5 million in 1996 (accounting for inflation, $20 million in 2010). The measures were constructed initially to decrease non-local traffic, reduce traffic speed, and increase safety/neighbourhood liveability.

The low-density Mount Pleasant area installed a combination of stop signs, forced-turn islands, road narrowing build-outs, roundabouts and one-way street conversions. The neighbourhood covers 20 city blocks. The traffic-calming measures were meant to improve safety and reduce commuter short-cutting. The traffic-calming measures cost $69 000 in 1991 (equivalent to $110 000 in 2010).

In the Willingdon-Parker neighbourhood, Burnaby installed traffic-calming measures in this medium-density, single-family residential zone. The traffic-calming implements were tasked to reduce commuter short-cutting, resulting from heavily congested area arterial streets. This 24-block neighbourhood received stop signs at every alternating intersection, and sometimes after every intersection. The stop signs cost $15 000 in 1993 ($25 000 in 2010).

New Westminster built traffic-calming measures in the single-family residential neighbourhood of Kelvin North in 1993. New Westminster hoped that traffic-calming would deter non-residential traffic from crossing through the 16-block neighbourhood. Measures include restricted turning signs and multiple speed humps within the streets. This endeavour cost $25 000 in 1996 ($36 000 in 2010).

In all four neighbourhoods, Vancouver realised a reduction in the frequency of collisions, severity of collisions and insurance claim payouts. The collision frequency drop ranged from 18% to 60% with a mean decrease of 40%. The annual claim drop ranged from 10% to 57%, with a mean decrease of 38%. In addition to the reduction of the accidents, all neighbourhoods experienced a drop in the local traffic volumes. While the study did not record traffic volumes in the arterial streets, volume decrease in the neighbourhood streets likely diverted commuter short-cutting traffic towards the arteries. All the traffic-calmed neighbourhoods experienced a decline in the frequency of collision, but none of the surrounding arterial thoroughfares near any of the neighbourhoods saw any change in the collision frequency. Consequently, the displaced traffic from the neighbourhoods caused no significant, deleterious, collision effect on the surrounding arterial streets.

Although the data gleaned from the Zein, Geddes, Hemsing and Johnson study show that traffic calming showed desired effects in differing density populations through Vancouver, the results may not be as robust as the data indicates. North American cities normally implement traffic-calming measures on residential streets, which have low traffic volumes in general. Thus, the variation in traffic accident incidences may attribute a considerable segment of its effect to normal variation, rather than traffic-calming measures (Ewing, 1999, p. 13). Variations in traffic accidents have high normal variations, thus the variation may or may not be entirely resultant from the traffic-calming efforts. Zein, Geddes, Hemsing and Johnson further add that their study limits to short-term effects; long-term effects of traffic-calming implements cannot be assessed properly with the current data. Results may fluctuate from year-to-year because of the low data samples and recidivism may occur with continued increase in arterial congestion.

However, from an immediate impact perspective, traffic-calming indeed bestows positive results. Whereas the broad implications of Zein, Geddes, Hemsing and Johnson’s study indicates that traffic-calming produced a net reduction in accident frequency and severity, accident frequency did not drop across the traffic-calming measures exhaustively. Specifically, the rate of bicycle–motor vehicle collisions only decreased in the Mount Pleasant and Kelvin North neighbourhoods. The Willingdon-Parker neighbourhood showed no significant change in accident rates after traffic-calming measures and the West End neighbourhood actually showed an increase in bicycle–motor vehicle collision frequencies. A number of reasons exist contributing to a possible increase in bicycle accidents in traffic-calmed neighbourhoods. One of the primary causes behind bicycle accidents comes from cyclist unwillingness to obey traffic laws and controls (Kim & Li, 1996, p. 77). Traffic-calming measures increase the amount of traffic control on the affected streets; because traffic-calmed neighbourhoods have more controls, cyclists who disregard traffic laws will potentially break more traffic laws in traffic-calmed neighbourhoods than non-affected neighbourhoods. Cyclists that disobey traffic laws have the greatest propensity to disregard traffic controls (including traffic lights and all traffic signs), travel in the wrong direction, and make illegal turns. Regardless of the neighbourhood make-up or design, failure to obey traffic laws increases the cyclist's risk to accident and injury. Traffic-calming measures alone cannot ensure enhanced safety for motorists or cyclists.

Traffic Regulation and Law Enforcement

Winnipeg enforces traffic regulations primarily through traditional laser/radar detection by police officers, and through radar-camera image capturing technology. Photographic traffic law enforcement efforts (photo enforcement) began in various countries in the 1970s and most jurisdictions show a reduction in the number of citations, indicating effectiveness in achieving adherence to traffic laws (Retting, Williams, Farmer & Feldman, 1998, p. 170). Photo enforcement is a low-cost, effective means of traffic law enforcement that requires minimal staffing. Winnipeg uses two standards of photo enforcement—mobile units and permanent units. The mobile units mount in unmarked vehicles that situate at various locations; these units only enforce speed limit violations. The mobile photo enforcement units only target vehicles that exceed posted speed limits in school zones, playground zones and construction zones. The permanent units mount on selected intersections and work in conjunction with traffic lights. These units monitor speed limit violations and red light violations. Sensors within both mobile and permanent units activate a camera, which captures two photographs of the violating vehicle when the vehicle exceeds the prescribed speed limits. The permanent units also capture photographs when a vehicle violates a red light signal. If a violation occurs, the registered vehicle owner receives a fine.

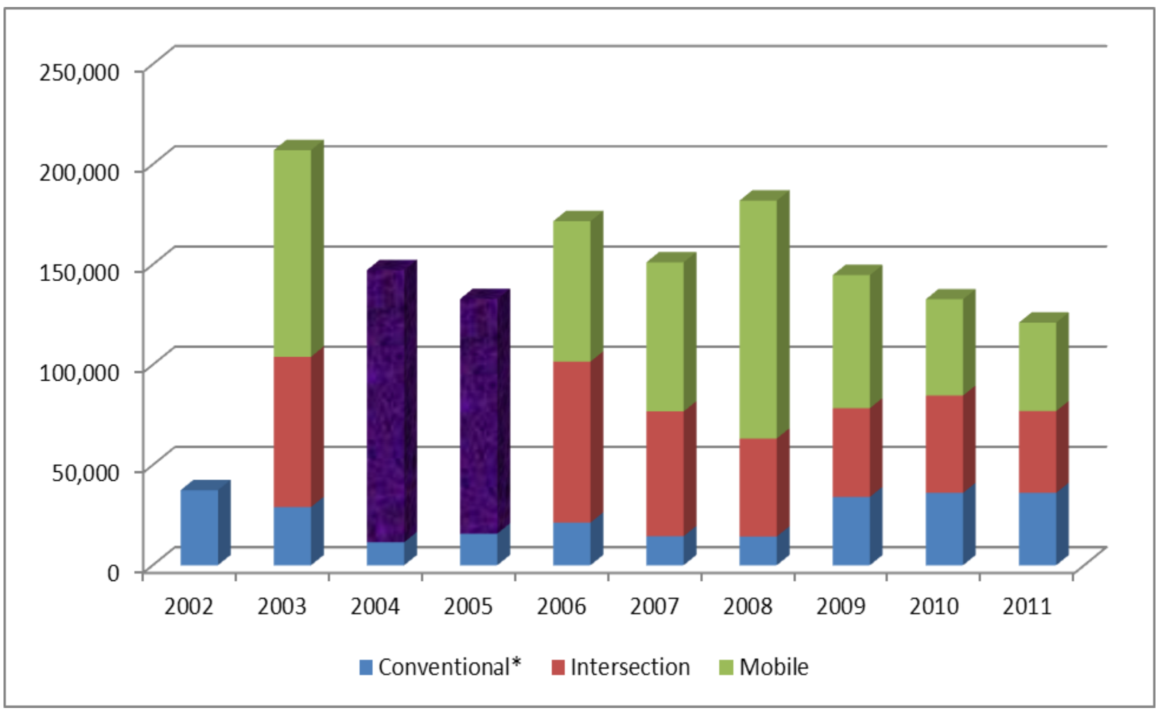
Winnipeg introduced mobile and intersection cameras in 2002 and started issuing citations in 2003. During its first full year, Winnipeg's traffic enforcement program issued 178 076 violations, with 5 mobile cameras, and 12 intersection cameras to July, and 24 from August to December. The numbers fluctuated until 2008, and have been on a decline; 2011 saw 84 935 camera captured violations.

Table #2: Violations by method and year

	Conventional*	Intersection	Mobile
2002	37,465		
2003	29,048	74,983	103,093
2004	11,493	135,768**	
2005	15,807	117,062**	
2006	21,255	80,321	70,051
2007	14,485	62,215	74,442
2008	14,345	48,877	118,692
2009	34,081	44,275	66,383
2010	36,100	48,551	48,043
2011	36,108	40,794	44,141

* Conventional only includes speeding and disobey traffic control device
** Separate intersection and mobile data is not available for 2004-2005.

Figure #14: City of Winnipeg traffic enforcement graph



As of 2011, Winnipeg employs ten mobile enforcement vehicles that deploy at various locations throughout the city. The enforcement units focus on reducing speed violations in areas with the presence of children and the presence of construction workers. The permanent enforcement units feature 31 capturing cameras rotated through 50 intersection sites.

Most traffic accidents occur at intersections, and chances of injury are greatest with intersection accidents (Retting, Williams, Farmer & Feldman, 1999, p. 169). Among accidents between cyclists and motorists, 75% of accidents occur at intersections (Hamilton & Stott, 2004, p. 162). Thus, all of the Winnipeg's permanent photo enforcement devices sit on intersecting street corners. Compared to the program's inception in 2003, 2011 sees a decrease of 52.8% in camera captured intersection infractions (Winnipeg Police Service, 2012).

The mobile units concentrate their efforts to street lengths, rather than intersections. Winnipeg's photo enforcement program purports to enhance all citizen safety on the streets but the mobile photo enforcement units concentrate on specific population segments, namely school zones, playground zones and construction zones. Winnipeg has no concerted effort to promote safety, specific to cyclists frequented zones.

Both mobile and intersection cameras have seen declines in the number of violations issued over the last two years, with considerable declines since 2003. In conjunction, the number of citations, the number of accidents has also decreased in this time period. The total number of collisions dropped by 10.7% at intersections with cameras; however, those numbers break down to a 14.1% increase in rear end collisions, and a 52.2% decrease in right angle collisions. Right angle collisions cause the most injuries, and the most severe injuries, both to motorists and to cyclists. The Winnipeg Police Service (2012) attribute the increase in rear end collisions to poor driving practices (tailgating) and driver urgency to stop (to avoid red light infractions).

Local implications

Winnipeg should extend the photo enforcement program to protect cyclists in routes highly frequented by cyclists. Similar to school zones and playground zones, Winnipeg can expand enforcement to heavily used bike routes, other streets frequented by cyclists, and street closure infractions. Winnipeg marks streets as cycling routes and some of those streets (Wellington Crescent, for example) have long stretches with no traffic control. Expanded mobile enforcement to popular cycling routes improve cyclist safety by reducing motorised traffic speeds and risky driving; some of these cycling routes act as major connectors between destinations and enhanced safety attracts more cyclists to use these routes. Generally, the public supports photo enforcement. When approaching a neighbourhood with the proposition of installing neighbourhood photo enforcement, 74% of the residents support the installation. After the installation, and a six-month trial period, local public support increases to 79% (Retting et al., 1999, p. 172). Only 10-15% of the population opposes photo enforcement and most of the opposition falls in the younger (16-29) male category—the category with the greatest propensity to transgress traffic laws (pp. 172-173). Winnipeg's citizens parallel this support with 50.6% strongly approving, and 32.1% moderately approving of mobile cameras, and 56.6%

strongly approving, and 27.5% moderately approving of intersection cameras. Furthermore, 42.4% strongly approve, and 30.8% moderately approve of expanding the mobile enforcement out of just school, playground or construction zones (Winnipeg Police Service, 2010). In fact, of those who had received a photo camera ticket:

- 45.3% strongly approve of photo radar cameras;
- 35.1% moderately approve of photo radar cameras;
- 50.1% strongly approve of red light cameras;
- 32.6% moderately approve of red light cameras;
- 37.9% strongly approve of expanding enforcement outside of the restricted zones;
- 31.8% moderately approve of expanding enforcement outside of the restricted zones;

(Winnipeg Police Service, 2010).

Policy implications

In 2011, Winnipeg's photo enforcement program reported a surplus of $3.7 million (Just Slow Down, 2011). The surplus reflects a higher-than-anticipated citation rate, indicating that motorists continue to disregard traffic laws. In every population and society, a segment of the population disregards traffic laws, regardless of road design or traffic enforcement; that is, certain drivers will always disregard traffic laws, in spite of the countermeasures in place. Because Winnipeg continues to experience higher-than-anticipated citation revenues, Winnipeg's traffic enforcement has not reached the threshold where only the habitual and adamant traffic law-breakers exist. Greater traffic enforcement efforts will continue to decrease the frequency of violation until the stabilised threshold of violations establishes (Retting et al., 1999, p. 170). The photo enforcement program is a fiscally self-sustaining program that protects citizens from risky driving and Winnipeg should consider its expansion. In addition, Winnipeg's citizens approve of the existing photo enforcement, and support its expansion. Winnipeg should consider further methods of law enforcement. All road users benefit from motorists abiding by traffic laws.

In addition to motorists, enforcement should target cyclists that break traffic laws. Cyclists must obey traffic laws as motor vehicles and those that disregard traffic controls should receive citations. As well, many cyclists perceive that travelling on sidewalks is safer than travelling on the road. This is not true and it is against the law. In Manitoba, bicycles with wheels 16 inches (40.6 cm) or larger are not permitted on sidewalks. Bicycle travel on sidewalks poses greater threats to injury and accidents than travel on roads (Aultman-Hall & Adams Jr., 1998, p. 75). Cycling on a sidewalk essentially brings a high-speed vehicle (the bicycle) into a conduit frequented by pedestrians and other slow-moving traffic (wheelchairs, carriages, etc.). The potential for collision increases insofar as most sidewalk occupants are not aware of, or alert to the presence of high-speed travellers. Moreover, cyclists on sidewalks travelling at cruising speeds often do not slow down nor stop on approaches to intersections. If cross motor vehicles do not stop before the sidewalk, a potential for bicycle-motor vehicle collision occurs. Studies show that accident levels occur most frequently on sidewalks when compared to lanes, trails and roads (Aultman-Hall & Hall, 1998, p. 42); however no studies were found to compare accident rates between travel exclusively on roadways without paved shoulders versus travel on sidewalks. In Manitoba, 20% of accidents involving injury to cyclist occur when the cyclist leaves the sidewalk into an intersection (Manitoba Public Insurance, 2012).

Fresno, California embarked on an aggressive traffic enforcement program in 2003 with the intent of decreasing traffic violations. Fresno augmented its complement of traffic patrol officers by more than four-fold (from 20 to 84 officers). Fresno obtained a grant to offset start-up costs for the program; future revenue acquired from violators will maintain funding for the program. Fresno expected that motorists will become more adherent to traffic laws and eventually, the size of the traffic enforcement unit will decrease conjunctively with violation revenues. That is, drivers will learn to obey traffic laws and the robust traffic enforcement unit will no longer be needed. However, from the program’s inception to 2005, the number of citations continues to increase—6% of Fresno’s drivers received citations in 2002; 14% of drivers received a citation in 2003; and 17% of drivers received a citation in 2004 (Davis, Bennink, Pepper, Parks, Lemaster & Townsend, 2006, p. 973). In this same span, the number of collisions, injury-causing collisions and fatalities dropped significantly since the traffic enforcement program. Fewer accident victims were admitted to hospital, and those admitted suffered less severe injuries.

Fresno's aggressive traffic enforcement program shows that drivers respond to immediate enforcement; however, the effects of the enforcement fade with the removal of enforcement. Drivers who receive a citation demonstrate obedient driving immediately afterwards. However, the effect diminishes significantly after two months; after three to four months, the effects become null (p. 975). Davis et al. infer that enforcement must be maintained in order to uphold traffic law adherence; the authors further claim that education has little effect on driving behaviours. Although education should remain a component towards safe roadway operation, continued traffic law enforcement acts as the key in maintaining traffic law adherence.

While education, traffic laws and regulations contribute to cyclist safety, incentives to cyclists' rights and well-being preservation can also arise from insurance or liability responsibility. Liability models from The Netherlands, Germany, Belgium and the Scandinavian countries hold the motorist responsible for almost all motorist-cyclist accidents (Fedtke, 2003, pp. 941-942); the only exception arises if the cyclist is proven to have acted in an extremely careless manner or is proven solely responsible for the accident (p. 944). Extremely careless manoeuvres include: passing a vehicle on the wrong (right hand) side; high speed travel on sidewalks; excessive and uncontrollable speeds; riding the wrong way on streets or lanes; taking on passengers without proper equipment; abruptly switching or swerving into lanes, etc. Even under these circumstances, the burden of proof lies with the motorist in countries where liability models place responsibility onuses on the motorist (p. 946). If accidents involve young cyclists

(16 years and under), elderly cyclists (70 years and above), or cyclists with disabilities, the fault automatically lies with the motorist, unless proof emerges showing wilful intent (such as a suicide attempt); the age limits and absoluteness of liability vary slightly between countries.

Manitoba's driving laws hold driver accident responsibility with cyclists in the same regard as with motor vehicles; that is, Manitoba's traffic laws consider bicycles as vehicles and in the event of a vehicle-bicycle accident, the law treats the bicycle as any motor vehicle. In an accident where a motor vehicle is involved in an accident with another motor vehicle, the driver receives two demerit points against the driver's licence; if fault is shared, Manitoba Public Insurance determines demerits according to each discrete circumstance. If any party suffers an injury, the incident must be reported to police (Manitoba Public Insurance, 2009).

As discussed earlier, statistics often understate the incidence of bicycle accidents. Studies often accrue bicycle accident data from hospital reports or police reports. If there is no injury, a police incident report does not need to be filed. Because of the large size and mass disparity between the motor vehicle and the bicycle, the bicycle rarely inflicts significant damage to the motor vehicle—rarely does a bicycle cause enough damage to a motor vehicle, or cause injury to a driver to warrant filing an incident report because of damage (Wessels, 1996, p. 82).

Policy implications

Manitoba’s licensing practice discounts drivers’ licences and insurance premiums to safe drivers (i.e. drivers with licence merit points). Incurring demerits can act as a significant incentive for drivers to maintain safe driving records. Winnipeg should embrace the possibility of imposing the demerit system on incidents between motorists and cyclists comprehensively. Insomuch as traffic violations play a large part in compromising safety to cyclists (and motorists), ensuring the adherence to traffic laws plays a major part in establishing safety for cyclists.

Helmet Use

While road design and traffic law enforcement can contribute to improving safety to cyclists, cyclists have a simple option for self-safety improvement—helmet usage. As discussed earlier, automobile designs continually innovate to protect drivers and passengers; because of its nature, the bicycle offers little or no protection to the rider. One of the few protective devices that a cyclist can use is the helmet. Helmet use can greatly reduce the likelihood of head trauma and the degree of head injury. Opponents of helmet use cite numerous factors in eschewing helmet use, including: inconvenience, looking silly, feeling hot, perspiring excessively, limiting freedom, a burden to carry, and expensive to purchase, among others (Unwin, 1992, p. 184). Although all of the cited reasons for not using a helmet hold some merit, the reasons sit negligible in comparison to the greatest reason why cyclists should wear helmets: helmets can save their lives. Some of the factors deterring cyclists from wearing helmets parallel the factors cited by opponents to seatbelt usage in motor vehicles (freedom limitations, feeling hot, inconvenient). When Manitoba enacted mandatory seatbelt usage in 1984, opponents vocalised against the legislation but usage jumped from 20% to 70% the succeeding year (Boase, 2008). However, acceptance comes with usage, familiarity and belief in the benefits (Steptoe, DPhil, Fuller, Davidsdottir, Davou & Justo, 2002, p. 255). Since the enactment of mandatory seatbelt usage, the public has accepted seatbelt usage as routine and beneficial. According to 2005 Transport Canada statistics, Manitoba ranks highly in seatbelt usage at 92.4% rural usage and 93.3% urban usage; Manitoba Public Insurance attributes strong seatbelt usage to harsh fines (among the highest in Canada) and demerit assessment for non-usage (Manitoba Public Insurance, 2009), and belief in its efficacy. Mandatory seatbelt use in Manitoba acted as the catalyst in boosting seatbelt usage among vehicle occupants; regulations and acceptance maintain their usage.

In 1997, Nova Scotia implemented mandatory bicycle helmet usage. LeBlanc, Beattie & Culligan (2002) conducted a study in Halifax to determine the compliance and longevity of bicycle helmet usage as a result of the helmet legislation. In 1995 and 1996, below 40% of cyclists wore helmets. With legislation in 1997, the rate of usage jumped to 75%. Usage rates continued to rise, eclipsing 80% in 1998 and 1999 (p. 593). However, LeBlanc et al. could not determine definitely how much of the increased usage attributed to legislation and how much resulted from the conjunctive helmet advertising campaign, although usage rates maintained after the completion of the advertising campaign. A similar study in Howard County, Maryland found 11% usage before helmet legislation and 37% usage after legislation; an educational advertising program accompanied the legislation. However, a neighbouring county imposed the same educational strategies without helmet legislation; the usage increased from 8% to 13% (p. 592). These studies show robust compliance to legislation with education and only moderate compliance stemming from education alone.

Most jurisdictions accompany helmet legislations with educational campaigns to increase the acceptance of helmet usage by cyclists. Thus, determining the degree of causation (or correlation) between adult helmet usage and legislation and/or education (advertising) presents a challenge. However, most studies agree that both methods of reinforcement contribute to the desired effect—increased helmet usage. Among children, officials can easily implement widespread educational programs in conjunction with the school systems; reaching adults provides greater challenges. Even among children, the amount of influence that education can impart on helmet use habits is limited; legislation yields greater results in impelling cyclists to use helmets (Rourke, 1994, p. 1122).

Helmet usage should be encouraged insomuch as overwhelming evidence exists in demonstrating the benefits of helmet use in promoting cyclist safety. Two-thirds of hospitalisations due to cycling accidents result from head injuries. Moreover, head trauma contributes to 85% of bicycle accident deaths (Wasserman & Buccini, 1990). Attewell, Glasea & McFadden (2001) conducted a meta-analysis into the efficacy of bicycle helmet usage. Attewell et al.

conclude that cyclists that wear helmets while cycling reduce the risk for head injury, brain injury and facial injury significantly. The injury risk reduction runs across all genders and ages, and applies across all study areas. Injury risk reduction appears in minor accidents and severe accidents. The only drawback in helmet-wearing seems to arise in neck injury; however, the authors attribute a segment of the data to hard-shelled helmet, where the greater helmet mass places exaggerated risk to the neck.

Opponents of helmet use, specifically mandatory helmet requirements, cite several reasons why helmet use does not protect cyclists as much as studies purport. Although mandatory helmet regulations increase the usage of helmets by cyclists, Manitoba faces challenges in following the leads of British Columbia, Ontario, New Brunswick and Nova Scotia (Alberta requires helmet use for everyone under 18 years of age), in imposing indiscriminate bicycle helmet laws. Considerable opposition voices disapproval of mandatory usage laws for the reasons cited earlier and others. Opponents claim that most of the research behind the protective nature of bicycle helmets stem from studies using hard-shelled helmets; the large majority of today’s cyclists wear soft-shelled helmets. The soft-shelled helmets provide little protection against severe impacts and hard-shelled helmets are obsolete. Even when in use, some hard-shelled helmets increase the velocity of the head prior to impact, thus augmenting the severity of the collision (Curnow, 2005, p. 570). Curnow further posits that much of the research in this field is flawed because of the nature of sampling. Test groups who normally wear helmets are by nature, more conservative in their riding habits and take fewer chances on the roads. This factor confounds the comparison of injuries between the helmet wearing groups and the non-helmet groups. Similarly, the possibility also exists where cyclists who normally do not wear helmets, will behave more daringly because of a fortified sense of security (p. 570). Attewell et al. (2001) confirm this position in a study that found lower non-head injuries among cyclists wearing helmets; however Attewell et al. also contrasted this theory with a study that found greater frequency and severity of non-head injuries among helmet-wearing cyclists. Attewell et al. conclude that evidence is inconclusive in determining whether cyclists engage in more daring manoeuvres because of helmet protection. While Curnow challenges the analysis methods and the testing methods of a number of helmet-injury studies, Curnow does not go so far as to state that bicycle helmets provide no protection to the head at all. Curnow does not believe that helmet efficacies are as robust as studies indicate; however, Curnow does not dismiss all effectiveness in the protectiveness of a bicycle helmet. While the degree of bicycle helmet value may remain in doubt, a cyclist can reduce the issue to a single question: if your head is about to hit a concrete curb, would you rather be wearing a helmet or not? Most people believe that wearing a helmet protects the rider and that cyclists should wear helmets while riding. In Canada, 95% agree or strongly agree that people should wear a helmet while riding a bicycle and 97% believe or strongly believe that wearing a helmet can reduce serious injury (Martin, 2002, p. 1282). In practice, only 35% of Canadians indicate that they always wear a helmet while cycling and 45% indicate that they never wear a helmet. Among those, the study found that riders in Saskatchewan and Manitoba have the worst record of helmet usage, at 12% of cyclists who always wear a helmet. Most believe that legislation, events, information and education are the best means of increasing helmet usage.

EDUCATION

As discussed earlier, education produces less effect on desired outcomes than legislation or punishment; that is, teaching cyclists about the importance of road safety and helmet efficacy imposes less impact than mandatory helmet use and punishing traffic violation (Davis et al., 2006, p. 975). Similarly, legislation and enforcement have a greater effect on motorist behaviour than education and instruction; moreover, Davis et al. further elucidate that punitive action (or the threat thereof) is absolutely necessary in the upholding of legislation. Without monitoring, enforcement and punishment, many road users would not readily obey traffic laws. However, legislative obedience only continues in the presence of enforcement. Enforcement withdrawal results in subsequent disregard for legislations. Although effective, enforcement and punishment, with regard to legislative obedience, only act as extrinsic motivators towards compliance.

People (largely) obey laws more because of the threat of punishment, than because it is the right thing to do. Education acts as an intrinsic motivator, impelling adherence to legislative directives because of personal belief, rather than the threat of punishment. Lee, Schofer and Koppelman (2005, p. 95) cite numerous studies confirming the increased effectiveness of legislation adherence as a result of a combination of enforcement and education. Legislators should include education as part of a comprehensive strategy in improving safety to cyclists, motorists and pedestrians. In addition to personal belief, education contributes to mass belief change, permanent change, and consequently social change. As an example, bicycle helmet introduction met with ridicule and derision among bicycle riders and non-riders. Today, although bicycle helmet usage is not ubiquitous, cyclists who wear helmets face fewer and lesser ridicule insomuch as bicycle helmets have become socially acceptable (p. 95). Although Manitoba has no legislation regarding mandatory bicycle helmet usage, a considerable ratio of cyclists (averaging 40%) embraces helmet usage (Warda & Briggs, 2003). Social change must play a part in imposing safe behaviours to cyclists and motorists, and social change begins with education.

For a number of reasons, education needs to begin with children. Although studies show that children only constitute a small percentage of total bicycle accidents, it is important for the education process to start with children. The crucial reasons behind accident occurrence include ignorance of traffic laws, disregard for traffic laws, and inability to operate a bicycle properly. Schramm, Rakotonirainy & Haworth (2008, p. 153) report that children up to 16 years of age account for 17% of bicycle accidents. However, children account for the majority of at-fault accidents, with children aged 0 to 4 responsible for 100% of accidents; children aged 5 to 11 responsible for 80% of at-fault accidents; and children aged 12 to 16 responsible for 55% of at-fault accidents. Ignorance and disregard of traffic laws places children at greatest risk on the roads; traffic safety education at a young age prepares children for a lifetime of road safety. Because Canadian law requires that all children attend school, the school system provides easily accessible grounds to address all children.

Rourke (1994) conducted a study involving the widespread dispersion of bicycling safety information to two northern Ontario towns, Goderich and Kincardine. With the resumption of classes in autumn 1991, both towns saw intervention in their elementary schools through the following: colouring and poster campaigns expounding bicycle safety, a bicycle helmet safety day, expert speakers, discounts for helmets, and various school events themed around bicycle safety (including plays, dramas, etc.). Local newspapers actively supported safe cycling and published community cycling events. In the summer of 1992, police spot-checkers issued T-shirt rewards to children seen cycling safely and wearing helmets. Goderich received additional reinforcement through two bicycle rodeos (one in June, 1992 and a follow-up in June 1993). The rodeos included written tests refreshing cycling safety habits, practical tests assessing cycling skills, applying reflector tape to bicycles, and bicycle licencing. Furthermore, Goderich received an extra, unexpected and tragic reinforcement when a car struck a nine-year-old cyclist as he ran through a stop sign. The boy died of head injuries the next day.

Data collection consisted of questionnaires issued by teachers and observational tracking of children’s cycling habits. Sampling occurred before intervention, after informational campaigns and helmet drives, after the first rodeo, after the cycling tragedy; the final sampling occurred after the last rodeo and helmet drive.

Prior to intervention, baseline data showed 0.98% of children self-reporting helmet use and 0.75% observed wearing helmets. After the education intervention and helmet drive, the self-reported helmet usage rose to 9.4% and the observation level rose to 11% usage. After the first rodeo, Goderich saw another rise to 12.7% self-reported usage and 12.8% observed usage. After the tragedy in April 1993, Goderich jumped to 56.3% self-reported usage and 51.8% observed usage, while Kincardine experienced 19.1% self-reported usage and 15.9% observed usage. Experiencing the loss of a peer and companion provided a profound effect towards belief and action. Usage between Goderich and Kincardine showed significant difference ($p < 0.001$) between helmet usage shortly after the accident. Goderich, after the second bicycle rodeo in June 1993, saw self-reported usage drop to 52.1% and observed usage drop to 50.2%. This drop in usage highlights the fleeting nature of immediacy of effects. While the tragedy provided immediate effect, the effect dropped after time elapse. This decline in usage reinforces the necessity of repeated education.

From this study, a number of important findings emerge, the most notable being the profound impact imparted by the tragedy of a peer. Witnessing the death of a peer instils impetus to adhere to safe practices insomuch as the reality of bicycling peril becomes salient. The tragedy provides a sombre example to the various educational methods; however, the study also reveals that salience ebbs with time. Repeated reinforcement must exist to re-instil the reality of cycling dangers. Summarising, children should receive comprehensive education regarding bicycling safety, and this education should periodically reiterate the issues to hold salience. Even after the second rodeo, the study shows that safety adherence dropped as the tragedy became more distant. The authors conclude that education must accompany other interventions (such as legislation) to elevate safety adherence.

Greater proportions of younger children engage in safe practices, including helmet usage, but those proportions decrease as children age. Children practise and adhere to safe methods as they are first taught to use a bicycle with safety as a forefront. With experience and familiarity, complacency changes a child's cycling habits and safety adherence ebbs. With helmet use as an indicator, Berg and Westerling (2001, p. 219) discovered that over 80% of children reported helmet use prior to entering the school system. After entering the school system, usage declined as a function of age. By age 15, only 1% of children continued to wear helmets regularly (p. 220). The authors also conclude that significant effects exist between the rates of helmet use and parents' instruction, helmet use and parents' example, and helmet use against school education. That is, school education, parents' education and parents' practice all significantly influence children in helmet usage. Parents' influence has the greatest effect on children's behaviour insomuch as the parents' education reinforces the education provided through the school system. Children look at parents as role models and embrace the wisdom imparted. Moreover, parents' usage reinforces children's convictions that parents believe what they teach.

Most of the education that the children receive through the school system exists in the form of classroom or theoretical teachings. Classroom teaching in itself is not sufficient to provide children with the necessary tools in bicycle operations, especially as a means of transportation. Processes such as bicycle rodeos provide children with practical experience and hands-on guidance with trouble areas; however, bicycle rodeos occur infrequently and do not endow lasting knowledge. Repeated parents' teachings are the most approachable and available means of education (Drott, Johansson & Åström, 2008, p. 143). However, this study also reveals a significant correlation between children that receive informal training from the parents and an increase in the frequency of accidents. The authors attribute the accident frequency increase with an increase in bicycle usage as a result of at-home training. However, the training received through the parents may not be sufficient to permit the child to operate the bicycle or the training may indeed be incorrect or improper (p. 158). Parents must have sufficient and correct knowledge of bicycle operation to impart proper operating knowledge to children.

By the ages of 11 to 12, children's usage of bicycles evolves from an entertainment source to a transportation mode. As children age, freedom also increases, thus necessitating travel to engage in activities. The bicycle offers these children freedom of movement and independence and becomes the child's primary source of transportation. Prior to, or around age 10, children should receive proper education regarding bicycle use and this education should receive periodic reinforcement in subsequent years. The education should bestow basic, physical skills knowledge, including bicycle control, proper mounting and dismounting, straight-line riding, stability and brake-usage. Education programs should also include practical factors, including behaviour in traffic, signal usage, street law adherence, and fundamental safety practices. Education focusing on the fundamental physical and practical usages of bicycles at age 10 sets a foundation for safe and lasting bicycle behaviours (McMahon & O'Reilly, 2005, pp. 306-307). It is important to note that administered education only establishes a basic foundation to bicycle safety; parents, and public parties must cooperate to continue the learning process. A compact, intensive learning program has very limited staying power, and knowledge dissolution sets in shortly after the completion of the education program. Children retain information more permanently through extended education programs that continue to reinforce the learned principles (p. 307). Ideally, education programs should consist of multiple stages, with each succeeding stage reinforcing the previous stage and introducing novel issues. The program should also encourage analytical components, rather than rely solely on instructional learning. Comprehensive bicycle safety derives from long familiarity and experience but setting a foundation offers children a starting-point from which to build sound safety experience.

Cyclist education must include instruction on site-specific operations; this includes instruction on interaction with pedestrians, other cyclists, roller skaters, skateboards and motor vehicles. When referring to bicycle safety, people normally perceive danger coming predominantly from motor vehicles; however, pedestrians and non-motorised forms of transportation can impose significant peril to the cyclist. Whereas the law requires that motorists follow the specifics of the *Highway Traffic Act,* roller skaters, skateboarders and pedestrians are not bound by many travelling laws, and often disregard the laws in place (jaywalking for example). Consequently, trail and sidewalk users easily become hazards (Forester, 1984). Pedestrians, roller skaters and skateboarders can stop, change or reverse direction without warning and create immediate dangers to cyclists insomuch as cyclists do not have as much control over speed or direction changes. Other cyclists also present challenges to cyclists. Especially since many cyclists can approach city, motorised vehicle cruising speeds, cyclists can face extreme peril from other erratic cyclists (p. 157). Cyclists need to learn to share the roads with motorists, and recreational trails with other users.

While it is very important for the cyclist to employ safe practices, much of the onus of safety lies outside the realm of cyclists' control. Schramm, Rakotonirainy & Haworth (2008, p. 153) report that the majority of cyclists that encounter accidents fall between the ages of 30 and 39 years. Within this age bracket, over 84% hold valid drivers' licences and have presumable knowledge of traffic laws. Regardless of whether the cyclist holds a driver's licence, the cyclist must practise travel according to traffic laws to promote safe travel. The majority of accidents (aged 30-39) occur in daylight over clear weather conditions. Schramm, Rakotonirainy and Haworth attribute the accidents to rider and motorist disregard for road regulations (2008, p. 157). Most of the accidents occur at intersections, with 70% of the fault attributing to the motorist—thus highlighting the importance of driver education towards cyclists' safety.

In attempting to increase safe bicycle use and better integrated bicycle-automobile road sharing, The City of Calgary, Canada initialised active efforts to educate all road users, with a concerted focus to the motor vehicle driver. In 1977 and subsequently, in 1984, Calgary issued *Cycle Plans,* which identified, developed, and improved bicycle infrastructures. In 1996, Calgary adopted *The Calgary Cycle Plan (1996)(The Plan),* which went beyond physical development and reached towards the creation of a comprehensive drive to further encourage bicycle facilities, improve enforcement, and spearheaded widespread education. *The Plan* was authored through the collaboration of representatives from the Transportation Department, the Calgary Parks & Recreation Department, the Engineering & Environmental Services Department, the Planning & Building Department, the Calgary Police Service, as well as bicycle enthusiasts' groups, including the Calgary Bicycle Advisory Council, the Calgary Pathway Advisory Council, and the Elbow Valley Cycle Club. *The Plan's* education program covers environmental interests, physical fitness interests, and recreational interests, but *The Plan* places significant weight on safety issues. *The Plan* concentrates on providing education to cyclists and all pathway users, including pedestrians, skaters, and all roadway users. The City of Calgary accepts responsibility for leading the education process in delivering programs, public service announcements, and active support and sanctioning of cycling advocacy associations. Key areas of educational needs include the physical ability to operate a bicycle properly, traffic laws, interactions with pedestrians, skaters and motorists; *The Plan* outlines education delivering these necessary skills across cyclists of various cycling ability and experience, and across all ages. Education must also reach adults, with emphasis on those adults passing their knowledge down to their children. Multi-pronged education diffusion acts as the first step towards social change. As a fundamental basis for education delivery, Calgary issues the *Cycling Safety Handbook,* which is a free resource designed to act as a reference for basic, practical cycling information. In cooperation with various groups, Calgary also issues and endorses a number of brochures and videos highlighting safety issues. Although these tools cannot act as a replacement for comprehensive education, they can act as reference materials to the novices, or refreshers and reinforcers to the experienced cyclists.

In a more active role, Calgary modified its drivers' manual and drivers' education program to include acceptance and space-sharing principles with cyclists. Public transit operators and public fleet drivers all necessarily receive bicycle-positive training. Essentially, the entire population entering the vehicle-driving realm must undergo cyclist-inclusive training. However, experienced drivers who underwent licencing training prior to the cyclist-positive education programs do not have this education component and are not required to upgrade their licencing. In this respect, Calgary relies on public awareness programs to act in changing the motor vehicle-centered society. Societal change will evolve through the transposition of the cyclist-accepting generation of drivers over the previous generation of drivers who did not receive the cyclist-positive education.

Local implications

Winnipeg has no mandatory cyclist education programs, nor government-endorsed cycling programs. However, a number of interest groups provide bicycle education for the cyclist. The Manitoba Cycling Association (in conjunction with the Canadian Cycling Association) administers the Can-BIKE courses, which are part of a formal program in providing cycling education to people of all ages. Cycling advocacy groups, including Bike to the Future, also offer bicycle training courses; however the impetus lies with the cyclist to seek these programs. Manitoba has no mandatory or sponsored program. In acquiring a driver's licence, all drivers and potential drivers must pass a written and practical road test. The road test has no specific application with regard to interaction and sharing the road with cyclists. The written test derives its questions out of the *Driver's Handbook,* issued by Manitoba Public Insurance (2012). The *Handbook* contains several pages of information on the basics of motor vehicle operation with regard to cyclist interaction and mutual safety. The information includes discussions on shared roads, shared rules and rights, lane positioning, passing cyclists, and turning positions, as well as other basic material (pp. 72-75). Manitoba Public Insurance also published a manual entitled *Bike Safe* (2012), which focuses more on proper bicycle operation, than motorist operation around cyclists. Manitoba Public Insurance also published, *I Cycle Safely,* a presentation/brochure for children, *Bike Safe* presentation for young adults, and the *Cycle Safely* booklet, aimed at adults. Each has truncated, relevant information derived from the *Bike Safe* manual.

Policy implications

Manitoba needs a comprehensive program involving school systems, police departments, driver education institutions, governments, advocacy groups, and cyclists to properly promote proper safe cycling. In reaching adults and motorists, the *Driver's Handbook* should provide more information to the motorist regarding sharing the roads. Calgary's model provides a usable template towards developing bicycle-friendly driving. In addition to motorists, Manitoba should make education available to cyclists in improving cycling habits. Inasmuch as interest groups already provide training to cyclists, Manitoba should endorse and fund these groups to expand their education provision. Finally, Manitoba should provide education to all children as they approach bicycle-usage ages. Programs across all schools reach virtually all children and provide an easy conduit for bicycle education.

As a starting point, Manitoba's governments should provide funding to all facets of cyclist education. Interest groups do not have adequate funding to launch a comprehensive campaign that reaches large population segments; the government should drive education initiatives and provide support to interest groups in furthering the movement. In 1995, the Québec provincial government adopted a bicycle policy intended to expand cycling with safety as a paramount objective. The province of Québec partnered with the cycling group Velo Québec and coordinated the use of $89 million for infrastructure and user expansion. Québec municipalities and other government sources contributed a further $180 million towards infrastructure and programs (Pucher & Buehler, 2006, pp. 271-272). British Columbia is the only other Canadian provincial government to provide funding for cycling initiatives, at about $1.5 million per year. Canada's federal government adds little funding support to cycling programs. With the ratification of the Kyoto Protocol in 2002, the Canadian federal government allocated $2 million annually to cycling initiatives, intended for country-wide usage. With the paucity of funding available from the federal government, the onus lies on Manitoba's provincial and municipal bodies to provide funding for cycling-positive programs. The $20.4 million active transportation improvement initiatives allocate all of its funding to infrastructure development with no consideration for educational purposes.

CURRENT / FUTURE DEVELOPMENTS

- Winnipeg has begun construction on a cycletrack on Pembina Highway, from Bishop Grandin Boulevard to the south, to Crescent Drive to the north. The completed cycletrack will connect the Bishop Grandin Greenway and the Crescent Drive bike route. The cycletrack will consist of pylons as barriers to traffic lanes, as well as cut-outs to direct cyclists away from embarking/disembarking transit users. This section of Pembina Highway has no alternative, parallel streets so this new construction will be important in facilitating cyclists through the area.

- The Osborne Street Bridge is currently under rehabilitation. The completed project will not have dedicated bicycle lanes, but will include widened shy lanes.
- The Disraeli Bridge reconstruction will feature a separate active transportation bridge, removed and adjacent to the motorised traffic bridge.
- The Northeast Pioneers Greenway will continue uninterrupted over the Chief Peguis Trail extension.
- Boulevard Lagimodière will see paved shoulders in 2014 from rue Maginot to Dugald Road.
- Winnipeg will allocate $500 000 each year, from 2013 to 2017, for active transportation, from the general capital budget.

GENERAL DISCUSSION

Interest in active transportation and bicycle commuting rises in Winnipeg and the three levels of government's injection of capital into active transportation infrastructure development propels this momentum. As Winnipeg offers better cycling facilities, hopefully more people will adopt the bicycle as a viable means of transportation and commuting. As the number of bicycle commuters rise, the governments should continue to inject funds into further infrastructure improvements and developments, and provide programs supporting existing users and potential users. In the cycle where funding is scarce because of scarce usership, and usership does not grow because of inadequate facilities, Winnipeg's three levels of government provided a critical impetus by dedicating $20.4 million to the promotion of active transportation. Winnipeg, through consultation with a number of interest groups, allocated the majority of the funding to bicycle facility development.

This study has outlined a number of deficiencies in Winnipeg's current bicycle facilities and the planned developments will address a number of deficiencies, including some of the deficiencies examined in this study; however, some key infrastructure inadequacies remain unaddressed and those problem areas should be rectified. Planned infrastructure projects should include developing deficient areas, improving inadequate areas, and ensuring that the projects conform to governmental and AASHTO requirements. Bicycle facilities that do not adhere to established guidelines endanger all road users and Winnipeg should ensure that presently inadequate facilities are improved and that all future developments meet industry standards. Rather than neglect insufficient facilities, or develop new, deficient facilities, bringing current facilities to standard and establishing new, standard-conforming facilities should sit paramount to facility construction initiatives.

Adequate bicycle facilities promote the safety of experienced cyclists, novice cyclists and learning cyclists. Winnipeg's goal should aim towards increasing the number of people who adopt cycling as transportation and this effort includes transforming Type B cyclists into Type A cyclists, and introducing Type C cyclists into active transportation. Properly designed and built bicycle facilities ease the transition of cyclists from leisure or non-cycling to transportation cycling, and these facilities reduce the amount of peril inherent to bicycle transportation. Bicycle facilities should provide protection and safety to all cyclists and all users of other modes of transportation.

While some of Winnipeg's bicycle facility developments improve safety to users, some recent facility endeavours continue to pose threats to users. Projects such as multi-use trail developments improve the cycling infrastructure but increasing the number of bicycle-bus shared lanes creates more challenges for cyclists. These facilities are not adequate for their intended use and Winnipeg should act to modify or overhaul their design. However, because Winnipeg considers them part of the active transportation network—and considers them adequate—plans for further developments on these sites may not exist, or be delayed in development. Winnipeg should ensure that all existing, developing and planned facilities are usable, safe to all road vehicles, and conform to industry and governmental standards.

As Winnipeg develops new bicycle facilities, and upgrades existing facilities, new and redesigned neighbourhoods should have bicycle facility incorporation. To date, many of Winnipeg's fractured bicycle facilities do not provide continuous access through the city. Improving bicycle facilities should include adequately connecting discontinuous facilities to provide safe, comprehensive access for users. Similarly, new neighbourhoods should provide adequate bicycle facilities within the neighbourhoods, and those facilities should connect to surrounding facilities to provide seamless facilities throughout the city. Winnipeg's initiatives should ensure the development of bicycle facilities in existing neighbourhoods, upgrade existing facilities where necessary, incorporate bicycle facilities in new neighbourhoods, and integrate all of those facilities.

Establishing and maintaining bicycle facilities only addresses one aspect of the total bicycle transportation issue. Cyclists, motorists, pedestrians and other users must know proper usage of the various facilities to promote mutual, safe coexistence. Winnipeg has provided little instructional and educational support to the proper usage of the various facilities to date. Public, driver and community education systems can provide education to users and Winnipeg has the possibility to improve accessibility, funding and comprehensiveness to the educating process. The public school systems reach children and the next generation of cyclists and motorists; the driver education system reaches new drivers; and community/public resources reach existing cyclists and motorists. Winnipeg should extend programs and funding to promote widespread education in active transportation and bicycle facility practices. The education should include, not only the proper usage and interaction of facilities, but also include comprehensive issues on personal safety, surrounding safety and safe use. Promoting safety should stand as the top consideration before facility design, program initiatives and programs enforcement.

Winnipeg had a modest start in developing bicycle facilities and bicycle-friendly programs but current developments and funding offers Winnipeg a great opportunity to address a history of neglect and disregard. Key issues in bicycle infrastructure development and bicycle program development include expedited implementations, vigilant maintenance and continued future consideration/funding. Winnipeg is currently behind many other urban centers in bicycle friendliness, but proper and continued efforts can propel Winnipeg to become a future leader and innovator in bicycle facilities and programs.

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Appendix A: Winnipeg's financial commitment to bicycle related facilities from 1994 to 2009:

- On July 24, 1994, Winnipeg authorised the construction of the Sturgeon Creek Parkway – $150 000.
- On November 17, 1994, Winnipeg authorised the widening of University Crescent from the University of Manitoba to Pembina Highway to better accommodate cyclists – $350 000.
- On April 5, 1995, Winnipeg authorised the implementation of bicycle racks at Elmwood-Kildonan Swimming Pool – $2000.
- On April 19, 1995, Winnipeg authorised the improvement of the St. Cross Street and Scotia Street pathway connection – $150 000.
- On December 11, 1996, Winnipeg approved a grant to the Burton Cummings Community Centre for the purchase of a bicycle rack – $536.
- On June 22, 2000, Winnipeg authorised the construction of the pedestrian cycle path along Fermor Avenue from rue des Meurons to St. Anne's Road, thus completing the cycling path along Fermor Avenue from Autumnwood Drive to Kingston Row – $102 500.
- On May 28, 2003, Winnipeg authorised the construction of the Bishop Grandin Greenway from St. Mary's Road to Dakota Street – $136 000.

- On May 28, 2003, Winnipeg authorised the construction of the Lagopoulos Way-Stradbrook Avenue pedestrian cycle path between Donald Street and Main Street – $143 700.
- On September 24, 2003, Winnipeg authorised the restoration of the Niakwa Park Bicycle Path (connecting Archibald Street to St. Anne’s Road, along Fermor Avenue) – $20 000.
- On July 27, 2005, Winnipeg committed to the development of the Cloutier Trail (along Cloutier Drive, parallel to the Perimeter Highway) – $30 000.
- On March 1, 2006, Winnipeg authorised the construction of the Preston Trail from Wilkes Avenue to Roblin Boulevard via Assiniboine Forest – $176 725.
- On September 12, 2006, Winnipeg authorised the extension of the Bishop Grandin Greenway between St. Anne’s Road and the Seine River – $40 000.
- On September 27, 2006, Winnipeg authorised the development of 2.4 kilometres of trail south of Douglas Avenue from Henderson Highway to Raleigh Street – $10 000.
- On January 25, 2007, Winnipeg authorised the acquisition of the CPR Marconi Rail Right-of-Way from Nairn Avenue to Glenway Avenue – $1.7 million.
- On April 25, 2007, the City of Winnipeg adopted the “Active Transportation Study Implementation Plan”

- On April 25, 2007, Winnipeg authorised the completion of the Preston Trail from Wilkes Avenue to Roblin Boulevard via Assiniboine Forest – $110 000.
- On May 8, 2007, Winnipeg authorised the construction of a portion of the trail from St. Mary's Road and the Glen Meadow Extension Trail – $105 000.
- On May 16, 2007, Winnipeg authorised the Phase 1 development of the (later renamed the Northwest Pioneers Trail) multi-use path between Talbot Avenue and Springfield Road – $1.2 million.
- On May 16, 2007, Winnipeg authorised the extension of the Bishop Grandin Greenway from the Seine River to Shorehill Drive – $100 000.
- On May 16, 2007, Winnipeg authorised the construction of the multi-use pathway along McGillivray Boulevard from Columbia Drive to Brady Road – $380 000.
- On October 24, 2007, Winnipeg authorised landscaping for the Harte Trail (connecting the Perimeter Highway to Elmhurt Road and Assiniboine Forest) – $1000.
- On May 1, 2008, Winnipeg adopted the 2008 Active Transportation Action Plan, including the implementation of Phase II of the Northeast Pioneers Greenway ($500 000), the extension of the Bishop Grandin Greenway from Glen Meadow Street to River Road ($500 000) the extension of the Bishop Grandin Greenway from the Red River to Pembina Highway ($400 000), the upgrade of the Harte Trail ($253 000), establishing the

WinSmart Pathway, connecting Osborne Street to the Red River trail system to Main Street ($150 000), and the establishment of the Southpoint Pathway, from Main Street, through Southpoint Park, to The Forks ($400 000).

- On March 10, 2009, Winnipeg adopted the 2009 Active Transportation Action Plan, including the extension of the Bishop Grandin Greenway from Pembina Highway to Waverley Street ($650 000), the development of the North Winnipeg Parkway, along the Red River from Leila Avenue to Cathedral Avenue ($405 000), the development of the Silver Avenue Trail ($370 000), and the establishment of the Donald Street Pathway ($325 000).

Appendix B:

- The Northeast Pioneers Greenway currently spans northeast Winnipeg from Nairn Avenue to McIvor Avenue. Future plans call for the extension of the Northeast Pioneers Greenway to originate at The Forks and reach Birds Hill Provincial Park in the future.
- The Yellow Ribbon Greenway runs through Winnipeg's west, originating at Silver Avenue and Hamilton Avenue, and continues parallel to Ness Avenue, ending at Ferry Street.
- To Winnipeg's southwest, the Harte Trail (unpaved) connects the Thundering Bison Trail and abuts Assiniboine Forest. It continues westward and concludes at the western Perimeter Highway.
- The Thundering Bison Trail connects the Harte Trail with Waverley Street's trail and Fort Whyte Alive!
- The McGillivray Trail provides access to the retail district of Kenaston Commons and connects Fort Whyte Alive! With the Bishop Grandin Trail and Waverley Street's trail, as well as a connection to Pembina Highway.
- In southeast Winnipeg, the Bishop Grandin Greenway trail runs from boulevard Lagimodière to McGillivray Boulevard, with future extension to Taylor Avenue. The trail connections major attractions including a connector to the University of Manitoba, St. Vital Park and the St. Vital Centre shopping district.

- The Dakota/Dunkirk Pathway originates from Kingston Row and terminates at Warde Avenue, with connections to the Bishop Grandin Greenway Trail and the South St. Vital Trail.
- The Niakwa Trail connects the Dakota/Dunkirk Pathway with Archibald Street's trail and terminates at Niakwa Road East, just past boulevard Lagimodière.
- Winnipeg's east features the Transcona Trail and the South Transcona Community Path, as well as a segment of trail along Pandora Avenue running through the Transcona Ward.

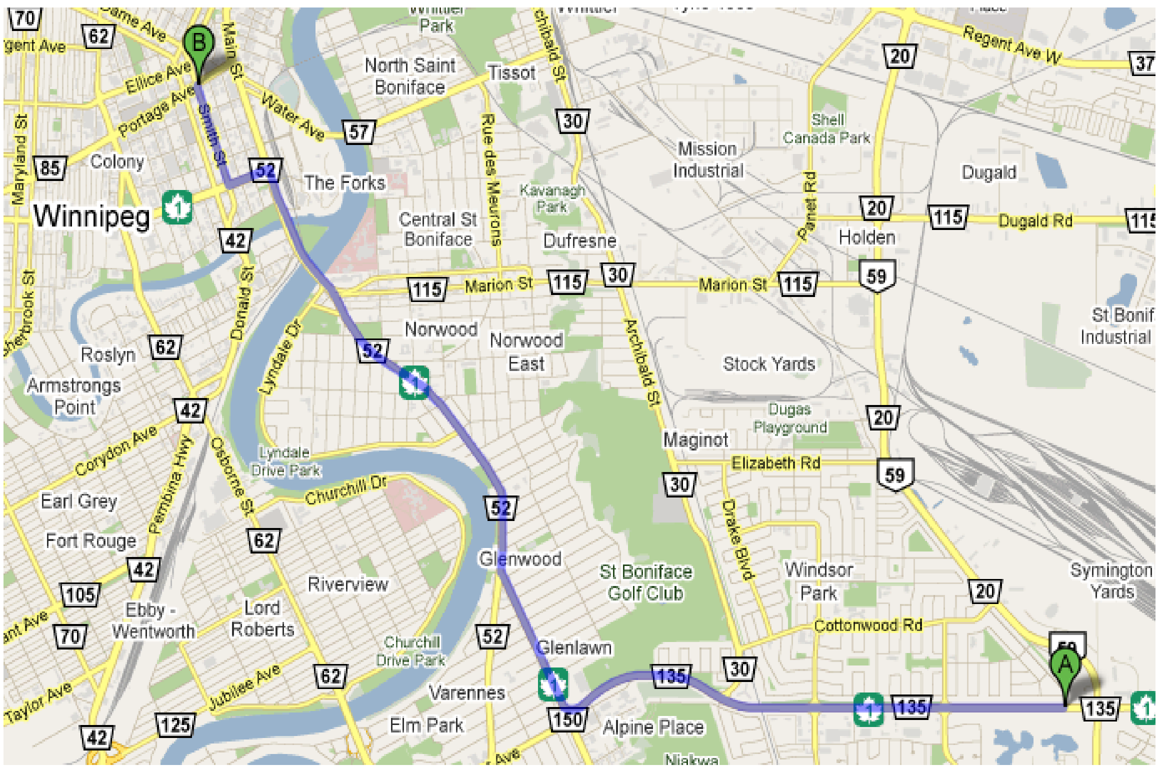
Appendix 1

Suppose you depart from the Winnipeg Mint and your destination is the MTS Centre at 300 Portage Avenue. Which route would you take?

Option #1

Traffic Volume is very high.
Total distance is 10.4 kilometres (6.4 miles).
Total travel time is 31 minutes at 20 km/h with no stopping.

The Route: Exit onto Fermor Avenue and travel west. Turn north on St. Anne's Road and continue onto Main Street. Turn west on Broadway and north onto Smith Street to the MTS Centre.

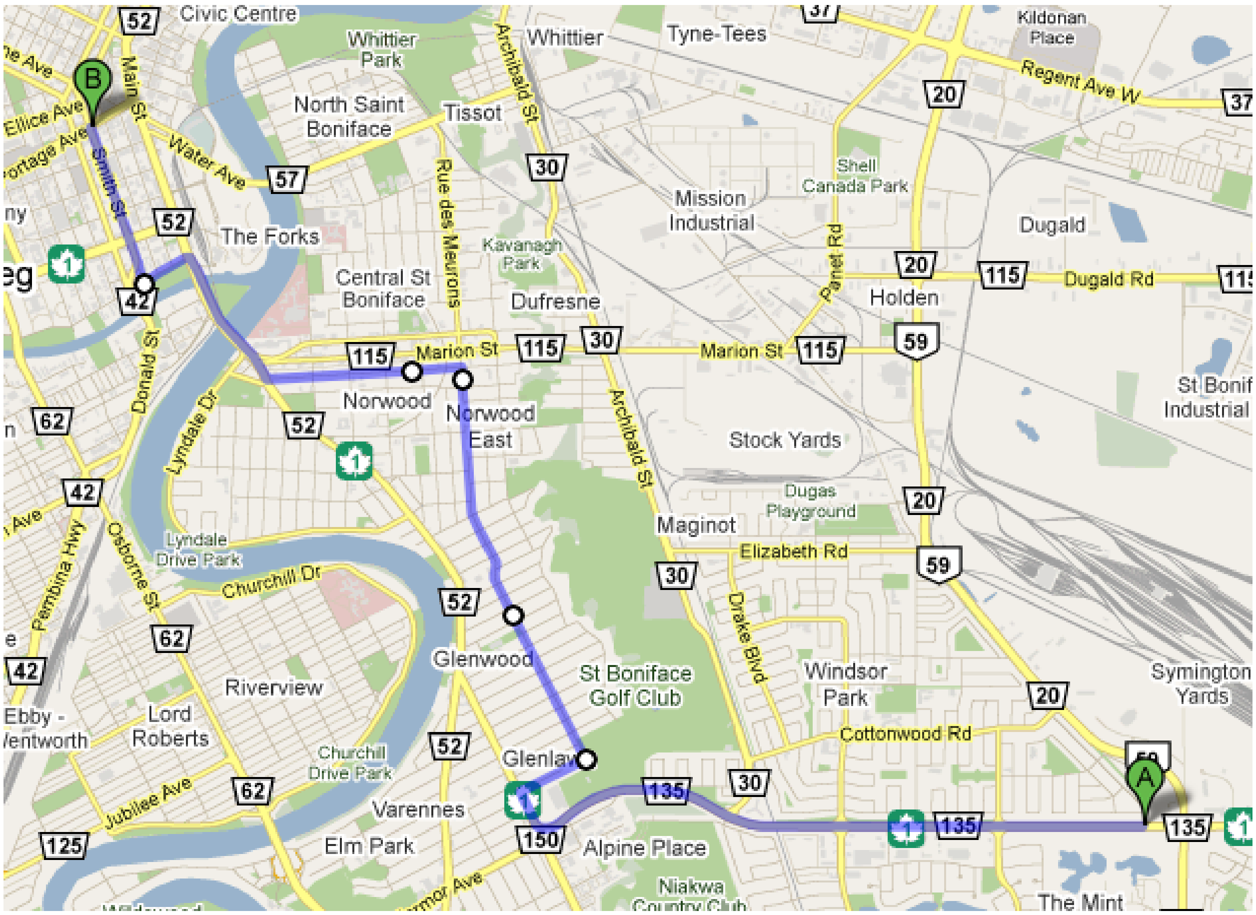


All maps source: Google Maps

Option #2

Traffic Volume is moderate-high.
Total distance is 11.8 kilometres (7.3 miles).
Total travel time is 36 minutes at 20 km/h with no stopping.

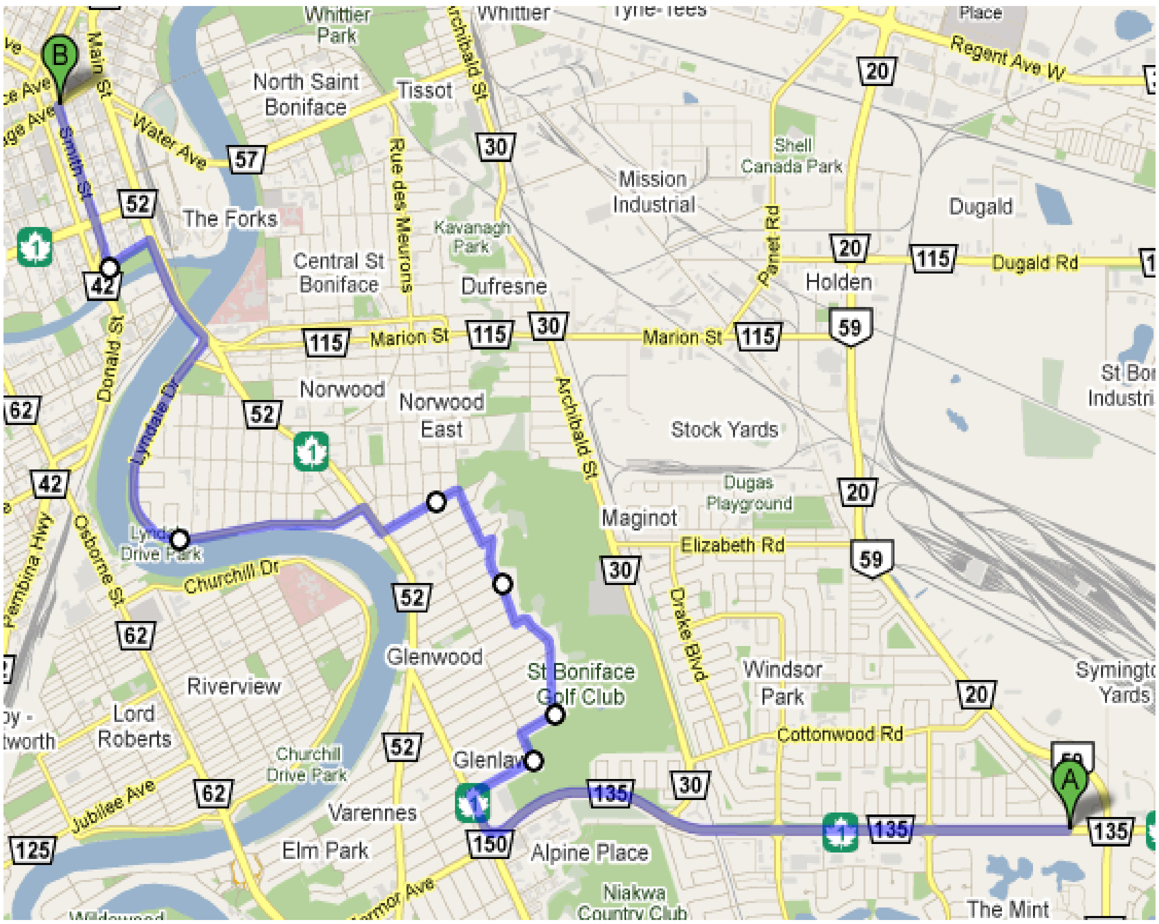
The Route: Exit onto Fermor Avenue and travel west. Turn off the pathway to connect to rue des Meurons. Head north and turn west on Horace Street. Turn north onto St. Mary's Road and cross the Norwood Bridge. Turn west onto Assiniboine Avenue and north on Smith Avenue to the MTS Centre.



Option #3

Traffic Volume is low.
Total distance is 13.8 kilometres (8.6 miles).
Total travel time is 42 minutes at 20 km/h with no stopping.

The Route: Exit onto Fermor Avenue and travel west. Turn off the pathway to connect to rue des Meurons and travel north. Turn east on Bank Avenue then north on Egerton Road. Turn west on Haig Avenue and north on rue Youville. Turn west on Carriere Avenue and enter onto Lyndale Drive. Continue over the Norwood Bridge. Turn west onto Assiniboine Avenue and north on Smith Avenue to the MTS Centre.



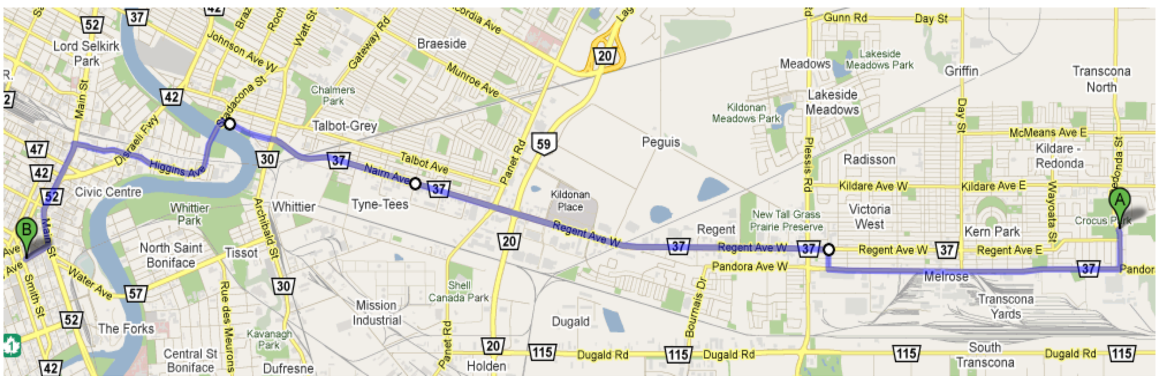
Appendix 2

Suppose you depart from Crocus Park and your destination is the MTS Centre at 300 Portage Avenue. Which route would you take?

Option #1

Traffic Volume is high.
Total distance is 14.1 kilometres (8.7 miles).
Total travel time is 42 minutes at 20 km/h with no stopping.

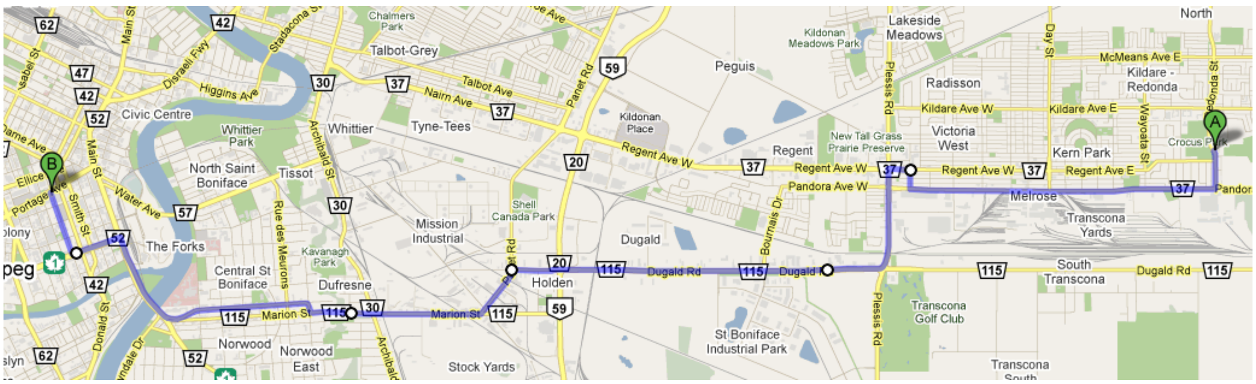
The Route: Exit Crocus Park and travel south on Redonda Street. Turn west on Pandora Avenue East and travel to Moroz Street. Turn west on Regent Avenue and continue on Nairn Avenue. Turn south on Stadacona Street over the Louise Bridge. Continue on Higgins Avenue and turn south on Main Street. Turn west on Portage Avenue to the MTS Centre.



Option #2

Traffic Volume is moderate-high.
Total distance is 14.7 kilometres (9.1 miles).
Total travel time is 44 minutes at 20 km/h with no stopping.

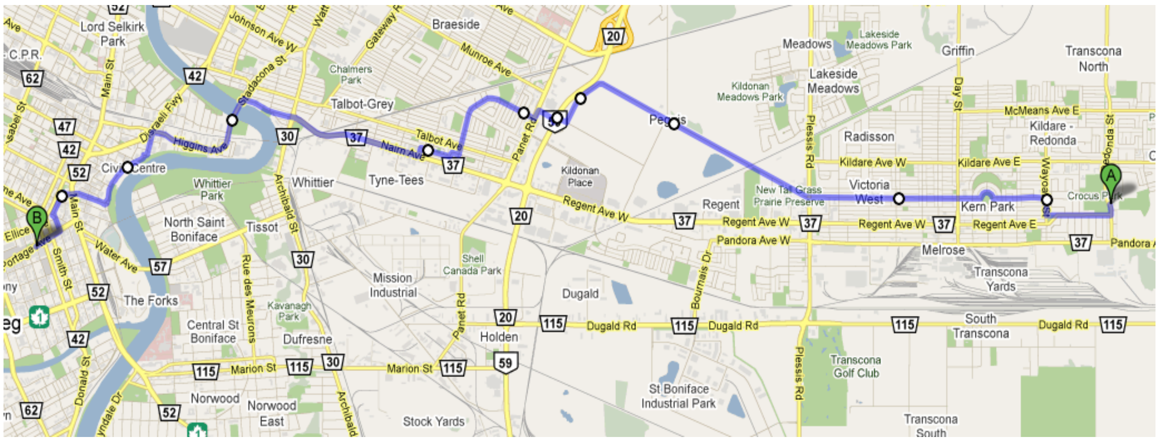
The Route: Exit Crocus Park and travel south on Redonda Street. Turn west on Pandora Avenue East, travel to Plessis Road and turn south. Go to Dugald Road and turn west. Follow Dugald Road to Panet Road and turn south to Marion Street. Continue to Goulet Street and cross the Norwood Bridge. Turn west on Broadway then north on Hargrave Street to the MTS Centre.



Option #3

Traffic Volume is moderate-low.
Total distance is 15.8 kilometres (9.8 miles).
Total travel time is 48 minutes at 20 km/h with no stopping.

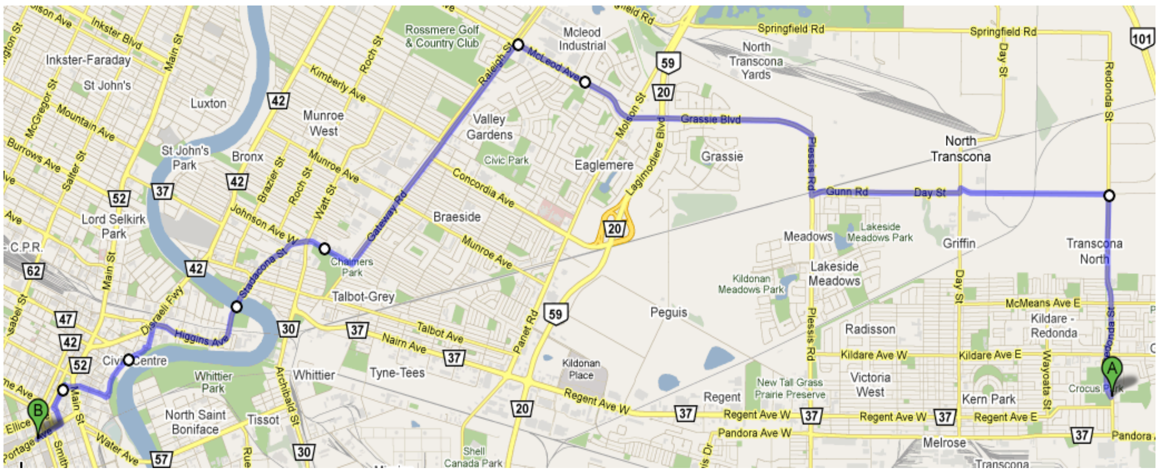
The Route: Exit Crocus Park from Victoria Avenue East to Wayoata Street. Turn west onto Ravelston Avenue East and continue past Park Circle. At Plessis Road, continue on Ravelston Avenue West to Almey Avenue and turn north. Turn south on Panet Road and west on Keenleyside Street. Turn west on McCalman Avenue, the north on Grey Street. Turn west on Talbot Avenue, cross the Louise Bridge and continue on Higgins Avenue. Turn south on Waterfront Drive and exit west on Bannatyne Avenue. Turn south on Arthur Street, continue to Garry Street. Turn west on Portage Avenue to the MTS Centre.



Option #4

Traffic Volume is low-minimal.
Total distance is 18 kilometres (11.2 miles).
Total travel time is 54 minutes at 20 km/h with no stopping.

The Route: Exit Crocus Park and head north on Redonda Street. Turn west on Gunn Road. Proceed to Day Street and turn west onto Gunn Road to continue west. Turn north on Plessis Road and then west on Grassie Boulevard. Continue to McLeod Avenue up to the Northwest Pioneers Trail. Follow the trail to Chalmers Avenue and turn west. Continue to Levis Street and onto Stadacona Street. Cross the Louise Bridge and onto Higgins Avenue. Turn south on Waterfront Drive then turn west to Bannatyne Avenue. Turn south on Arthur Street and continue west to the MTS Centre.



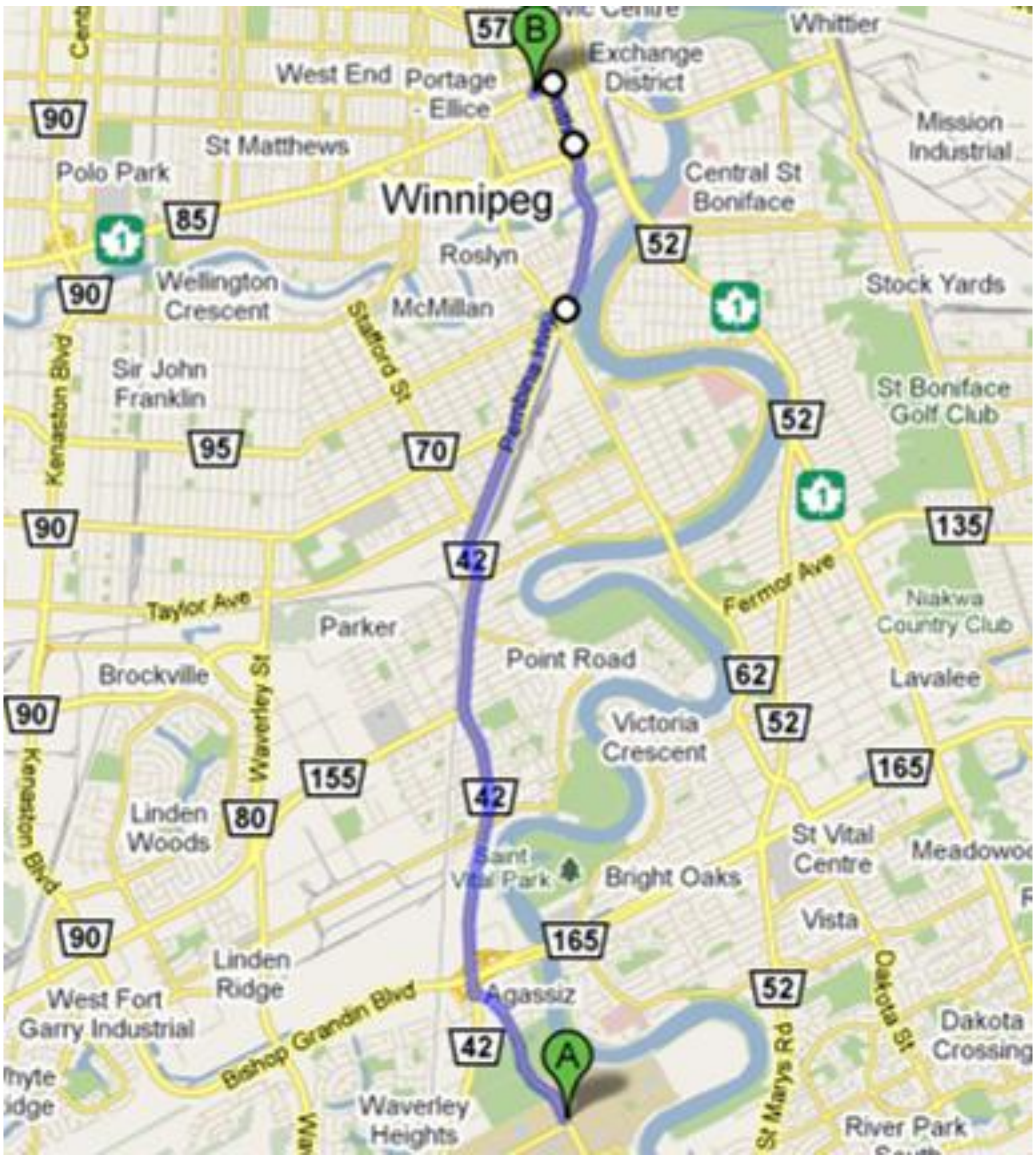
Appendix 3

Suppose you depart from The University of Manitoba and your destination is the MTS Centre at 300 Portage Avenue. Which route would you take?

Option #1

Traffic Volume is Very high.
Total distance is 11.6 kilometres (7.2 miles).
Total travel time is 35 minutes at 20 km/h with no stopping.

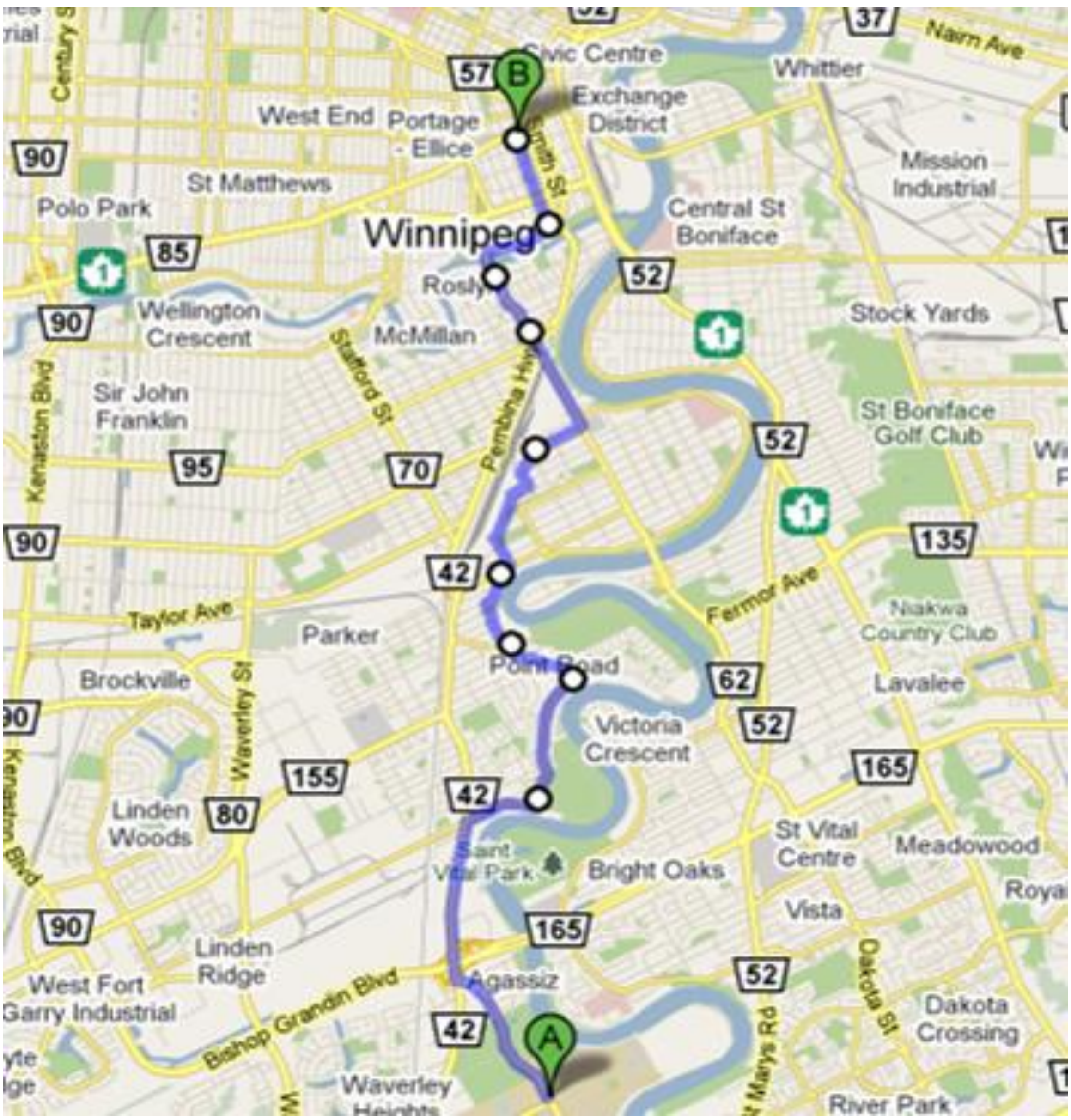
The Route: Exit the UofM on University Crescent and continue north to Pembina Highway. Turn east at Corydon Avenue (Confusion Corner) and cross the Norwood Bridge. Follow to Portage Avenue then the MTS Centre.



Option #2

Traffic Volume is moderate-low.
Total distance is 14 kilometres (8.7 miles).
Total travel time is 42 minutes at 20 km/h with no stopping.

The Route: Exit the UofM onto University Crescent and travel north. Continue on Pembina Highway and turn east at Crescent Drive. Follow Crescent Drive to South Drive—continue to Point Road and turn north. At Lyon Street, turn west onto North Drive. Follow Riverside Drive north and continue to Jubilee Avenue. Cross Jubilee to Argue Street. Turn north on Daly Street South then turn east on Carlaw Avenue. Turn north on Osborne Street and follow to Assiniboine Avenue. Turn north on Hargrave Street to the MTS Centre.



Appendix 4

Suppose you depart from East St. Paul and your destination is the MTS Centre at 300 Portage Avenue. Which route would you take?

Option #1

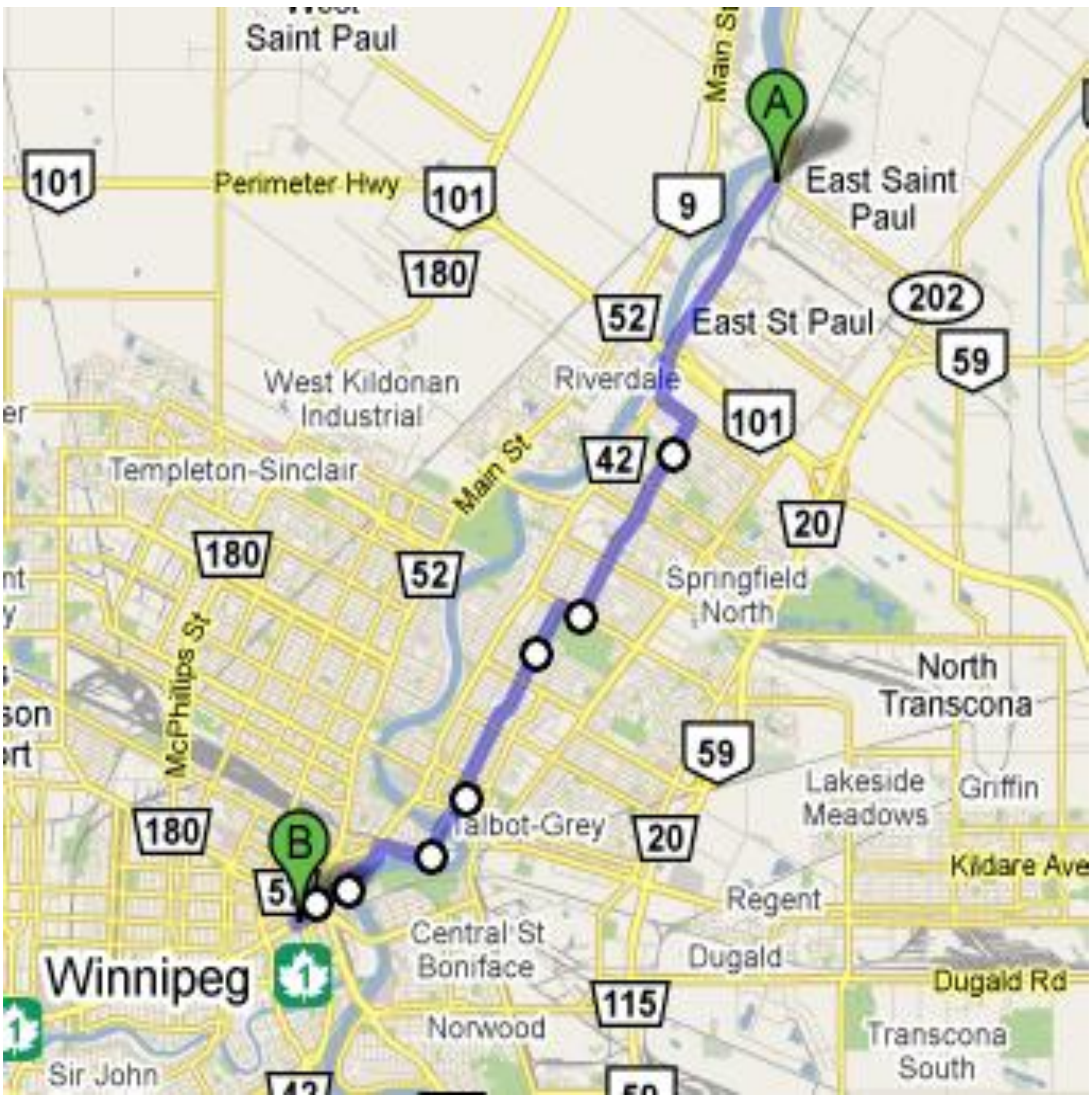
Traffic Volume is High.
Total distance is 10.8 kilometres (6.7 miles).
Total travel time is 32 minutes at 20 km/h with no stopping.

The Route: Travel south on Henderson Highway to Main Street. Follow Main Street to Portage Avenue. Turn west to the MTS Centre.

Option #2

Traffic Volume is Moderate-low.
Total distance is 12.7 kilometres (7.9 miles).
Total travel time is 38 minutes at 20 km/h with no stopping.

The Route: From Henderson Highway, turn east on Foxgrove Avenue. Turn south on Rothesay Street and follow to Rothesay Street. Turn west on McLeod Avenue then south on Roch Street. Continue to Chalmers Avenue and turn east. Turn south at Levis Street and onto Stadacona Street. Cross the Louise Bridge and onto Higgins Avenue. Turn south on Waterfront Drive then turn west to Bannatyne Avenue. Turn south on Arthur Street and continue west to the MTS Centre.



Option #3

Traffic Volume is Low-minimal.
Total distance is 13.9 kilometres (8.6 miles).
Total travel time is 42 minutes at 20 km/h with no stopping.

The Route: Heading south on Henderson Highway, turn east on Foxgrove Avenue to the Northwest Pioneers Trail. Follow the trail to Chalmers Avenue and turn west. Continue to Levis Street and onto Stadacona Street. Cross the Louise Bridge and onto Higgins Avenue. Turn south on Waterfront Drive then turn west to Bannatyne Avenue. Turn south on Arthur Street and continue west to the MTS Centre.

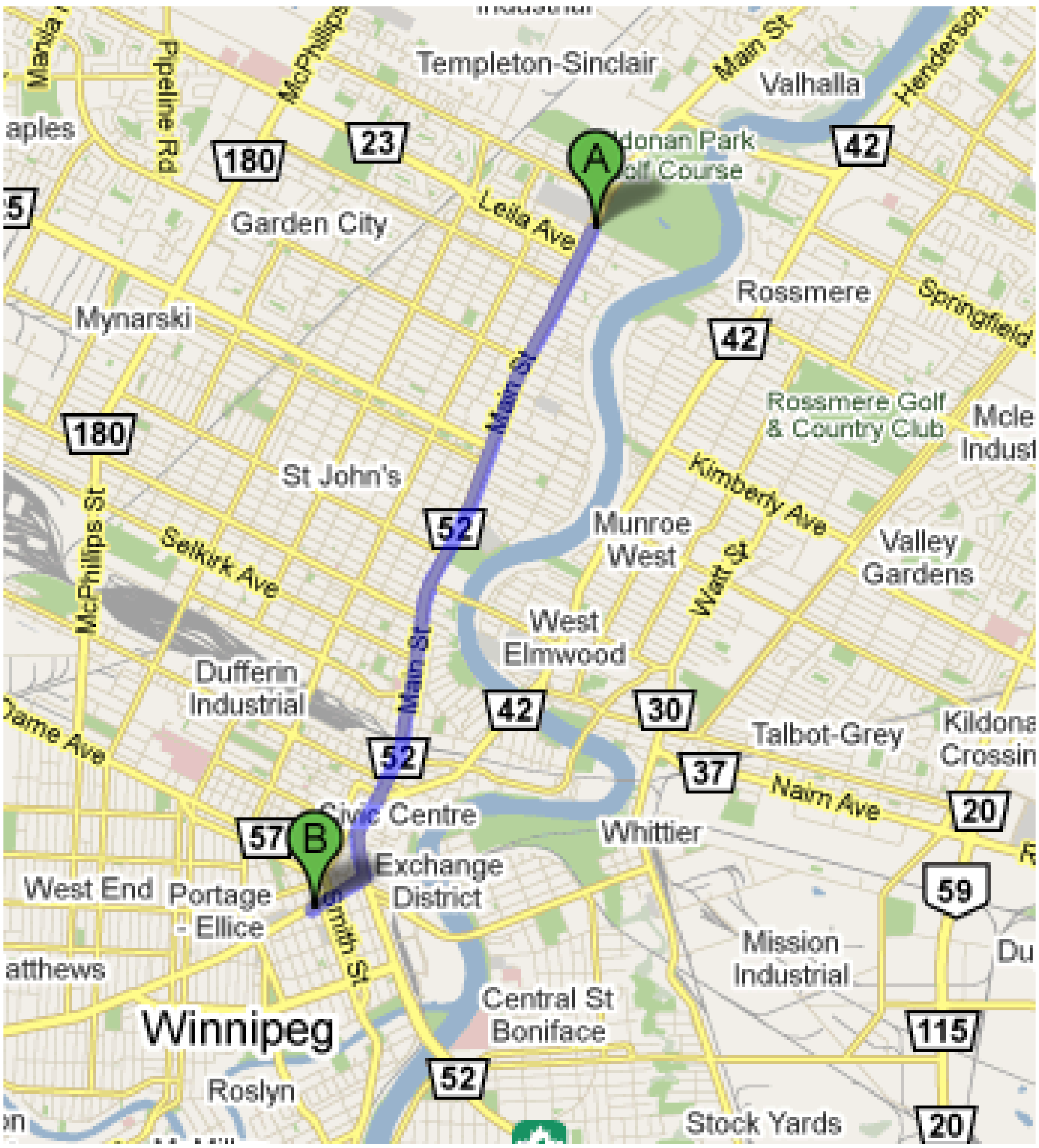
Appendix 5

Suppose you depart from Kildonan Park and your destination is the MTS Centre at 300 Portage Avenue. Which route would you take?

Option #1

Traffic Volume is Very high.
Total distance is 7 kilometres (4.3 miles).
Total travel time is 21 minutes at 20 km/h with no stopping.

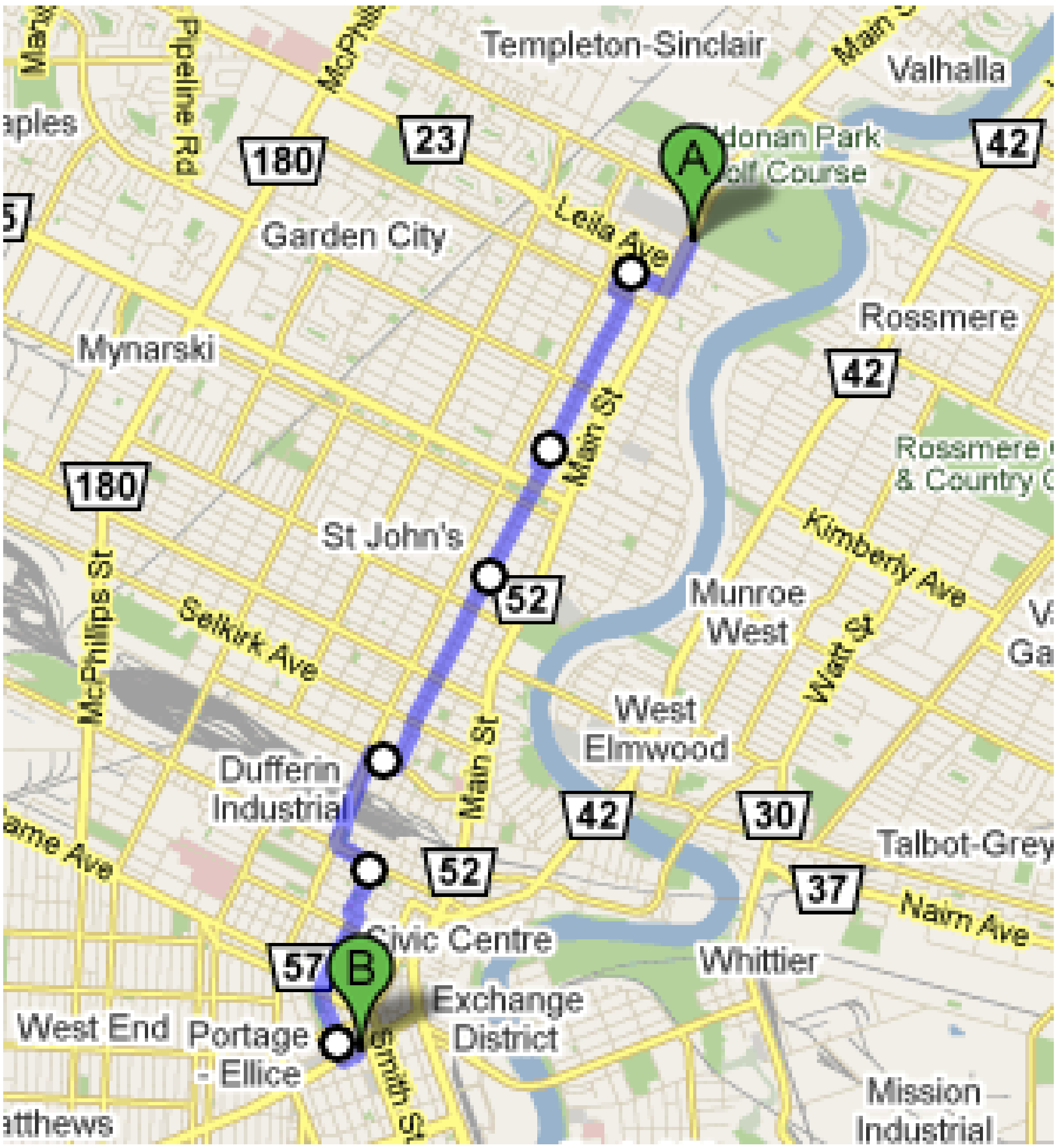
The Route: Exit Kildonan Park onto Main Street. Follow Main Street to Portage Avenue to the MTS Centre.



Option #2

Traffic Volume is Moderate.
Total distance is 7.9 kilometres (4.9 miles).
Total travel time is 23 minutes at 20 km/h with no stopping.

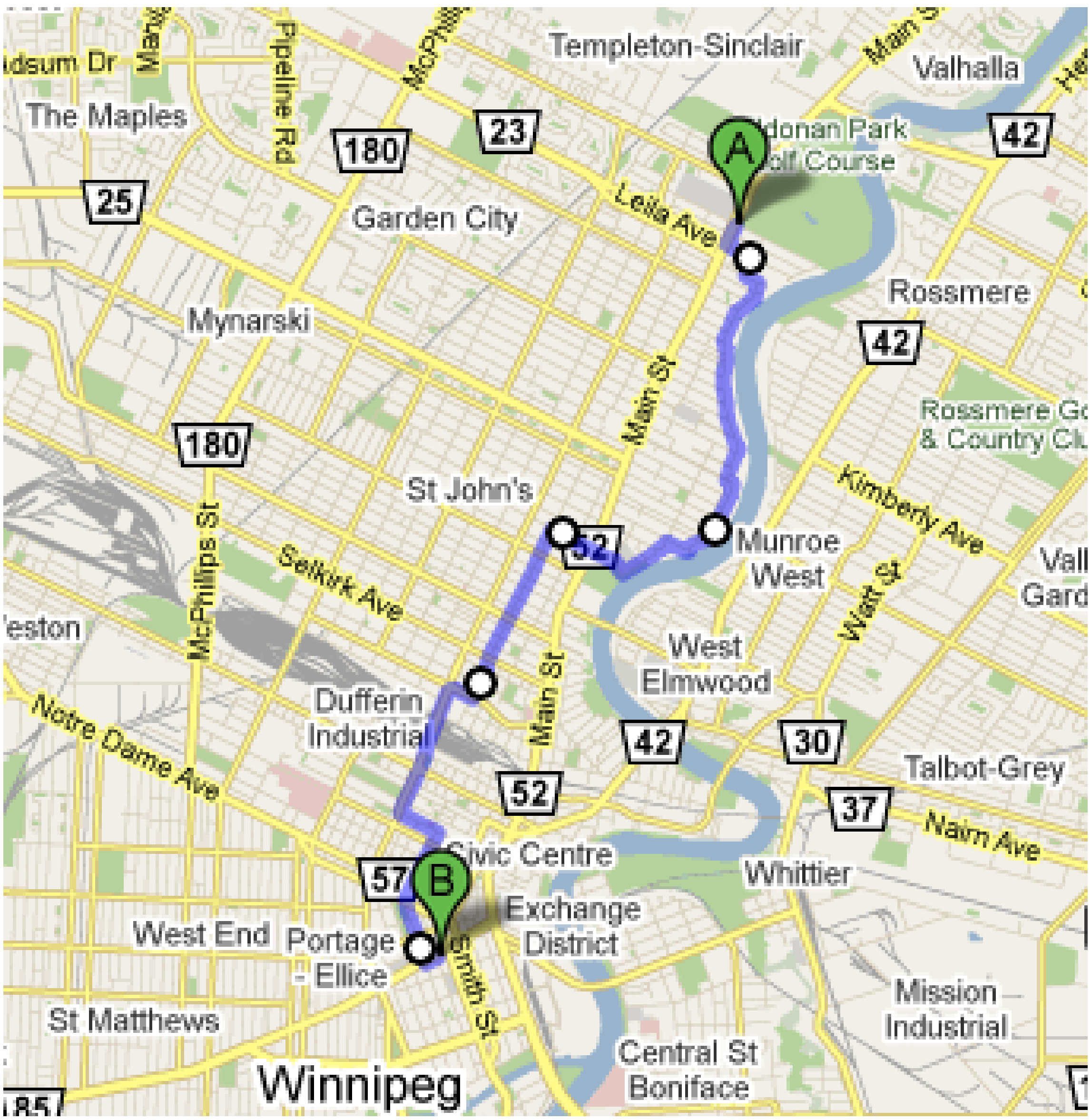
The Route: Exit Kildonan Park onto Main Street and head south. Turn west at Forrest Avenue to Aikins Street. Continue on Aikens to Dufferin Avenue and turn west to Salter Street. Cross the Slaw Rechuk Bridge and turn east on Logan Avenue then south on Ellen Avenue. Follow Carlton Street to Portage Avenue and the MTS Centre.



Option #3

Traffic Volume is Low-minimal-moderate.
Total distance is 9.1 kilometres (5.6 miles).
Total travel time is 27 minutes at 20 km/h with no stopping.

The Route: Exit Kildonan Park onto Main Street. Head south to Leila Avenue and turn east to Ord Street. Turn east on Forrest Avenue and continue on Scotia Street until Cathedral Avenue. Turn south on St. Cross Street and continue to Anderson Avenue. Turn south on Aikens Street and then west on Dufferin Avenue. Turn south on Salter Street to cross the Slaw Rebchuk Bridge. Turn east on Logan Avenue then south on Ellen Avenue. Follow Carlton Street to Portage Avenue and the MTS Centre.



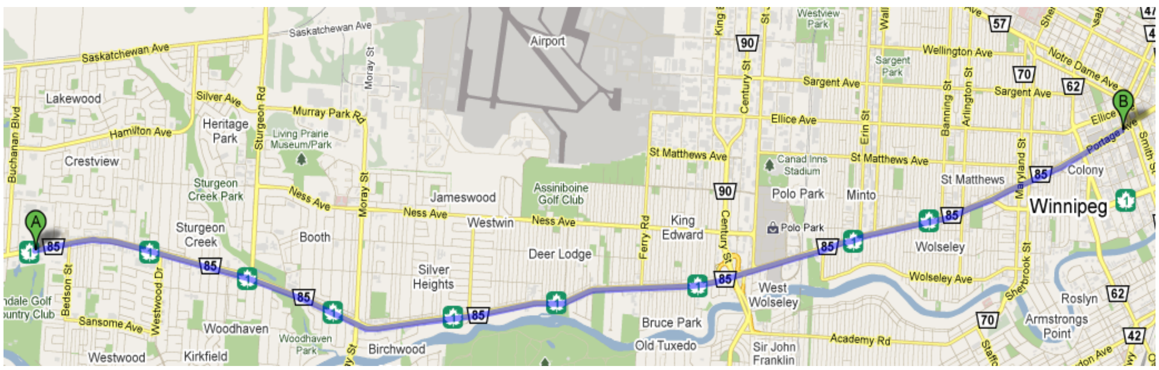
Appendix 6

Suppose you depart from Unicity and your destination is the MTS Centre at 300 Portage Avenue. Which route would you take?

Option #1

Traffic Volume is Very high.
Total distance is 12.6 kilometres (7.8 miles).
Total travel time is 38 minutes at 20 km/h with no stopping.

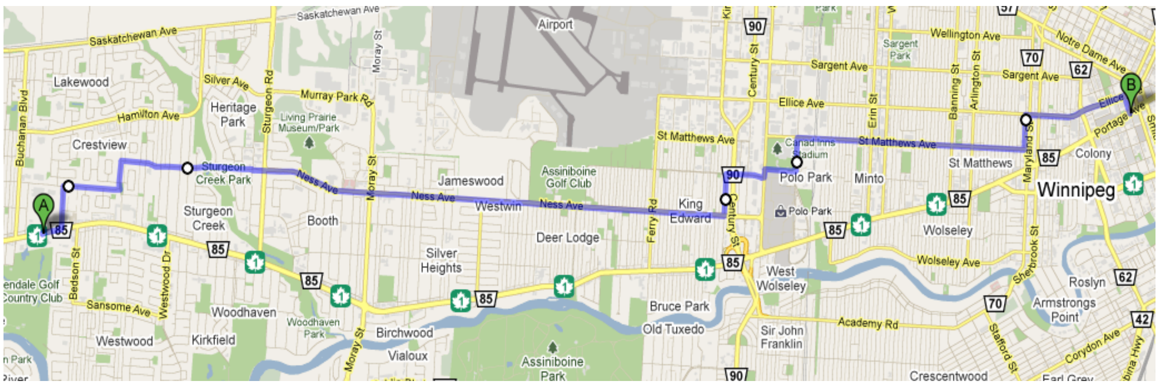
The Route: Exit on Portage Avenue and travel to the MTS Centre.



Option #2

Traffic Volume is High-moderate.
Total distance is 13.8 kilometres (8.6 miles).
Total travel time is 42 minutes at 20 km/h with no stopping.

The Route: Exit Unicity on Fairlane Avenue. Travel east and turn north on Cavalier Drive. Turn east at Ness Avenue and follow to Queen Street. Turn north and follow to Silver Avenue. Travel east and turn north at St. James Street. Turn east at Maroons Road and then north on Empress Street. Turn east on St. Matthews Avenue up to McGee Street and turn north. Turn east at Ellice Avenue and south on Donald Street to the MTS Centre.



Option #3

Traffic Volume is Low-minimal.
Total distance is 16.5 kilometres (10.23 miles).
Total travel time is 50 minutes at 20 km/h with no stopping.

The Route: Exit Unicity on Fairlane Avenue. Travel east and turn north on Cavalier Drive. Turn east at Ness Avenue and then south on Sturgeon Drive. Turn east on Booth Drive and turn east on Bruce Avenue. Travel to Ferry Road and turn south. Follow to the Assiniboine River pathway and continue to Wolseley Avenue. Follow Wolesley Avenue to Furby Street and turn north, then east on Westminster Avenue. From Young Street, turn east on Balmoral Street. Reconnect with the Assiniboine River pathway and turn north on Hargrave Avenue to the MTS Centre.