Walkability Audits in Winter Cities: Planning for a Healthier Canada

by

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ABSTRACT

As connections are drawn between physical activity and the built environment, various elements have emerged as key contributors to the viability of walking as a form of transportation, including land-use patterns, architecture and landscape, and the transportation system. The resulting concept of walkability is strongly correlated with transportation physical activity. Developing efficient measures of the built environment is essential to the advancement of further research in this area. This project envisions enhancing walkability as an urban intervention to support community health. The research assesses qualities of the urban street environment that may improve the walkability of Winnipeg, identifying climatic gaps that exist in current walkability auditing tools. This research is based on literature review of the health benefits surrounding walkability, unobtrusive observation of three neighbourhoods, and a systematic review of seven walkability audits. The result is a set of research, planning and design recommendations for how to better design audits to reflect the reality of winter, in order to more fittingly assess and improve upon the walkability needs of winter cities in Canada.

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LIST OF ACRONYMS

- **WSB** – Walking School Bus
- **SPACES** – Systematic Pedestrian and Cycling Environmental Scan
- **NALP** – Neighbourhood Active Living Potential
- **WSAF** – Walking Suitability Assessment Form
- **AAT** – Analytic Audit Tool
- **ACT** – Audit Checklist Tool
- **SAT** – Sidewalk Assessment Tool
- **ANC** – Active Neighbourhood Checklist
- **PEDS** – Pedestrian Environmental Data Scan

1.0 INTRODUCTION

I grew up happily in St. James-Assiniboine, deep in the suburbs of Winnipeg, walking to and from school and my friends' homes. When I began carpooling or bussing to the University of Manitoba, the concept of walkable communities still had not crossed my mind. However, when I moved to Melbourne, Australia to study abroad in 2009, I immediately found myself an apartment within walking distance of everything I needed. It suddenly seemed the natural choice to live in a well-connected neighbourhood. Since then, I have travelled enough to witness some of both the positive and negative effects urban environments can have on their residents.

Having studied Kinesiology in Canada, and Exercise and Sport Science in Australia during my undergrad, I am passionate about population health. Time and experience have further honed my specific interest in how a physically active lifestyle can be achieved, through such accessible means as active transportation. This thesis project developed with this concept as its primary inspiration. It is about the health benefits we stand to gain from active lifestyles – about encouraging walking as a feasible means of transportation. It is about the urban experience during Canadian prairie winters, and how planners may better encourage year-round walking behaviour by first properly evaluating the everyday issues facing pedestrians. It is my hope the recommendations produced here will help contribute to the evolution of more walkable cities in Canada, and particularly, a more walkable Winnipeg.

1.1 Topic Overview & Background

The location of this study is Winnipeg, Manitoba. In a slow growth, sprawling city such as Winnipeg, it can be an uphill battle to promote walking as a mode of transportation. In addition, the city is known for its continental climate; summers are short and hot, while winters are long

and cold, with strong winds sweeping down from the Arctic across the prairie flatlands (Living in Canada, 2015). Cold temperatures, snow and shortened daylight hours influence both the ability of people to walk in the winter and their desire to do so (Coleman, n.d.). The neighbourhoods of West Broadway, Crescentwood, and Crestview, were chosen for more critical observation within the city, as three distinct neighbourhoods representing examples of high, medium, and low walkability, respectively. Site selection and level of walkability was based off numerical walkability scores from the publicly available walkability assessment tool, Walk Score (2016). Recently, studies have shown Walk Score to be a valid and reliable metric of estimating access to amenities (Carr, Dunsiger & Marcus, 2010; Carr, Dunsiger & Marcus, 2011; Cole, Dunn, Hunter, Owen & Sugivama, 2015). For the purposes of this research, it proved a convenient and inexpensive option for considering walkability as it may pertain to physical activity (Carr et al., 2011).

The boundary maps of each neighbourhood can be found in Appendix A. Observing a greater range of environmental features across three different sites will hopefully make results more widely transferable to other winter cities. Furthermore, observing neighbourhoods with varying levels of walkability provided some insight into pedestrian behaviour during the winter season. Recurrent and/or unique strengths and weakness of each neighbourhood's walkability were highlighted by the season.

Much research has been done on the health benefits of walking, and subsequently, the effects of walkability on health. However, for the purposes of this project, the focus is on how walkability audits may be used as tools to help address opportunities for physical activity. Specifically, commonly used audits were reviewed for their consideration of climatic issues in winter cities. I hope to increase general awareness surrounding the topic of walkability in

Winnipeg, and how auditing tools may be used to direct policy implementation for building healthier winter cities.

Winnipeg has provided a good site for this study, due to the unique challenges posed to planners in trying to make the winter city walkable. Being the quintessential winter city, lessons learned about cold weather walkability in Winnipeg may be applicable toward other North American cities. Based on review of the literature, very little research appears to exist on the topic of winter walkability, and this project intends to start filling the gap.

1.2 Purpose

This work explores how to adapt auditing tools to measure more effectively – and hopefully improve upon – the baseline walkability of communities. It examines the capacity of standard walkability auditing tools to assess accurately the physical environment with regard to winter conditions. While climatic issues must be considered in order to progress toward a more walkable winter city, many standard auditing tools do not, in their current form, address cold weather questions.

I have examined this gap within a micro context – observing the conditions present in three diverse Winnipeg neighbourhoods. Through the detailed observation of sites and the systematic review of standard auditing tools, I have identified several key barriers to walkability not generally addressed in the audits. In this document, I aim to focus my observations in order to develop a set of recommendations for adaptations to walkability audits. I also used photographic documentation to help illustrate some of the conditions observed during site observations and provide visual examples of the possible concerns currently absent in auditing tools.

Key themes in the walkability literature include the positive health effects associated with regular, short bouts of walking, as well as the higher level of physical activity observed among those living in walkable communities (Lee et al., 2012; Murphy et al., 2002). In addressing the apparent climatic gap in standard audit design, this thesis asks how the walkability of a community can be improved upon, if the wrong questions are being asked? It explores how planners can better use walkability auditing tools to promote active transportation within their cities, and subsequently promote general population health.

1.3 Key Research Questions

Throughout this thesis I endeavour to answer the following questions:

1. **To what extent do current walkability audits reflect the realities of urban winter living?**
2. **How can walkability audits be better designed to address walkability issues residents in Canadian winter cities face?**

1.4 Brief Overview of Research Methods

This project used qualitative research and analysis to answer the proposed research questions:

- *Walkability site overviews and unobtrusive observation* were used to answer 1) To what extent do current walkability audits reflect the realities of urban winter living?
- *Systematic review* of the data from the four stages of my research was used to answer 2) How can walkability audits be better designed to address walkability issues residents in Canadian winter cities face?

This research provides recommendations for how to manage the challenge of improving walkability in Winnipeg through potential adaptation of existing walkability audits. Further explanation of research methods follows in Chapter 3.

1.5 Significance of Research

In Canada, heart disease and stroke are two of the top three leadings causes of death (Statistics Canada, 2011). In the most recent data set available from Statistics Canada, 68,342 deaths were attributed to major cardiovascular diseases (Statistics Canada, 2009). However, changes in lifestyle can greatly reduce cardiometabolic risk. One of those lifestyle changes is exercising regularly. Achieving recommended levels of daily physical activity can be daunting, but studies of public health, medicine and urban planning are showing evidence walking can be a primary means of accomplishing the task (Mehta, 2008). Designing the built environment with consideration towards encouraging physical activity offers the opportunity to engage in physical activity as a *natural* part of *daily* routines, rather than a scheduled requirement. Further, while walking may not be accessible to all people, design of the pedestrian environment remains important for everyone, including those with mobility disabilities who may have limited travel choices (Boodlal, 2001). Walkable design will encourage the physical activity needed to improve population health by very attainable and modest means.

The concept of walkability is multidisciplinary, crossing the fields of health sciences, social sciences, urban planning, architecture, economy and geography. Planners have a unique set of skills that combine the fields of community consultation, social activism, strategic planning, urban design, and mapping, arming them with the ability to address community walkability confidently. However, appropriate tools are required in order to properly assess and

improve upon walkability. Researchers trying to connect transportation physical activity and environmental features must be able to accurately measure elements of the walking environment. Identifying climatic gaps in walkability audits will be useful in helping planners design better tools that reflect the reality of winter cities. By addressing these gaps, auditing tools can be designed to assess more accurately, and ultimately, improve upon walkability in cities, such as Winnipeg. In this way, Winnipeg planners can use their expertise to contribute to broader community health in creative ways.

1.6 Outline of Chapters

In **Chapter 1**, I introduced the topic of research, the purpose and significance of the work, and the problem statement. Two research questions were posed, accompanied by a brief overview of the methods by which they will be answered.

In **Chapter 2**, relevant academic literature is reviewed on topics including the health benefits of walking, the effect of walkable neighbourhoods on walking behaviour, the relationship between walkability and health, perceptions of walkability and the built environment, function of the built environment, form of the built environment, winter pedestrian challenges, and walkability audits measuring walkability.

Chapter 3 discusses the methodology used, describing each research method, rationale for use, and reliability of the combined methods.

In **Chapter 4**, the routes taken through each of the three neighbourhoods observed are mapped. In addition, a brief background is provided regarding each study area.

Chapter 5 contains unobtrusive observations gained, from walking each of the mapped routes. The observations include transcribed notes from the walks, as well as written directly afterward in the instance of equipment malfunction. In addition, it includes 15 photographs, selected to illustrate key observations regarding issues that arise in an urban winter environment. The photos were selected to complement the raw data of recorded and written field notes, as well as draw attention to climatic gaps existing in current walkability audits. They also help to demonstrate the certain pedestrian resolve that endures in Winnipeg, regardless of the climate.

Chapter 6 systematically reviews seven walkability auditing tools, including background and content, as well as an assessment of climatic gaps. These gaps are addressed from the perspective that with certain adaptation, these tools remain useful instruments with which to assess community walkability, regardless of season. While this may necessitate broadening the scope of assessment by including more items, or by adapting the language used, both strengths and weaknesses of each tool are considered.

Chapter 7 summarizes the findings, including limitations, implications of the research on planning practice, possible directions for future research, as well as recommendations for improving auditing tools for general use in winter cities.

2.0 LITERATURE REVIEW

A literature review is intended to build a foundation of knowledge, develop a conceptual framework, and provide a point of reference from which to interpret findings (Rocco and Plakhotnik, 2009). Furthermore, it can provide clues about where future research is headed, as well as identify gaps in the literature that may guide recommended areas of focus (University of Guelph, n.d.).

The multidisciplinary literature examined belonged to various areas of research, including health sciences, social sciences, urban planning, architecture, economics and geography. The literature is extensive, and this review focused on journal articles, though some municipal strategies and relevant press articles were also studied. Articles reviewed were published during a 16-year period (2000 and 2015), in various places around the world, including Australia, Belgium, Canada, Denmark, Malaysia, New Zealand and the United States. Regarding the health effects of walkable neighbourhoods, an emphasis was placed on articles published within the last five years, with some reflection on earlier articles to demonstrate the consistency of guidelines about physical activity, and acclaim for walking as a form of exercise over the years. The same effort was made when considering examples of walkable cities worldwide, in order to depict accurately current walkability standards and projects.

Overwhelmingly, the literature reviewed reveals regular exercise can greatly reduce the risk of many chronic conditions, including heart disease and stroke. Studies of public health, medicine and urban planning are showing evidence that walking can be the primary means of achieving recommended levels of daily physical activity (Mehta, 2008). From a planning perspective, various elements of the built environment are now widely considered to encourage

walking. As a major concept associated with sustainable urban design, the term 'walkability' represents the capacity of the built environment either to facilitate or impede walking for the purposes of daily living (Andrews, Hall, Evans, & Colls, 2012).

Increasingly, connections are being drawn between physical activity and the physical form of communities (Brownson, Hoehner, Day, Forsyth & Sallis, 2009). Various elements of the physical or built environment contribute to the accessibility of physical activity, including land-use patterns, architecture and landscape, and the transportation system (Brownson et al., 2009). Transportation physical activity may be most related to walkability, the concept of which is made up of several components. Factors associated with greater frequency of walking for transportation purposes include residential density, diversity of land-use mix, street connectivity, access to services, pedestrian infrastructure, aesthetics, traffic safety, and safety from crime (Lo, 2009; Nyunt et al., 2015; Saelens & Handy, 2008; Saelens, Sallis, Black & Chen, 2003).

It is now commonly recognized the fields of urban design and public health have a mutual interest in walkable communities. Designing communities and cities to be more walkable enables people to engage in physical activity as a natural part of daily routine, rather than a scheduled requirement. It naturally encourages the physical activity needed to improve population health, by very attainable and very modest means. With so many variables to consider when designing communities and cities to be walkable, applying lessons and strategies from around the world will prove useful in helping Winnipeg to become more walkable. However, the following review highlights an apparent gap in the existing literature on the topic of winter walkability, particularly in a North American context. This gap begs the need for further research.

2.1 The health benefits derived from physical activity/walking

This theme represents the vast body of available research that examines the various health effects of walking as a form of physical activity. The many health benefits of physical activity are well documented. For years, recommended guidelines for physical activity have had similar minimum standards, ranging from 30 minutes of moderate-intensity physical activity, most days of the week; to 30 minutes, 3-5 days a week at 50% of peak oxygen consumption; to current Canadian standards of 150 minutes of moderate- to vigorous-intensity physical activity per week, in bouts of at least ten minutes (CSEP, 2014; Hennekens, 2000; Morton, West, Stephens, Bain, & Bracken, 2010; Wong & Wong, 2002). However, despite evidence of the innumerable health benefits of physical activity, many people do not adhere to the current recommendations. A large percentage of the population does not exercise enough to maintain optimal health, and physical inactivity is a prevailing cardiovascular risk factor (Lee et al., 2012; Murtagh, Murphy, & Boone-Heinonen, 2010; Wong & Wong, 2002). Though it is possible low compliance with physical activity guidelines is due to ignorance, "it is also possible that setting a standard that is perceived as being too high could deter some people from even trying" (Lee et al., 2012, p. 227).

Currently, health professionals are facing "the challenge of prescribing physical activity that will be sustained by the sedentary majority" (Murtagh et al., 2010, p. 490). The Canadian Physical Activity Guidelines outlines bouts as small as ten minutes of moderate-intensity physical activity can yield important benefits. Walking is an accessible form of exercise prescription, low-cost, requiring no special skills or equipment, achievable by virtually all age groups and populations – sedentary or otherwise, with little risk of injury (Murphy, Nevill, Neville, Biddle, & Hardman 2002; Murtagh et al., 2010). Intermediate goals of short bouts of exercise at intervals throughout the day may be more achievable for the larger population, and

walking is an ideal activity for such a task (Lee et al., 2012, p. 230; Murphy et al., 2002). In addition, the prescription of walking may better skirt such barriers to physical activity as 'lack of time,' and embarrassment or self-consciousness (Murtagh et al., 2010). Through short bouts of brisk walking, moderate-intensity physical activity may be accumulated throughout the day, promoting better adherence to exercise than vigorous-intensity physical activity, and enabling people to reach the goal of 150 minutes per week (Murtagh et al., 2010). The value of walking is such that it "has been described as the nearest activity to perfect exercise" (Murtagh et al., 2010, p. 490).

Research on the effects of walking on cardiometabolic risk as a sum of its factors is limited; however, there is sufficient research focusing on the individual or multiple factors that can result in a diagnosis of cardiometabolic syndrome. These factors include: abdominal obesity, atherogenic dyslipidemia, persistent high blood pressure, insulin resistance and proinflammatory state (Dragana & Milica, 2013). Epidemiological studies show regular walking is associated with a lower risk of cardiovascular disease and type II diabetes, whether conducted at moderate-intensity, vigorous-intensity, or by accumulating steps, in longer bouts, or in multiple short bouts (Lee et al., 2012; Morton et al., 2010; Murphy et al., 2002; Murtagh et al., 2010; Woolf-May, Scott, Kearney, & Jones 2011). Various methods have been employed and different factors of health measured in different studies, but all point to the benefits of walking.

A study by Lee et al. (2012) used accelerometers to measure minutes spent walking at light intensity, minutes spent walking at moderate intensity and number of steps, against seven health conditions, including hypertension, cancer, stroke, depression, physical function, pulse rate, and blood pressure. Those who participated included people who reported daily levels of zero to low physical activity. The trial lasted only four days, yet still had significant effects on health

indicators. Interestingly, number of steps walked per day was most strongly associated with the seven indicators of health, with pulse rate and blood pressure having the weakest correlations. The lack of association between walking and high blood pressure is a comparable finding to other studies (Lee et al., 2012; Woolf-May et al., 2011). In another study on the effects of 24 weeks of walking upon cardiometabolic risk factors in sedentary men, only abdominal adiposity was significantly reduced (Woolf-May et al., 2011). However, as reductions in waist circumference were accompanied by a reduction in serum insulin, the findings indicate for 'at risk' men, even an increase of 1.4 hours per week of moderate-intensity walking can decrease their risk of developing cardiometabolic syndrome and type II diabetes (Woolf-May et al., 2011). Similarly, Morton et al. (2010) found decreases in waist circumference after 28 walking sessions with an average length of 35 minutes were recorded over seven weeks. This study noted abdominal adipose tissue as a predictor of cardiometabolic risk, as well its associations with possible reduction to insulin resistance (Morton et al., 2010).

Several limitations have been noted in these studies. Oftentimes participation in a trial is based on self-reported levels of physical activity, which are based on different routines and types of recreation. These factors may make it difficult to achieve a level of consistency among participants (Lee et al., 2012). In addition, data is missing on people's motivation for walking, so it is possible those with various diagnoses are more aware of the health benefits of walking and exert a greater level of effort throughout a trial (Lee et al., 2012). Though participants may be asked to control diet, this is often based on trust and can be difficult to manage (Woolf-May et al., 2011). Finally, criticism exists for not considering intensity of physical activity, when studying the number of steps accomplished and health benefits conferred; further research is required on this association (Lee et al., 2012).

When reviewing the advantages to walking as a form of exercise, there are several important points to consider. Engaging in short bouts of regular walking, even at low intensity, can result in health benefits similar to those achieved from fewer, longer bouts of walking (Lee et al., 2012; Murphy et al., 2002). Furthermore, intermediate goals of shorter bouts of walking may be more realistic for previously sedentary people, showing higher rates of completion and fewer signs of attrition (Lee et al., 2012; Murphy et al., 2002). In addition to length of time spent walking, number of steps accumulated appears to be associated with fewer health problems, which may entice those people who list 'lack of time' as a barrier to physical activity (Lee et al., 2012; Murtagh et al., 2010). Evidence suggests even small daily improvements in the amount of walking engagement are better than no walking, but the greater the increase, the larger the cardiovascular health benefits (Lee et al., 2012; Murtagh et al., 2010). Health benefits may be enjoyed by people of all ages and abilities, and include "short-term gains such as improved fitness, body composition, blood pressure, and lipid profiles. Longer-term benefits include reduced risk of coronary heart disease, coronary events, and mortality" (Murtagh et al., 2010, p. 494). Ultimately, it is important to note that even if a small improvement in health indicators was achieved at a general population level, the public health implications for protecting against cardiovascular disease and stroke would be great (Murphy et al., 2002).

2.2 The effect of walkable neighbourhoods on walking behaviour

As previously stated, the definition of walkability is built upon the themes of connectivity, population and dwelling density, intersection density, and mixed land use (Coffee et al., 2013; Van Dyck, Cardon, Deforche, & De Bourdeaudhuij, 2009). The majority of studies point to findings that suggest living in walkable communities is associated with higher levels of physical activity; however, the reasons for this require further investigation. Residential self-selection

suggests people are likely to choose to live in a neighbourhood according to their lifestyle preferences, so those who lead active lifestyles may want to live in more walkable neighbourhoods (Van Dyck, Cardon, Deforche, Owen, & De Bourdeaudhuij, 2011).

One study about walkability, physical activity and residential self-selection in Belgium unexpectedly found residents of both low and high walkable neighbourhoods considered walkability to be important when selecting a home (Van Dyck et al., 2011). A major limitation of this study is that it lacks generalizability on an international scale. Despite the objective of plotting maximal variation between high and low walkable neighbourhoods, European cities tend to vary less in this aspect than cities in the United States or Canada (Van Dyck et al., 2011). However, higher levels of physical activity were still present among residents who lived in the neighbourhoods considered highly walkable (Van Dyck et al., 2011). Even adults with a low intention to walk and/or a preference for passive transportation achieve an average 2000 steps more per day when living in a high – as opposed to a low – walkable neighbourhood (Van Dyck et al., 2009).

Furthermore, when walkability and walking behaviour were tested in relation to socio-economic status, no relation between walkability and level of income was found (Sundquist et al., 2011; Van Dyck et al., 2010a). Additional studies have noted the positive relationship between higher levels of physical activity and high walkable neighbourhoods in Sweden, Canada and Australia, while highlighting different limitations and aspects of the association (Morency, Trépanier, & Demers, 2011; Sundquist et al., 2011; Villanueva et al., 2013).

In Perth, a study was conducted across adult life stages to assess walking within a range of distances from home, including 200 m, 400 m, 800 m, and 1600 m (Villanueva et al., 2013).

Little difference was found across buffer distance or stage of life, concluding neighbourhood walkability results in higher levels of physical activity for people of many ages, as well as across a range of neighbourhood sizes (Villanueva et al., 2013). Interestingly, the exception was the group aged 18-29, whose physical activity levels corresponded only to neighbourhood buffers of 200 m. This may reflect younger adults' mobility around the greater city, and use of public transit (Villanueva, Giles-Corti, & McCormack, 2008; Villanueva et al., 2013; Morency et al., 2011). However, walking behaviour also shows increases in association with availability and accessibility of public transit (Morency et al., 2011; Villanueva et al., 2008). This modal choice results in more steps taken daily, and has potential for helping the greater population reach recommended levels of physical activity (Morency et al., 2011; Villanueva et al., 2008). In fact, at a general population level, public transit may offer more potential for increasing levels of physical activity than active transportation (Morency et al., 2011).

In contrast with most findings, two studies in Belgium found an inverse relationship between high walkability and physical activity. Van Dyck et al. (2010b) found highly walkable neighbourhoods were actually associated with higher levels of sedentary time. Furthermore, being younger, male, more highly educated, unemployed, having a white-collar job (when employed), and living with no children were all correlated with more time spent sitting (Van Dyck et al., 2010b). It was also found that adolescents living further away from school, in less walkable neighbourhoods achieved higher levels of daily physical activity than those living in more walkable neighbourhoods (Van Dyck et al., 2009). A similar number of Belgian adolescents engage in active transportation on their way to school whether they live in cities or suburbs. A possible explanation for these findings may be the longer distance to school for those living in the suburbs (Van Dyck et al., 2009).

Among the studies in this section of the review, limitations included the use of cross-sectional studies rather than longitudinal, low variation in the walkability of neighbourhoods in the target towns and cities, and potential malfunctioning of pedometers. Given the lack of generalizability and discrepancy in the findings, further study is needed on the topic of walkable communities and walking behaviour. Future research may also investigate a broader range of life stages, including more studies on children and oldest-old adults. Health care professionals may also consider increased advocacy for the importance of public transportation, given the many potential environmental, physical and mental health benefits (Villanueva et al., 2008).

2.3 The relationship between walkability and health

This review has shown walking can positively affect the risk factors associated with cardiometabolic syndrome. The walkability of residential environments has also been associated with increased levels of walking. The third, and least studied theme in this review is the direct relationship between walkability and health, as represented by lower cardiometabolic risk.

Both studies reviewed took place in Australia, and found that a lower cardiometabolic score was connected to higher walkability (Coffee, Howard, Paquet, Hugo, & Daniel, 2013; Paquet et al., 2014). Size of public open spaces, and walkability were inversely correlated to incident diabetes, while protecting against the development of impaired glycaemic function (Coffee et al., 2013; Paquet et al., 2014). The advances of these studies are based in their objectively measured indexes of neighbourhood walkability. Coffee et al. (2013) used an objectively measured GIS index of walkability to show a 3% reduction of cardiometabolic risk for a 500 m buffer of distance, and a 6% risk reduction with buffers of 1000 m and 1600 m.

These studies show modest positive correlations and highlight a need for further research in this direction.

Future research should compare individuals who have recently moved into a neighbourhood with long-term residents, considering environmental exposure over time (Paquet et al., 2014). It should bridge the gap from studying the relationships between the built environment and walking, to studying chronic disease risk factors and outcomes that relate to walkability (Coffee et al., 2013). In addition, more distinct characteristics of the built environment, such as the quality and quantity of public open spaces should be examined (Coffee et al., 2013; Paquet et al., 2014).

2.4 Perceptions of walkability and the built environment

According to Ariffin & Zahari (2013), walkability "can be interpreted as a match between residents' desires and expectations for types of destinations, their willingness to walk a given distance and the quality of the path" (p. 591). However, it is important to note matters of public perception associated with encouraging people to engage in active commuting behaviour. When residents of a neighbourhood perceive high walkability, land use mix, or dwelling density to, in fact, be low, this can significantly and negatively affect both transport choice and leisure walking behaviour in comparison to those with matched perceptions (Ariffin & Zahari, 2013; Gebel, Bauman, Sugiyama, & Owen, 2011). Interventions aimed at improving perceptions of walkability may prove extremely helpful to increase active commuting and daily levels of physical activity.

Qualitative studies on school travel behaviour have indicated a variety of perceived barriers to active transportation, including inclement weather, inconvenience, sidewalk

conditions, and neighbourhood safety concerns that range from fear of violence, child abduction, and traffic congestion, to distrust of children's judgments (Faulkner, Richichi, Buliung, Fusco, & Moola, 2010; Hinckson, Garrett, & Duncan, 2011; Mendoza et al., 2011; Napier, Brown, Werner, & Gallimore, 2011). Though many of these studies do not control for geographic differences across built environments, one study in the Greater Toronto Area reported traffic concerns in inner suburban locations and lack of time to walk children to school in lower socioeconomic status neighbourhoods (Faulkner et al., 2010).

The "Walking School Bus" (WSB) program sees parents or other adults picking up children throughout the neighbourhood and walking them to and from school. The initiative has been deemed useful, not only for increasing children's levels of daily physical activity, but also for observed improvements in measures of street-crossing safety and reducing parental apprehension about active school transportation (Faulkner et al., 2010; Hinckson et al., 2011; Mendoza, et al., 2011). The WSB program may reinforce the concept of active commuting, improving the independent mobility of children, as they grow older; however, it is important to note a behavioural change from passive to active transportation may take up to three years to develop a strong habit (Hinckson et al., 2011). Winnipeg's Green Action Centre provides opportunity for communities to organize and participate in walking and cycling school buses, including making steps and guidelines for startup available. For communities wishing to support children's physical activity, autonomy and good commuting habits, while improving perceptions of walkability, this is an extremely worthwhile program in which to invest time.

In today's society, hypersensitivity exists around the dangers of children being outside. Working to foster positive perceptions and trust of a neighbourhood can help to moderate parental fears about their children's maturity, resulting in a greater likelihood of allowing

independent travel (Faulkner et al., 2010). A "go along" walk between parents and children can help address perceived barriers by allowing the recognition of points of pride in the neighbourhood; discussing strengths and highlights of the community may help to provide a more balanced view, beyond the deficits of a neighbourhood (Napier et al., 2011). Furthermore, perceptions of traffic-related barriers can be improved with crosswalks, school crossing guards and the designation of drop-off zones (Napier et al., 2011).

During the review of this theme, several studies noted limitations in the demographic of their sample or the lack of diverse urban environments examined. Future studies should continue to consider differences across socio-economic status and compare neighbourhoods with distinctly different levels of actual walkability. However, this review attempted to analyse articles with a variety of samples, including studies centered on neighbourhoods with a lower socio-economic status, as well as those that looked at middle to upper socioeconomic strata. Further research is needed on which specific environmental changes or educational strategies are worthwhile to implement at regional and national levels in order to improve public perception of walkability (Hinckson et al., 2010). Finally, studies that objectively measure neighbourhood safety and evaluate the influence of the built environment on the Walking School Bus and children's pedestrian safety are needed (Mendoza et al., 2011).

2.5 Function of the built environment

As previously stated, inconvenience – perceived or real – plays a role in decision making about travel mode choice. Studies have shown an association between the number of land-use types and active commuting (Christian et al., 2011; McConville, Rodriquez, Clifton, Cho, & Frleischhacker, 2011; McCormack et al., 2012). This provides an important incentive to consider

the links between school/work travel and the broader land use, with a particular focus on reorganizing community space to realign housing, transport, and other activities in order to render the environment more functional (Faulkner et al., 2010). The proximity of amenities people visit regularly to meet their daily needs can inspire destination-related physical activity. Public transit stops, restaurants, grocery stores and banks have all been associated with transportation walking (Bhattacharyya & Mitra, 2013; McConville et al., 2011; McCormack et al., 2012). Mixed results, however, suggest variations may depend on geographic location or participating sample.

Neighbourhood characteristics, such as a highly connected pedestrian network, high population density, accessibility of sidewalks and paths, and a large variety of businesses encourage more people to spend more time walking for transportation, but not for recreation (McCormack et al., 2012). Christian et al. (2011) found walking for more than one hour per week for transportation had the most significant and strongest correlation in neighbourhoods that included community, health, office, residential, and retail land use, *in addition* to entertainment, culture and recreation. Conversely, recreational walking was more strongly related to sporting infrastructure and public open space (Christian et al., 2011).

Further research is needed to analyse the relationship between land-use patterns and walking transportation. Studies need to account for a greater variety of land use patterns, and clearer definitions need to be established regarding to "every day uses," which may vary greatly among populations. Furthermore, it is interesting to note that although McConville et al. (2011) found destinations such as restaurants, banks, grocery stores and transit stops to be strong predictors of walking behaviour, the presence of retail stores did not appear to be as strongly correlated. This emphasizes the need to further distinguish specific types of land-use, even

different types of retail, into specialized categories in order to investigate more nuanced associations with walking (McConville et al., 2011).

2.6 Structure of the Built Environment

In addition to a well-connected pedestrian network, safety, mixed land-use and linkages with other modes of transport, the quality of the urban environment is a critical aspect to consider. Walkability, in the most basic sense of the physical environment, is an issue of urban structure, in part about path quality and in part about path configuration, relative to origin and destination (Forsyth, 2015). However, many factors affect the choice to walk for transportation, including attractiveness of the route (Krizek, Handy & Forsyth, 2009). Consequently, a walkable community is often further defined as being "rich in pedestrian-oriented infrastructure, including wide and well-maintained sidewalks, active street frontages, traffic calming measures, street trees and vegetated buffers, marked and signalized pedestrian crossings, benches, way-finding signage, and pedestrian-scaled lighting" (Forsyth, 2015, p. 13).

A study of Siliguri, India notes footpaths should be wide enough for two to three people (to allow for easy passage), free of obstructions, and oriented in ways that better connect the pedestrian network and feed public transportation routes (Bhattacharyya & Mitra, 2013). The possibility of pedestrian overpasses as a solution to highly congested areas of traffic is also suggested. Walk Score's (2015) most walkable Canadian city of 2014 was Vancouver[1]. Despite drastically different climates in Siliguri and Vancouver, priorities for the pedestrian environment remain similar, with Vancouver's Transportation Plan also identifying sidewalks that are narrow, uneven or missing curb cuts as possible areas for improvement. Policies address actions such as

[1] https://www.walkscore.com/cities-and-neighborhoods/

extending curbs at intersections to shorten crossing distances, providing accessible public toilets in high pedestrian traffic areas, and incorporating rain-friendly design features into public space (City of Vancouver, 2012). While altering the built environment of existing neighbourhoods is challenging, "policies to promote infill development, programs that aim to revitalize or protect traditional neighbourhood commercial areas, and investments in pedestrian infrastructure such as sidewalks and specially designed street crossings can help" (Handy, Cao & Mokhtarian, 2006, p. 71).

Sustrans, a UK charity organization, promotes active and public transportation through various initiatives, including working with people to improve their street environment to create more enjoyable places to walk and cycle. As part of the Liveable Neighbourhoods program, Sustrans piloted 'DIY (Do It Yourself) Streets' projects, collaborating with local communities across a range of socioeconomic contexts, with the goal of developing safer and more attractive streets (Thompson, Curl, Aspinall, Alves, & Zuin, 2012). Efforts included the addition of planters, changing the space provision and layout of parking, and the introduction of features to reduce the speed and volume of traffic. The environmental changes associated with the project seem to have positively impacted older adults' perceptions of walkability and safety at night, though they have not affected overall levels of physical activity (Thompson et al., 2012). However, as previously recognized, positive community perceptions are a key factor in promoting walking as a mode of transportation. It is also important to recognize the possibility of negative effects on older people's outdoor accessibility if traffic or parking patterns change outside their home (Thompson et al., 2012). The World Health Organization has recognized the need for better design of built environments to create age-friendly cities that will support public health into old age and allow for aging-in-place.

Finally, Danish urban designer Jan Gehl has been a major force in creating the people-oriented city Copenhagen is today. In a 2002 interview with Paul Makovsky for Metropolis Mag, he outlined a ten-step program for a more pedestrian-friendly city. Though not all the steps may be appropriate or viable in a North American context, the list provides some very useful lessons. Steps that would be of particular use to the city of Winnipeg include: convert parking lots into public squares; keep the scale of buildings dense and low – building up previously empty or open spaces may help to moderate temperature through better wind blockage; populate the core to help downtown street presence and increase perceptions of safety; encourage student living, allowing students' presence to animate the city both day and night; and adapt the cityscape to the seasons with features such as outdoor patios in the summer, and heated benches and gas-lit street corner heaters in the winter (Makovsky, 2002).

A limitation of the reviewed literature on the structure of the built environment is the cross-sectional analysis of neighbourhoods. In communities where interventions have taken place to improve safety and enjoyment, such as with Sustrans' DIY Street Projects, longitudinal studies would be valuable to assess behaviour change over time. Will improved street environment perceptions begin to positively affect daily levels of walking? Overall, any interventions that may take place to help improve the quality of the urban environment should be closely monitored to understand the effects or unintended consequences they are having. Strategies with positive results for one place and population may not work in all settings, but may provide useful guides and inspiration for urban designers worldwide.

2.7 Winter Pedestrian Challenges

Walking is both a necessary part of urban mobility in cities and an important, recurrent form of physical activity for many adults. Yet over the past several decades, pedestrians have been paid minimal attention in the design of roadway systems, and traffic flow continues to be the priority for road engineers (Morency, Voyer, Burrows & Goudreau, 2012). As concerns surrounding chronic health and climate change issues increase, "it is essential that efforts to promote active transportation take into account the safety of pedestrian travel" (Morency et al., 2012, p. 221). Studies have indicated inclement weather is one factor affecting pedestrian behaviour and safety, and requiring further consideration, with average daily levels of physical activity decreasing as temperatures drop, and rain and snowfall increase (Koetse & Rietveld, 2009; Li, Hsu & Fernie, 2013; Miranda-Moreno & Lahti, 2013).

Climatic conditions such as cold temperatures, snowstorms and presence of ice are correlated with riskier road crossing behaviour and increased rates of falling (Morency et al., 2012; Pavol, Owings, Foley & Grabiner, 1999). One study determined a lower pedestrian compliance rate at crossing signals during cold weather than during warm (Li & Fernie, 2010). When it was snowing, the crossing signal compliance rate was reduced to an almost non-existent 3%. Falls are responsible for approximately 2,300 deaths and 110,170 hospitalizations annually in Canada, with a further study demonstrating a peak in fall-related hospitalizations and emergency visits four to eight days after an ice storm (Morency et al., 2012). Police accident reports are not currently recorded for pedestrian falls with any regularity, and hospital registries do not require information on location of injury. More information regarding the circumstance of outdoor falls is necessary in order to better understand the environmental factors associated with injury (Morency et al., 2012). However, municipal snow removal and sanding operations should

prioritize areas with a high volume of pedestrians in an effort to increase safety and encourage walking during the winter months (Morency et al., 2012).

A study conducted in Montréal found most people injured outdoors were under the age of 65 years, potentially reflecting a reduction in outdoor activity among older people during the winter season (Morency et al., 2012). Outdoor falls tended to be concentrated in central neighbourhoods. This likely corresponds with the city's pedestrian distribution, reflecting increased walking activity where residential, commercial and office density is higher.

While existing literature emphasizes a need for multi-season planning, limited studies have been reported to date, indicating a need for additional research on the topic. Future studies may include investigation of alternative curb ramp design, adaptive pedestrian behaviour that may influence slip-and-fall incidents, and how climate change affects both destination and transportation mode choice (Böcker et al., 2013; Li et al., 2013; Pavol et al., 1999).

2.8 Walkability audits and measuring walkability

Land-use patterns, built and natural features of the environment, and the transportation system all contribute to the access of opportunities for physical activity, as well as the choice to be physically active (Brownson et al., 2009; Cain et al., 2014; Moudon & Lee, 2003; Roemmich, Epstein, Raja & Yin, 2007). In order to advance understanding of the influence of the built environment on physical activity, high quality measures of assessment are essential. Walkability audits are one such measure, used to quantify and inventory various elements of the built environment (Moudon & Lee, 2003). These tools allow for "systematic observation of the physical environment, including the presence and qualities of features hypothesized to affect

physical activity (e.g., street pattern, number and quality of public spaces, sidewalk quality)" (Brownson et al., 2009, p. 106).

Typically, auditing tools feature a series of close-ended questions in paper form, often with opportunity for comments. The tools require researchers to walk or drive through neighbourhoods assessing environmental characteristics. Segments comprised of one street block are often audited, as it is not feasible to audit an entire neighbourhood. Environmental variables assessed may be categorized as macro-scale, relating to structural features such as street connectivity, or micro-scale, relating to details that may affect one's experience in a place (Cain et al., 2014). Micro-scale details of a neighbourhood may include such features as quality of sidewalks and crosswalk design. While auditing tools vary in the detail with which they evaluate environmental elements, most instruments include one or more measures of land use, sidewalks, streets and traffic, parking and/or presence of driveways, bicycling infrastructure, public space, amenities, building characteristics, general maintenance, and indicators of safety (Brownson et al., 2009; Cain et al., 2014; Lee et al., 2008). Useful for measuring the more detailed micro-scale qualities of a neighbourhood, walkability audits may highlight environmental characteristics that have positive associations with physical activity, while also being modifiable at a lower cost and within a shorter time frame (Cain et al., 2014).

2.9 Summary

For non-disabled people, walking is an accessible form of physical activity, which doubles as a regular mode of transportation. The literature reveals several factors of health can improve almost immediately after incorporating regular walking into one's weekly routine. There are many inspiring projects around the world that look to improve pedestrian activity. With the

intent to assess different perceptions, climates and land use patterns, studies reviewed ranged in location, including cities in Australia, Europe and North America. However, available evidence is more limited within a Canadian context.

Winnipeg may face greater challenges regarding walkability, due to climate and level of urban sprawl, compared to some European cities. While multi-season planning is being encouraged in such places as Denmark, further research is needed on the topic (Gehl, 2010). Regardless, this review has shown resounding evidence that working towards improving the walkability of Winnipeg will directly and positively affect the levels of physical activity of its residents. Furthermore, many useful lessons can still be recognized from cities pursuing walkability worldwide. It is clear any successful walking strategies should include the views of professionals from an array of fields, such as transport planning, transport engineering, health faculties, and urban design (Bhattacharyya & Mitra, 2013).

As shown by the growing body of literature, the potential for the built environment to promote transportation physical activity effectively is great. However, researchers trying to connect physical activity and environmental characteristics must be able to properly assess multiple facets of the walking environment (Boarnet, Forsyth, Day, & Oakes, 2011). The continued development of effective auditing tools is very important to the advancement of this area of research.

In the next chapter, three Winnipeg neighbourhoods are reviewed to provide context within which to review the walkability auditing tools. The sites were chosen for observation within the city, representing varying levels of walkability. The critical observation of neighbourhoods with differing levels of walkability was intended to provide insight into the difficulties faced by

pedestrians during the winter season, whether alike or unique. It helps to answer the research question: To what extent do current walkability audits reflect the realities of urban winter living?

3.0 RESEARCH METHODS

This chapter outlines the qualitative research and analysis methods used to answer the proposed research questions:

- *Site overviews and unobtrusive observation* were used to answer **1) To what extent do current walkability audits reflect the realities of urban winter living?**
- *Systematic review of the auditing tools* was used to answer **2) How can walkability audits be better designed to address walkability issues residents in Canadian winter cities face?**

Description of methodology, rationale for use, and reliability of the work are discussed.

3.1 Walkability Site Overview

In Chapter 4, the context within which the audits were reviewed is explored. An overview of characteristics including location, land-use, population demographics and public transit accessibility is presented for each of the three selected Winnipeg neighbourhoods of West Broadway, Crescentwood and Crestview. The intention of this overview was to help provide context against which the auditing tools could be compared. Three diverse sites were chosen in order to better answer the question: To what extent do current walkability audits reflect the realities of urban winter living?

Routes through each neighbourhood were mapped prior to site observation in order to an effort to ensure they would accurately portray the structure and layout of each area, and assure survey of key environmental features. When observing West Broadway and Crescentwood, these routes were followed as intended. When conducting observations in Crestview, I diverged from

the route I had originally intended to take, due to extreme weather conditions and the desire to seek a course more sheltered from the wind. Furthermore, I made the decision to travel through the Unicity Mall parking lot, in an effort to follow pedestrian tracks in the fresh snow (maps of both the intended and updated routes can be found in Appendix B).

In order to help illustrate walking distance to Winnipeg Transit bus stops in each neighbourhood, isochrome travel maps were outlined with the use of Free Map Tools[2], online. The tool incorporates mode of transportation (walking), speed (5 km/hr), and travel time to draw an approximate travel radius according to available street network. The walking speed was extrapolated from an average pedestrian pace of 84 metres per minute in Calgary, Canada (Rastogi, Thaniarasu &Chandra, 2011). The travel maps were then layered over Winnipeg Transit maps to demonstrate bus stops in the vicinity.

Finally, two tables compare relevant neighbourhood statistics from the 2006 Census and the 2011 National Household Survey. Information on population density, modes of transportation, and number of people using various modes of transportation is presented for each of the three neighbourhoods as well as the City of Winnipeg.

3.2 Unobtrusive Observation

Accompanying the site overviews, unobtrusive observation was used to provide further context for the subsequent analysis of walkability auditing tools. Observation of the three neighbourhoods helped to provide information regarding "expected uses, new uses, and misuses of the place; and about behavioural opportunities and constraints that environments provide" (Zeisel, 1984, p. 111). The unobtrusive method allowed for observations to be made without the

[2] https://www.freemaptools.com/how-far-can-i-travel.htm

knowledge of any being observed, thus reducing subjects' potential awareness of the research so as not to affect pedestrian behaviour and alter results gathered (Crossman, 2013).

The choice to record an overview of the neighbourhood resulted in a limited data set due to the lack of indication of personal involvement or change in behaviours over time (Zeisel, 1984). Due to seasonal limitations, and the reality of fluctuating weather patterns, each neighbourhood was only observed one time. However, observations were recorded in as much detail as possible, with voice-recorded and written notes used for documentation. The intended function of the unobtrusive observation stage of this research was to gather information about each neighbourhood in an interactive, multidimensional way that could not be achieved through more structured methods such as interview (Mason, 2002). Transcriptions of recorded observations have been included in order to bring the issues to light in a tangible way, conveying a sense of discomfort, cold, urgency, or danger to the reader.

Often used as a method of support in qualitative research, photography is especially prevalent in the fields of urban and social studies (Harper, 2005). Select images are used to complement the raw field notes, illustrating examples of pedestrian infrastructure in the neighbourhoods observed, as well as portraying the effects of winter weather on the built environment that may affect walking behaviour. Photographic documentation assists the field research by providing visual cues for what has been observed, and helping to support written description by capturing "subtleties that other methods may not record" (Zeisel, 1984, p. 123). Given photography's extensive involvement in everyday society, the images also serve to better illustrate field conditions to all those who read the complete document (Markwell, 2000).

3.3 Systematic Review

In order to progress understanding of the relationship between physical activity and the built environment, it is necessary to develop high quality measures of assessment. Walkability auditing tools are one such measure, used to quantify and record various elements of the built environment (Moudon & Lee, 2003). They allow for methodical observation of the physical environment, including analysis of factors thought to affect physical activity (Brownson et al., 2009). In winter cities such as Winnipeg, Canada, these tools must consider climatic issues, and the influence they have on pedestrians. To this end, a systematic review of seven auditing tools was completed in order to analyse the degree to which each instrument performs well in assessing winter walkability conditions. The seven audits were selected based on relevance and usability from *Measuring the Built Environment for Physical Activity*, wherein Brownson et al. (2009) reviewed key characteristics of twenty auditing tools.

In order to identify existing climatic gaps that would prevent tools from properly assessing the urban winter environment, the content of each audit was analysed in comparison to the information compiled from the site overviews and unobtrusive observations. Both strengths and weaknesses of each auditing tool were reviewed, with further comments made on the user-friendliness of the audit design. A table was created to compile and organize a full list of items found across each of the tools to better compare strengths, limitations, and breadth of information each audit was designed to collect. Gaps are examined from the perspective that with some adaptation, these audits may remain useful tools for assessing community walkability year-round.

3.4 Summary

In summary, this research involved site overviews, unobtrusive observations, including photographic documentation, and systematic analysis of walkability audits. The implementation of multiple methodological approaches allowed complementing sources of information to increase validity of this research by enhancing the scope, depth and consistency of the findings (Bauwens, 2010; Wilson, 2016). Information gathered through site overview and unobtrusive site observation was used to support systematic analysis of the auditing tools. Together, data from the three stages of research informed the final recommendations for how to better design walkability audits to address issues faced by winter cities such as Winnipeg, implications for planning practice and suggested directions for future research.

4.0 WALKABILITY SITE OVERVIEW

Understanding and improving walkability is important for influencing the transportation choices of both residents and visitors. Neighbourhoods deemed more walkable are often centrally located, encouraging both residents and tourists to use walking as a mode of transportation. The walkability of both urban *and* suburban areas must be considered, however, in order to encourage local pedestrian activity and foster healthy, lasting lifestyle habits. Furthermore, as this project focuses on the design of walkability auditing tools, my hope is that the results will be transferable beyond Winnipeg to other North American winter cities with similar land use applications. While certain variables of walkability differ in their importance for encouraging residents or tourists to choose walking as a form of transportation, many indicators are important for both groups of pedestrians. For example, the presence of places to explore, or the presence of good views may be more important for encouraging walking decisions among tourists, while variables such as safety from traffic, presence of connecting roads, and presence of street lamps will influence residents and tourists, alike (Samarasekara, Fukahori & Kubota, 2011).

This chapter introduces the context within which the audits were reviewed – the neighbourhoods of West Broadway, Crescentwood and Crestview in Winnipeg, Manitoba, Canada. It includes the rationale for choosing these three sites, as well as a brief overview of each area. Research was conducted in the three diverse sites in order to better answer the question: **To what extent do current walkability audits reflect the realities of urban winter living?** Routes through each site were mapped and followed, in order to have a detailed course analysis represent the greater neighbourhood. An effort was made to design routes that would accurately portray the structure and layout of each site, and assure the opportunity to observe key

environmental features. As Brownson et al. (2009) suggest, these deliberate routes represent a purposeful sampling of street segments (in contrast to a random sample), as observing each neighbourhood in its entirety was not feasible (Brownson et al., 2009).

4.1 Overview: City of Winnipeg

Population statistics provided in this chapter were collected from the 2011 Canadian National Household Survey (Statistics Canada, 2011). It is important to note data gathered by the 2011 voluntary National Household Survey might not be as accurate as the data gathered with the 2006 mandatory Long-Form Census. The change from mandatory to voluntary survey administration resulted in a lower response rate. Specifically, minorities and lower-income populations were less likely to respond, resulting in potentially misrepresented data. At the time of writing, only the first data set from the Canada 2016 Census had been released, containing population and dwelling counts.

Between the years of 2006 and 2011, the population of the City of Winnipeg grew 4.8%, from 633,451 to 663,617. In that time, subtle changes occurred in the primary mode of transportation used among people in the employed labour force, aged 15 years and older. For example, those traveling by car, truck or van – as the driver – increased from 68% to 69.1% of the total population. Interestingly, over the same period of time, the percentage of people using walking as their mode of transportation decreased from 6.2% to 5.5%. As per the first data released by the Canada 2016 Census, the total population of the City of Winnipeg grew another 6.3% since 2011, from 663,617 to 705,244 (Statistics Canada, 2016).

4.2 Overview: West Broadway

West Broadway is an inner city neighbourhood west of Downtown Winnipeg. The neighbourhood is bound by Portage Avenue (north), Colony Street (east), the Assiniboine River and Cornish Street (south), and Maryland Street (west) (a map outlining the borders can be found in Appendix A). Bordering neighbourhoods include Wolseley, Spence and the Legislature. The route and study area included portions of the bordering and innermost streets, spanning approximately 3.4 kilometres (see Appendix B). West Broadway was chosen as resident-dense, mixed land-use representative of a community with apparently high walkability. Amenities available in the vicinity include grocery stores, restaurants and bars, retail stores, pharmacies, schools, and parks. In 2011, the population density of the area was 7,904.0 per square kilometre.

As referenced in Section 3.1, the population of the City of Winnipeg grew 4.8% between the years of 2006 and 2011. In that time, the population of West Broadway remained stable, increasing only 0.1%, to a total of 5,330 people in 2011. Despite this stability in the total population of the neighbourhood, changes exist in the demographic make-up of the area. Notably, the percentage of people in the employed labour force, aged 15 years and older whom use walking as a primary mode of transportation decreased from 23.4% to 17.1%. Furthermore, while the number of males using walking as a mode of transportation remained stable (increasing from 255 to 260), the number of females walking diminished by half from 330 to 165. Over the same period of time, the total number of people driving remained stable, decreasing from 32.7% to 32.2% of the population. Those using bicycle as a primary mode of transportation increased from 5.6% to 9.3%, with the number of women increasing from 55 to 125.

Many bus routes service West Broadway. Available routes include 11, 21, 22, 24, 25, 67 along Portage Avenue, 17, 20, 29, 36 and 99 along Marion and Sherbrook Streets, and 10 along

Balmoral Street and Westminster Avenue. The 17, 20, and 29 are also accessible along Broadway Avenue. Given the neighbourhood's close proximity to the downtown, numerous other routes are also easily accessible by foot or public transit transfer. Using an average walking speed of 84 metres per minute[3], transit lines are available within an approximate five-minute walk throughout the area. Figure 1 provides an example of an approximated walking radius in relation to available Winnipeg Transit bus stops[4]. The time-based isochrone map was generated using Free Map Tools[5], at 5 km/hr walking speed and 5 minutes time. A centrally located point was chosen (161 Langside Street, at Sara Avenue) for the travel map to provide a sample illustration of bus stops within an approximate five-minute walk that may be accessed by street network.

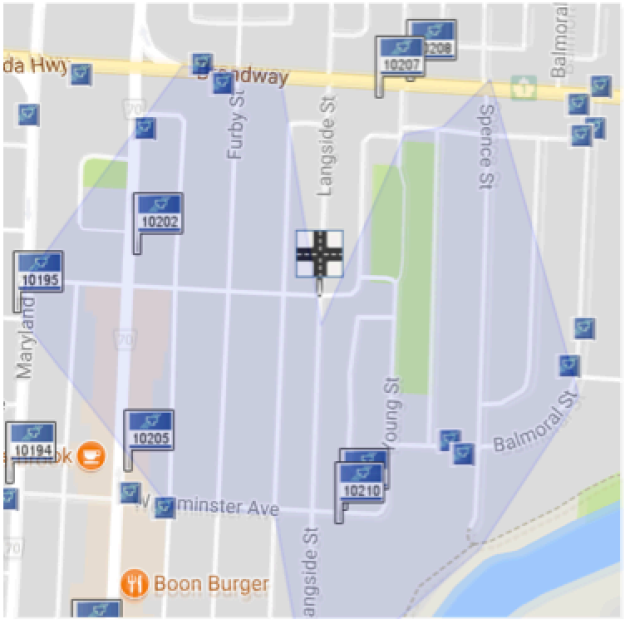

Figure 1: bus stops near 161 Langside Street

[3] Average walking speed of pedestrians in Calgary, Canada, as assessed by Morrall, Ratnayake & Seneviratne, 1991, and referenced by Rastagi, Thaniarasu & Chandra, 2011.

[4]http://winnipegtransit.com/en/stops/find?location=Langside+Street+%40+Sara+Avenue&location_id=intersections%2F41266%3A2075%403215&commit=Submit

[5] https://www.freemaptools.com/how-far-can-i-travel.htm?address=161%20Langside%20Street,%20Winnipeg,%20MB,%20Canada&speed=5&time=5&accuracy=5&u=km&hw=false&at=false&m=false&mode=WALKING

4.3 Overview: Crescentwood

Crescentwood is a neighbourhood in the River Heights West area of Winnipeg, located southwest of downtown. The neighbourhood is bound by Academy Road (north), the Assiniboine river (east), Corydon Avenue (south), and Cambridge Street (west) (a map of the neighbourhood's border can be found in Appendix A). Surrounding neighbourhoods include Wellington Crescent, North River Heights, Rockwood, and McMillan. The route and study area included sections of bordering streets, and major throughways, as well as inner streets, and spanned approximately 3.3 kilometres (see Appendix B). Crescentwood was chosen as a medium-density residential neighbourhood, with some land-use diversity. While not as easily accessible as in West Broadway, many amenities are still available within walking distance, either in the periphery of the neighbourhood, or in the nearby locality of Corydon. Schools, parks, restaurants, retail stores, a post office and a pharmacy are all within the borders of the neighbourhood, while nearby Corydon has further abundance of entertainment amenities, as well as grocery stores and banks. In 2011, the population density of the area was 2,519.5 per square kilometre.

Between the years 2006 and 2011, the total population of Crescentwood decreased by 0.9%, from 2,705 to 2,680. In those years, the percentage of the employed labour force, aged 15 years and older that drive as a primary mode of transportation also decreased, from 70.7% to 67.2%. Those using public transit remained stable, decreasing a mere 0.2%. Those using bicycle for transportation more than doubled from 1.5% to 3.4%. The percentage of people walking increased significantly from 7.1% to 11.6%. In comparison to West Broadway, where the population of females walking decreased by half, the number of women walking in Crescentwood increased from 45 to 130. The number of men walking decreased from 50 to 40.

Bus routes servicing Crescentwood include the 18 along Corydon Avenue, the 68 along Grosvenor Avenue, the 20 along Academy Avenue, the 99 along Wellington Crescent, and the 29 and 36 along Stafford. While fewer buses are accessible within Crescentwood than some other neighbourhoods, available transit routes travel toward and through major destinations. For example, the 36 express bus route travels to the University of Manitoba, and the 18 travels through Osborne Village past the Rapid Transit Corridor and to downtown where further connections can be made. Buses may be accessed within approximately ten minutes walk of any place in the area, at the previously mentioned average walking speed of 84 metres per minute. Figure 2 provides an example of an approximated walking radius at 5 km/hr and ten minutes time in relation to available Winnipeg Transit bus stops[6]. The address 125 Yale Avenue was chosen to represent a central location within Crescentwood and help illustrate the range of bus stops accessible within an approximate ten-minute walk[7].

[6]http://winnipegtransit.com/en/stops/find?location=125+Yale+Avenue&location_id=addresses%2F142421&commit=Submit

[7] https://www.freemaptools.com/how-far-can-i-travel.htm?address=125%20Yale%20Avenue,%20Winnipeg,%20MB,%20Canada&speed=5&time=10&accuracy=5&u=km&hw=false&at=false&m=false&mode=WALKING

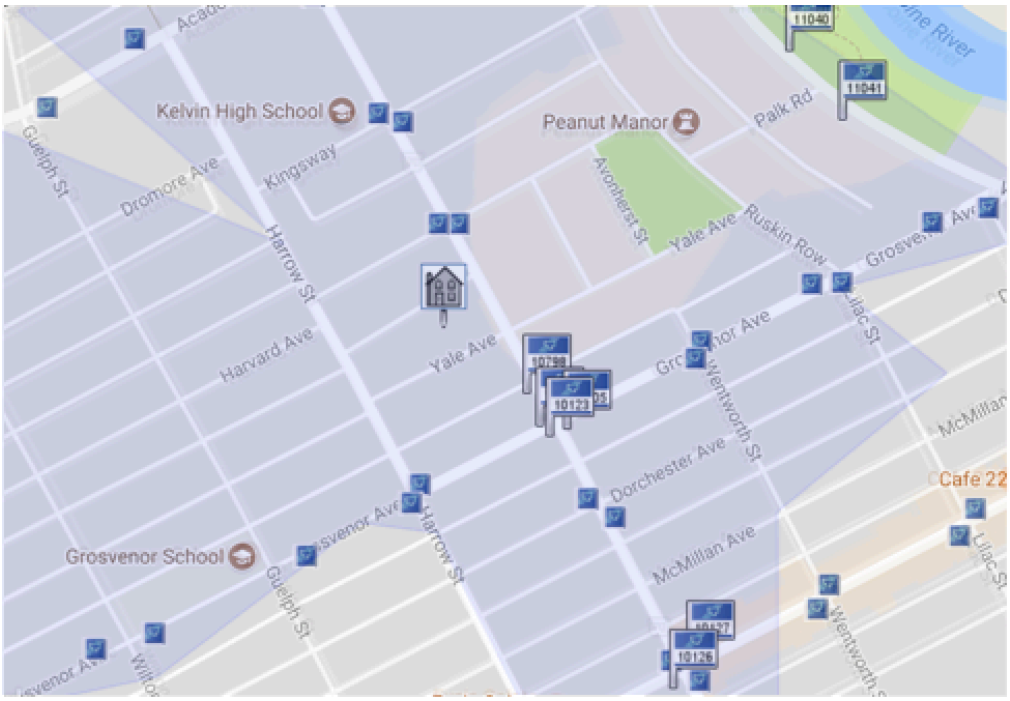

Figure 2: Bus stops near 125 Yale Avenue

4.4 Overview: Crestview

Crestview is a neighbourhood in the St. James-Assiniboia West area of Winnipeg, located in the western suburbs of the city, close to the Perimeter Highway. The neighbourhood is bound by Saskatchewan Avenue (north), Sturgeon Creek, Hamilton Avenue, Parkdale Street and Muriel Street (east), Portage Avenue (south), and Buchanan Boulevard (west) (see Appendix A). Bordering neighbourhoods include Saskatchewan North, Heritage Park, Sturgeon Creek, Westwood, Glendale, and Buchanan. The route and study area included major throughways and bordering streets, inner residential roads, as well as the major commercial locale of Unicity Mall. Total route length was approximately 4.6 kilometres (Appendix B).

Crestview was chosen as medium-density residential neighbourhood, with little land-use diversity, and low walkability. Most of the nearby amenities are located along the area's southern border of Portage Avenue. While these amenities include grocery stores, banks, pharmacies,

restaurants, bars, and retail stores, the land area of Crestview is larger than West Broadway (0.7 km^2) or Crescentwood (1.1 km^2), at 2.8 km^2, greatly increasing the walking distance to reach these conveniences. Amenities throughout the neighbourhood are generally reduced to schools and parks, with one grocery store available centrally. In 2011, the population density of the neighbourhood was 3133.1 per square kilometre.

The total population of Crestview increased 0.8% from 8,855 to 8,925 between 2006 and 2011. In that time, the percentage of the employed labour force aged 15 years and older who drive, as a primary mode of transportation, remained stable, increasing only 0.5% from 71.1% to 71.6%. Those using public transit for transportation increased from 11.9% to 13.4%, with the increase being due to female ridership rising from 330 to 400 individuals. Those riding a bicycle increased marginally from 0.7% to 1.1%, with an exclusively male ridership noted at 50 people in 2011. The percentage of people walking as a mode of transportation decreased from 6.0% to 5.1%, with a drop in both male and female pedestrians.

Several buses service Crestview, including the 11, 21, 22, 24, 25, 66, 82, 83, and 98. Unicity Mall is a major transit hub, with eight of nine neighbourhood bus routes making stops there. The bus routes run along main perimeter and throughways, including Portage, Buchanan, Lumsden, and Hamilton Avenues, and Cavalier Drive. Despite the relative low walkability of the neighbourhood, buses are accessible within an approximate ten-minute walk of any point. With several routes traveling downtown, connecting routes are accessible centrally or at Polo Park. Figure 3 provides an example of an approximate walking radius at 5 km/hr and ten minutes time

from the centrally chosen location of Lakewood Elementary School at 55 Kay Crescent[8]. The figure intends to illustrate the range of Winnipeg Transit bus stops that may be accessed within an approximate ten-minute walk[9].

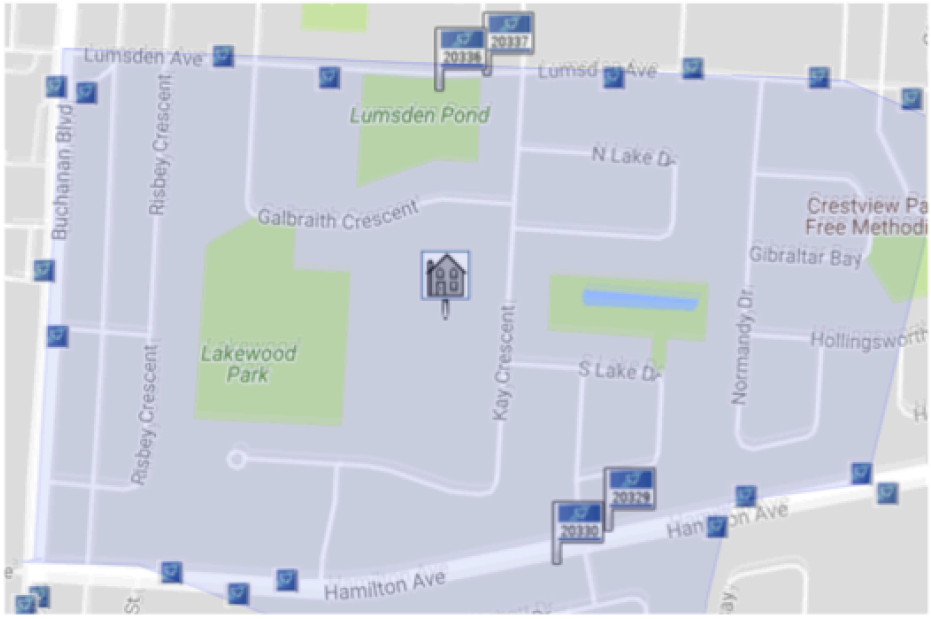

Figure 3: Bus stops near 55 Kay Crescent

4.5 Summary

This chapter introduced the research context and areas of study. The neighbourhoods of West Broadway, Crescentwood and Crestview were reviewed within the city of Winnipeg, Manitoba, considering basic population statistics from the 2006 Canadian Census and the 2011 National Household Survey. It is important to acknowledge the limitations of the data produced by the National Household Survey, as response rate was affected by the altered collection

[8] https://www.freemaptools.com/how-far-can-i-travel.htm?address=55%20Kay%20Crescent,%20Winnipeg,%20MB,%20Canada&speed=5&time=10&accuracy=5&u=km&hw=false&at=false&m=false&mode=WALKING

[9] http://winnipegtransit.com/en/stops/find?location=55+Kay+Crescent&location_id=addresses%2F73576&commit=Submit

method from mandatory census to voluntary survey. Further, such population groups as low-income individuals and minority groups are less likely to have responded, and detailed response rates cannot be determined. However, relevant neighbourhood statistics from both 2006 and 2011 are seen below in Tables 1 and 2, respectively. Land-use was described, and access to public transit was illustrated using travel maps representing five- and ten-minute walking radii according to street network. Boundary maps of each neighbourhood can be found in Appendix A.

Table 1: 2006 Neighbourhood Statistics

2006	**West Broadway**	**Crescentwood**	**Crestview**	**City of Winnipeg**
Population	5,325	2,705	8,855	633,451
Density	7895.8/km^2	2,542.6/km^2	3,108.5/km^2	475.2/km^2
Travel by vehicle (As driver)	32.7%	70.7%	71.1%	68% of total population
Walking for transportation	23.4%	7.1%	6.0%	6.2% of total population
Number of males walking	255	50	75	--
Number of females walking	330	45	185	--
Travel by bicycle	5.6%	1.5%	0.7%	1.8% of total population
Travel by public transportation	31.1%	13.2%	11.9%	14.2% of total population
Number of transit lines accessible	12	6	9	[All]

Table 2: 2011 Neighbourhood Statistics

2011	**West Broadway**	**Crescentwood**	**Crestview**	**City of Winnipeg**
Population	5,330	2,680	8,925	663,617
Density	7,904.0/ km^2	2,519.5/km^2	3,133.1/km^2	475.2/ km^2
Travel by vehicle (As driver)	32.3%	67.2%	71.6%	69.1% of total population

Walking for transportation	17.1%	11.6%	5.1%	5.5% of total population
Number of males walking	260	40	60	--
Number of females walking	165	130	165	--
Travel by bicycle	9.3%	3.4%	1.1%	2.1%
Travel by public transportation	34%	13.0%	13.4%	14.6%
Number of transit lines accessible	12	6	9	[All]

In the following chapter, the raw field notes and photographic documentation of each set of site observations are discussed in order to help answer the research question: To what extent do current walkability audits reflect the realities of urban winter living?

5.0 UNOBTRUSIVE OBSERVATIONS

This chapter includes the raw field notes as transcribed from voice recording during my analysis of each neighbourhood or written following site observations, as well as an analysis of the each set of field notes. Each set of observations differs slightly given the varying weather conditions and associated difficulty with recording equipment. Voice recordings were successfully saved to iPhone during my visit to West Broadway. While visiting Crescentwood, my iPhone turned off approximately ten minutes into the walk, and while visiting Crestview, precipitation severely affected the quality of the voice recordings taken before the device eventually turned off. In the occurrence of equipment malfunction, hand-written field notes were written immediately following completion of the site walks in order for key observations to be recorded with as much accuracy as memory would allow.

The use of photographic documentation complements the field notes to better illustrate winter conditions in Winnipeg and highlight some of the obstacles pedestrians may face. Given the pervasive use of photo imagery in our everyday lives, the communicative power of photography can be compared to that of verbal language in its ability to emphasize and explain certain issues encountered (Close, 2007; Markwell, 2000). The photos I've chosen to include both demonstrate common winter issues as well as intimate the resilience of pedestrians who either choose to continue walking through the winter, or rely on walking as their main mode of transportation. One of the photographs depicts a sign found south of Grosvenor on Harrow, announcing the abrupt end of the sidewalk (Figure 4). However, a narrow desire path is visible, continuing where the sidewalk ends, despite the substantial snowbank covering most of the boulevard. I believe the photo speaks eloquently about the perseverance of Winnipeggers even in the harshest winter conditions. Other photos show examples of desire paths in places where

sidewalks exist, but have not been plowed (Figures 17, 18). Several of the photos illustrate poor path conditions, including sidewalks covered in ice (Figures 5, 6, 14), unevenly packed snow (Figures 8), or mixed conditions that may force changes in gait over short distances (Figure 17).

Despite its usefulness as a tool, there are some limitations to using photography as a research tool, particularly when conducting a walkability project in winter. Both iPhone 5S and Canon point-and-shoot cameras were used to take photos. An effort was made to keep equipment warm in the pockets of my winter jacket, however, cold temperatures and precipitation affected the working ability of the technology. As a result of the varying conditions over a three-day period of observation, equipment shut off at various points during each of the walks. The Canon camera proved to be more tolerant of the cold and snow, still shutting off eventually, but allowing for observations to continue for most of each walk.

Figure 4: Dead end sidewalk in Crescentwood, Harrow and Grosvenor

Physical traces are the evidence of human interaction with the environment that reflect conscious or unconscious adaptations made by users of the space (Zeisel, 2006). The unobtrusive observation of physical traces allows the researcher to "begin to infer how an environment got to be the way it is, what decisions its designers and builders made about the place, how people actually use it, how they feel toward their surroundings, and generally how that particular environment meets the needs of its users" (Zeisel, 1984, p. 89). In this research, the purpose of this method was to critically examine different neighbourhoods under winter conditions in order to better

understand what an auditing tool would need to incorporate to accurately evaluate walkability. The inclusion of my transcribed, unedited field notes provides a sense of immediacy regarding the environmental issues faced, whereby my own sense of cold, danger, frustration, pleasure, or amusement can be perceived.

A systematic review of the auditing tools follows in Chapter 6 of this document, wherein the conditions observed through these site observations are used to help identify the climatic gaps of the instruments.

5.1 West Broadway:

Thursday, March 3, 2016 3:00-4:00 p.m.

- Mean daily temperature: -13.3 °C
- Precipitation accumulation: 0 mm
- Colony St. → Balmoral St. → Broadway Ave. → Maryland St. → Sara Ave. → Sherbrook St. → Cornish Ave. → Langside St. → Westminster Ave. → Young St. → [lane south of Broadway] → Spence St. → Spence and Balmoral
- A map of this route is shown in Appendix B.

Voice-Recorded Notes:

The sidewalk has been cleared. There are treads showing that it has been plowed, but the snow has been packed, so it's a little bit uneven. As I walked that block (Granite), I saw four people walking – two of them carrying bags with groceries, one with a backpack, one with nothing on him. Three middle aged, one older. One person on a bicycle. One person jogging.

I'm now on Balmoral. The first bus stop that I'm coming to has been cleared, some of it down to the cement. No bench, no shelter. Some icy patches. I'm passing two more people about my age – three more. All wearing bags. There are three more people walking toward me. One with groceries, two with backpacks. Again, about my age. There's a desire line running from the Great West Life parking lot through to the sidewalk on the east side of Balmoral.

The sidewalk is definitely wide enough for two people to walk next to each other or for people to pass, as I just did – the two people I passed walked single file to walk past me. But again, I can't see the condition of the pavement, just the packed snow. The traffic seems to be traveling at the speed limit – maybe a little fast. The snow banks on the boulevard are quite sizeable so there isn't really a place to cross other than at the sidewalk.

There are actually quite a few tracks *in* the snow, next to the sidewalk. There are dog tracks in there as well, so potentially from people walking their dogs.

The bus stops at Broadway, both east and west sides of Broadway have been cleared, but not to the pavement. The one on the east side has a garbage can. Neither has a bench or shelter.

I'm crossing Balmoral, now going Westbound on Broadway. There was plenty of time for me to cross at the light – a full minute of time to cross at the light.

There are a few more people walking by – one girl about my age carrying boxed leftovers from a restaurant, another carrying a grocery bag. I can see five people walking with nothing on them. And the light to cross Broadway here was 25 seconds.

Figure 5: Ice-covered sidewalk, Westbound Broadway at Balmoral

Figure 6: Close-up of icy, uneven sidewalk surface, Broadway and Balmorals

So now the sidewalk is pretty icy (Figure 5). It's obviously melted and then frozen again. It's fairly pockmarked with footprints (Figure 6). It's quite slippery. The sidewalk on the North side of the street has bare pavement, seemingly quite even. The older woman walking near me with grocery bags has crossed to that side. She's walking around a puddle. So the North side of the street, I suppose where there's been more sun, is quite bare. Between Spence and Young, it's cobblestone on the south side, where I am. It's quite uneven – the same sort of icy, pock-marked stretch, though I think three or four people could walk abreast. I'm passing a pawnshop and Art City. The bus stops at Young are clear, still no benches – oh, actually the bus stop east bound has a bench and a garbage can.

Traffic is steady, but seems to be following the speed limit. A couple people who were walking nearby me are now at the bus stop, showing that they walked at least a couple blocks to get to the

bus stop. I can see a medical clinic, Wannabe's Diner, Pal's Supermarket, Broadway pharmacy, Art City, the Broadway pawnshop.

The streetlights here, there are overhead streetlights as well as shorter, West Broadway BIZ lanterns, though they are not on.

So now I'm going northbound on Young. It's very icy. I saw two people walk over the ice here, who were treading lightly, as I was. More ice. And then it becomes packed snow again, which is easier to walk on because there is more traction. I still can't see the pavement. There is a path through the community garden… benches: picnic benches and regular. One of the benches, it looks as though someone has pulled up for a minute to sit down, but it is otherwise not clear around it.

Much as in Crescentwood, the sidewalk sort of goes up and down a little bit, with packed snow. You can still see treads – it's obviously been plowed, but because there are no driveways along Young, it is less up and down.

The houses are still in pretty good condition, more chipped paint, and the fences aren't as in quite as good shape. This is a long block – Young, between Broadway and Portage. There were two people I passed walking, both wearing backpacks, about my age, maybe students walking home. I can see another woman walking in scrubs, potentially to or from Lion's Place. There are a couple of garbage cans in quick succession as I approach Portage Avenue. Junior's is here, an empty building for lease. The sidewalk is very clear here, though there is some loose gravel on the pavement. I'm turning onto Portage. More garbage cans. Still clear sidewalk, except for the gravel. More people walking. Some icy patches, going in and out of businesses, most are drier, showing pavement.

I'm still going westbound on Portage Avenue. I'm taking a picture of Portage Avenue at Langside, looking Southbound. Anytime I pass a big ice ridge, I'm avoiding it and walking on dry ground. The bus stop is very icy. It's actually at eastbound Portage and Langside bus stop, it's sheer ice where people are meant to wait and board the bus. There is a shelter and a bench. Traffic is heavy along Portage, though I just crossed in front of Lion's Place and a vehicle did wait for me to cross first.

So I'm turning onto Furby, going Southbound. Really high, gross-looking snow banks. Very dirty. The sidewalk is clear, though sometimes when the sidewalk and lane don't meet, there is broken ice and the pavement is also broken. All the streets I've walked on so far have sidewalks on both sides. Tall streetlights here, apartment buildings. Still lots of people walking. The packed snow on Furby is still offering more traction. Snow banks are quite high. There are some places where people have shovelled their walks to the street, providing access points at which to cross, though informal. The man walking ahead of me is carrying several grocery bags. There is quite a bit of construction on this street. The houses are mostly in good shape. There's some unfinished work around doorframes, some chipping paint, some broken windows.

"Good, you?"

Someone just said hi and asked how I was doing. At Furby and Broadway there is a crosswalk, so I am going to take it. **Pedestrian crossing signal sound**

"There is a bus stopping for me, I feel like a jerk." **bus horn sounds**

Okay, so as I went to cross, the bus stopped for me, and honked as another car went to pass by even though the crossing signal was on. So my heart actually stopped a little bit, but thank you to the nice bus driver. There is a man crossing now without the crossing signal on, but the cars are stopping for him (Figure 7). So that's nice.

Figure 7: Pedestrian Crosswalk, Broadway and Furby

I'm walking westbound on Broadway – there's cobblestone again, or brick lay, I guess. It's pretty clear. Lots more people walking still. The sidewalk, where you can see it, isn't as level. There's definitely some broken pavement, and still some rising and falling, even of the dry sidewalk.

So this intersection actually has crossing light countdowns, so you know as a pedestrian how long you have to cross the intersection, which is kind of reassuring. There's a bench here, which is often occupied by panhandlers and the light here at Broadway and Sherbrook seems to be quite long – 45 seconds, with a 16-second warning. So more dry, level pavement. Once again, strangely, at the bus stop there is less even ground, lots of broken ice. I'm going southbound on Maryland. It's very slippery. People waiting for buses, still more people walking. There is a bus shelter at Maryland and Knappen. There's a woman waiting to cross the street at Knappen, but she'll have to wait till the traffic stops, 'cause there's no crosswalk. The houses are in the same sort of condition – some of the front stoops are rickety, there are a few run-down houses. Some – a lot – need paint. The woman, middle-aged, probably 60-65, is now instead walking north toward Broadway, I imagine to cross with the light. At Fawcett, there are signs indicating that there is a

crosswalk coming up, but the cars don't seem to be slowing down at all. Which is fine – I just saw a person cross at the light without starting it, so maybe it's not always necessary.

At Alloway I can see a bus stop, again it's been cleared, but no bench and no shelter. There are some loose pieces of ice strewn on the sidewalk. I'm now turning left onto Sarah, going eastbound on Sarah. Same thing – rising and falling sidewalk. High, dirty snowbanks. And here when you cross the back lane, it reminds me of Crescentwood 'cause there's a drop and it's icier as the sidewalk meets the lane.

So now I'm turning southbound on Sherbrook. There's also a pedestrian crosswalk at Sherbrook and Sarah. There's an antique store, a children's wear store. Sherbrook is the sort of commercial-retail strip in this area. The sidewalks are well walked, kind of curving, mixed packed snow and clear. The houses that are actually on Sherbrook are not in as good shape; they're pretty run down. The Melbourne apartment block is completely boarded up – well no, the windows aren't, but the front door is boarded. I'm walking past a sushi place, a camera repair shop, Stella's, which is still closed. There's a back lane just north of Stella's that is very icy looking. There are people waiting at the bus stop.

Here on Sherbrook, the sidewalk actually isn't as level even when it is bare. There are definitely lots of people out and about.

So often *at* the intersections there is ice that has been chipped away. I don't know whether it's by the business owner, for example at this chiropractic and dental clinic [Westminster and Sherbrook], the ice has been chipped away, so it's bare. But then it creates a ridge of ice and there ends up being a pockmarked and very icy surface around it. Still lots of people walking around – some with backpacks, some not. Some are waiting for the bus; potentially indicating

they are actually using walking as a mode of transportation. There are lots of cars parked along here as well.

Okay, I'm going to stop into Thom Bargen for a warm-up because I am cold, and it's been 36 minutes.

Coffee shop noise

So I'm walking out of Thom Bargen, south on Sherbrook, I just watched some people very cautiously cross a patch of ice.

I'm crossing with the light, watching traffic, to the east side of Sherbrook, in front of Cousins Deli. There is lots of traffic hanging late on the light, crossing through the stale yellow. The bus stop at the Misericordia, on Sherbrook has a bench and a shelter, though it's very icy. There is a lot of loose gravel along this strip. A car just came out of the parkade [Misericordia Place] and I had to stop while he went. There is a woman walking by with a grocery bag and yoga matt, as well as a couple kids who are probably about 15. There are still plenty of people out walking.

I'm now turning toward The Gates [West Gate, Middle Gate, East Gate]. I think school just let out because there are lots of kids walking with backpacks. The snowbanks are still really high, with mixed condition sidewalks – where I can see the pavement it's actually quite good and level, just impeded by some snow and ice.

There's another example of a laneway creating some trouble in path consistency. I've been walking east on Cornish.

There's kind of a steep decline now towards the road, which is really Langside where there definitely is a sidewalk. Now I can see that there *is* a sidewalk here [east], but there's just no boulevard so the sidewalk is curbside, which is fine on this part of the street. But on the other [west] side of the street, it's a little cramped with the parked cars – I'm jaywalking back across to see. There are some roadblock signs, so it *is* very narrow, though someone is walking there anyway.

Figure 8: Sidewalk "cleared" due to pedestrian traffic, Cornish and Langside

Back on the east side, the sidewalk is quite slanted toward the street. It's pretty icy and the sidewalk is pretty cracked here. Though there is still a sidewalk on both sides of the street, so there's that. Curiously, the sidewalk on the west side is now dry and super level, while on the east side – the Balmoral Hall school side – it's *very* uneven with ice and snow and footprints.

I am crossing at Young and Balmoral. There is a painted crosswalk, no lights, but cars are stopping for me. Again, on the north side of Balmoral, it is super icy. The bus stop here has no bench and no shelter (Figure 9). It actually looks pretty dangerous with so much ice on the path leading toward where you would board the bus (Figure 10).

Figure 9: No frills bus stop, westbound Westminster and Langside

Figure 10: Icy path to board bus, Westminster and Langside

There is a stop sign at Balmoral and Young, though some people definitely don't stop as they pass through – in particular the people who are going forward into Balmoral Hall [parking lot] seem not to stop all the way. The lane on Young where the dumpsters are is really bad. It's very uneven – to the point it's almost like steps that you need to go up and down while crossing. Apartment buildings – the sidewalks have been cleared outward, straight ahead from the entrances, but not to the sides.

There are some desire lines cutting through so that people can get to the sidewalk from the street, so it's not the most accessible (Figure 11). And on Young, there are streetlights, trees, snowbanks, pretty packed snow with some icy spots. It is definitely wide enough for two people though I also seem some people walking on the street, which is in horrible condition.

I'm walking up Young because I wanted to look at the park. There is definitely a makeshift path in this way [toward the park] versus having it be cleared. There are innumerable tracks all

through the snow in the field, as well as some benches, though no shelter, so realistically no one is going to sit there in the winter.

There are fewer icy spots on Spence. I'd say overall it's more level. The snow is quite packed, and there is definitely room for three people to walk abreast. The houses are in really good shape between Broadway and Balmoral. There are paths running from most people's sidewalks through the boulevard down to the street, some of them more developed than others. Here's one patch of sidewalk that's totally bare (Figure 12).

Figure 11: Pedestrian desire line cuts through snowbank, Young and Balmoral

Yeah, Spence is good. I'm at Spence and Balmoral, and I'm going to stop, and go home because I'm cold."

Figure 12: Sidewalk cleared by homeowner on Spence Street

Post-Walk Analysis:

According to general parameters of walkability identified in the literature, West Broadway is understood to be a walkable neighbourhood. There is a high level of land use integration with residential destinations including single-family homes, apartment buildings, rooming houses, seniors

housing and assisted care homes; commercial destinations ranging from grocery and convenience stores, to retail shops, restaurants and coffee shops; and public destinations including post offices, pharmacies, and schools. There is wide availability of accessible transportation modes, with sidewalks on both sides of every street, bike lanes, access to a multitude of bus routes from various stops throughout the neighbourhood, as well as on street parking and several central parking lots. The social environment was also extremely welcoming, with plenty of people out walking for what seemed to be a variety of reasons. Children and people of all ages walked alone or in groups, carrying backpacks, groceries, take-out containers, or nothing at all. Much of the neighbourhood was pleasant and cared for, with colourful murals on buildings and in the public parks. Most of the residential properties were in good condition, with some houses and apartment buildings being more obviously run-down or boarded up.

However, despite these strengths in infrastructure, direct experience winter-walking belies this understanding of the neighbourhood. While the area remains more walkable than subsequent explorations of neighbourhoods Crescentwood and Crestview revealed, there are several primary issues that arise due to seasonal factors. The main issues throughout the neighbourhood had to do with sidewalk maintenance, specifically path condition and smoothness. Sidewalk condition was greatly affected by the presence of snow, ice and grit (Figures 5, 6, 8). These issues were reflected in the observed behaviour of pedestrians cautiously adapting their natural gait along questionable stretches of various paths. Issues of maintenance also affected sidewalk continuity, where certain connections that exist during milder months disappear when the snow is not cleared. Desire lines may be observed in some of these places, with pedestrians forging connections that have not been cleared (Figures 8, 11).

Bus stops are plentiful in the neighbourhood, and many of them have benches and/or shelters that become particularly important during winter months. However, due to high pedestrian traffic, many of the paths surrounding the stops that would lead onto the bus are particularly treacherous, with thick expanses of ice (Figure 10).

Finally, aggressive drivers were encountered on more than one occasion during my walk in West Broadway, with the threat of traffic to pedestrians becoming more of a risk in the winter when road conditions and visibility may become diminished by ice and snow.

5.2 Crescentwood:

Wednesday, March 2, 2016, 3:00-4:00 p.m.

- Mean daily temperature: -12.5 °C
- Precipitation accumulation: 0 mm
- Corydon and Stafford → Stafford St. → Grosvenor Ave. → Cambridge St. → Harvard Ave. → Wilton St. → Dromore Ave. → Harrow St. → Kingsway Ave. → Ruskin Row → Palk Rd. → Wellington Cres. → Arbuthnot St. → Corydon Ave. → MAKE Coffee
- A map of this route can be found in Appendix B.

My walk around Crescentwood was the first of my three days of observations around the chosen sights. It was clear and cold, and while I had my iPhone in my winter jacket pocket, it shut off abruptly, within the first ten minutes of my walk. My Canon point-and-shoot camera lasted throughout the walk, occasionally turning off from the cold, but regaining power after being warmed up in my hands. This allowed me to take photos throughout most of the walk.

Immediately following this session of observations, I sought refuge from the cold at MAKE Coffee on Corydon Avenue, where I jotted key observations from memory.

Unfortunately, while my iPhone's voice memos allotted for 11:29 minutes of recorded notes, the track would not play, and no voice-recorded notes were salvaged. The hand-written observations that were recorded post-walk are as follows:

Hand-Written Notes:

- Crossing times 20-50 seconds at Stafford and Grosvenor.
- Quite a few people out walking – on Stafford and Corydon, seem to be more potential that people were walking for transportation, carrying purses or backpacks or a tote (groceries), or nothing at all. Sidewalks clearer, but areas of standing water, or slushy ice. Vehicles traveling at speed limit, but wide street, and no crosswalks between Corydon and Grosvenor.
- Turning toward more residential streets, sidewalks covered in packed snow. Not as slippery as ice, but not often level. On Grosvenor, room for two people to walk comfortably next to each other.
- Sidewalks on both sides.
- Cars noticeably slowing down at "school zone" sign.
- On main thoroughfares, cars running stale yellow lights.
- Off main streets, cars always waited for me to cross, even if I hadn't yet approached the street. Very polite behaviour.
- Many students obviously walking home. Several dog-walkers.
- High tree canopy throughout the neighbourhood, though less so along Stafford.

- Access points to lanes were often very uneven, with deep tire treads. Sometimes slushy, sometimes bare ice, sometimes uneven snow, sometimes down to the pavement.
- Dead end sidewalks a problem (Figure 4). Often sidewalks on only one side of the street. Desire lines throughout neighbourhood. Sometimes couldn't tell if there was a sidewalk underneath narrow path (i.e., on east side of Cambridge?). No sidewalk on west side of Cambridge. Path uneven, meandering, narrow.
- Speed bumps on Cambridge to slow traffic.
- Bus stops had mostly been plowed, but rarely had benches or shelter.
- No places to sit, except in Peanut park or the odd bus bench. No shelter – even at bus stops on Stafford where there was less windbreak from trees.
- Neighbourhood very clean, over all. Houses in very good condition. Sidewalks and driveways shovelled, sometimes causing same unevenness as lanes. Minimal physical disorder.
- Sidewalks bare in front of Grosvenor School and church at Grosvenor and Wilton.

Post-Walk Analysis:

Chosen as a neighbourhood with medium walkability, Crescentwood still has a fairly high level of land-use integration. Residential destinations are predominantly single-family dwelling, along with apartment buildings. Commercial destinations are more localized to the neighbourhood's south peripheral borders of Corydon and Grosvenor, as well as along Stafford Street, and include coffee shops, restaurants and some retailers. Public amenities include a bank, pharmacy, post office parks, and several schools, including Kelvin High School. However, many commercial and public destinations can be found in the neighbouring locality of Corydon Village. In general, fewer commercial destinations allowed for less opportunity to find reprieve

from the cold. At one point during my walk in West Broadway, I stopped for coffee at Thom Bargen Coffee & Tea to warm up. In Crescentwood, the only recurrent shelter is due to the extensive tree canopy, which helps to block the wind, but provides no opportunity to escape the cold.

The social environment remained very welcoming in Crescentwood. This set of observations took place at approximately the same time school was being let out, so I crossed paths with people of all ages – children in groups or with parents, and teenagers seemingly walking home from school, people walking dogs, as well as several adult students near to the university express bus route on Stafford. In comparison to West Broadway, there was significantly less public art visible on my route, however properties and houses were all kept in good condition. Interestingly, one frequently encountered issue arose based on private property management in contrast to the management of public spaces. Throughout the neighbourhood, sidewalks and driveways were typically cleared of snow, presumably by shovel or snowblower. Often the snow was more carefully cleared from paths on private properties than on sidewalks, resulting in path inconsistencies from driveway crossover. At best, these crossovers caused the snow-covered sidewalk to intersect and pass by bare patches of concrete. At worst, deep, uneven, and icy ridges were formed by the tire tracks of vehicles entering and exiting properties. Due to the high number of single-family dwellings, driveways are extremely common in the area, and proved to be a frequent cause for inconsistency in path condition and smoothness.

Crescentwood has good access to public transit, with routes running peripherally along Corydon, Grosvenor, and Academy and through the middle via Stafford. Bus stops throughout the neighbourhood had generally been plowed, with some of the same icy path issues encountered as in West Broadway. However, in comparison to West Broadway, benches and/or

shelters rarely accompanied bus stops. This was especially notable along Stafford Street where the wind exposure was much greater due to fewer trees acting as windbreak.

Sidewalk continuity was a much greater issue in Crescentwood than West Broadway, with some streets having paths only on one side of the street, and other sidewalks arriving at abrupt and inexplicable dead ends (Figure 4). In these situations, desire lines were obvious and frequent, carving paths where there were none in existence, or where sidewalks had not been properly plowed. For example, on the east side of Cambridge Street, it was unclear whether the path in existence was an unplowed sidewalk or route entirely of pedestrian making. Based on the meandering and unlevel nature of the path, I believe there was no sidewalk in place. There was also no sidewalk on the west side of the street. Lack of sidewalk continuity becomes even more of a hindrance to walkability in the winter when those using walking as a mode of transportation seek the shortest routes between destinations. The extensive network of desire lines in Crescentwood evidences pedestrian perseverance.

On main thoroughfares, aggressive driver behaviour was still clear, with vehicles rushing through stale yellow lights. In contrast, drivers were extremely considerate of people walking along the more central, residential streets. Cars noticeably slowed down when approaching and traveling through designated school zones. As I approached intersections to cross, drivers were always patient, allowing me the right of way if there was no crossing light. The route I took through the neighbourhood allowed me to travel on sidewalks or on desire lines over boulevards; based on driver behaviour, however, I would have felt safe walking along many of the streets.

5.3 Crestview:

Friday, Mar. 4, 2016, 9:30-10:30 a.m.

- Mean daily temperature: -7.4 °C
- Precipitation accumulation: 3.4 mm
- Portage and Cavalier → Unicity Mall → David St. → Fairlane Ave. → Goswell Rd. → Corbett Dr. → Chapman Rd. → Hamilton Ave. → Normandy Dr. → Hollingsworth Ave. → Cavalier Dr. → Hamilton Ave. → Bellavista Cres. → Rogan Dr. → Radar Pl. → Voyageur Ave. → Crestview Park Dr. → Crestview and Cavalier
- A map of this route can be found in Appendix B.

While my iPhone remained on and recording until approximately 10:00 a.m., the wet snowfall severely affected the quality of the voice recording. Intermittent patches of the voice notes were salvageable, but much of the audio was obscured. I was not aware of the problem until I had finished the walk, charged my iPhone and attempted to listen to the track. Fortunately, my Canon point-and-shoot camera fared better, remaining on until about 10:10 a.m. Upon returning indoors, I charged my equipment and wrote key notes to the best of my ability from memory, to accompany both the segment of the walk where photos were taken, as well as where no voice notes or photos were generated. The salvaged voice notes have been transcribed as follows.

Voice Recorded Notes:

"I'm at Portage and Cavalier (Figure 13). The crosswalk time to cross Cavalier at Portage is about 20 seconds. And it looks like unless you actually press the crosswalk button to cross Portage, there is no automatic pedestrian signal.

The speed limit is 60km/hr here.

There is a bus stop at Portage and Sumach with a bench but no shelter. There also aren't many trees around here.

There are snowbanks blocking access to the boulevard.

The sidewalk where I *can* see it looks to be in good shape.

Figure 13: Pedestrian at Portage and Cavalier

It is not, *this* is *not* pedestrian friendly.

…a lot of ice.

There are really very few other sets of tracks…

There is a sidewalk on the east side of the street, so that's good. [David Street]

Not a footprint in sight.

Underneath my footprints you can see bare ice (Figure 14).

Fairlane and David. I'm going to cross.

Figure 14: Footprints reveal sheer ice under snowfall on David Street

There is a – **woo!** – super slippery. There is a school zone sign. There aren't any cars in sight… I'm going to walk onto Goswell. Also no sidewalks on Goswell.

It's very peaceful. Still no sidewalks. There is a bench, but it's surrounded by snow (Figure 15).

There is a crosswalk at Costello at Corbett. I know that this is for students, but it's funny, actually I guess it's not a crosswalk, it's a pedestrian crossing sign. Since there's no sidewalk, it's funny that there would be a crossing sign, but it is for students to go through the catwalk into the field toward John Taylor [Collegiate]. I'm going to keep walking down Corbett. I'm going to temporarily pause my recording to keep warm and to keep my phone battery alive because there is nothing happening here at all.

Figure 15: Corbett Park bench

There is a four-way stop at Hamilton and Chapman. I'm going to cross.

I'm going to walk along Hamilton.

…bus stop, no bench, no shelter. It has been sort of cleared. But there is a big ledge even just to get up to the bus stop (Figure 16). [Hamilton at Chapman]

I am going to take this catwalk at Chapman off of Hamilton because it's cold and not nice to walk on.

Figure 16: No shelter and uneven footing to board bus, Hamilton and Chapman

Still no sidewalks, but there is a "children playing" sign. So that's good, I guess.

So there are some tracks with footprints. Wow, Hamilton is quiet – or Cavalier, I meant Cavalier. Okay, I'm crossing at Hollingsworth.

Dogs barking Okay, this is Hamilton and Cavalier and there is nothing happening. I am going to cross north just to take a picture…

There are desire lines from either direction here toward the parking lot. I'm coming onto Bellavista Crescent. So that does show that people have walked here…"

-- End of voice recorded notes due to iPhone shutting off --

Hand-Written Notes:

- Sidewalk very icy and snow-blown on Portage. Path wide and definitely had been cleared by snowplow, but surface pockmarked with patches of ice (likely due to intermittent thaw and freeze) (Figure 17).
- I walked more slowly because snow was blowing and covering up ice in some spots.
- Vehicle access points from Portage into commercial and residential parking lots were well used. The difference between sidewalk surface and access points was not as uneven as along residential streets. Sidewalk seemingly cleared regularly.
- Blocks very long on Portage, with crosswalks only at intersections with streetlights. If crossing between intersections, need to cross eight lanes – sometimes median wide enough to stand on, sometimes not. Snowbanks along street also hinder crossing between intersections.

Figure 17: Mixed terrain of bare ice, packed and blowing snow, westbound Portage and Cavalier

- No shelter between Cavalier Drive and Unicity Parking lot access west of David Street (700 m). A few trees in boulevard, but wind protection minimal to non-existent.
- Unicity not oriented to pedestrian shopping experience. About 500 m from Portage to the two stores furthest from main strip (Sobeys and Walmart). Observed fresh tracks in the parking lot from someone pulling a two-wheel shopping cart (Figure 18). No path continuity – sidewalks along box stores, alternating with vast, open parking lots. Only

narrow path cleared. Didn't see many pedestrians – those observed dressed very warmly (boots, hoods, scarves, carrying shopping bags).

- More windbreak on David Street due to trees. Sidewalk only on one side, had been cleared, but was extremely slippery, with fresh snow covering ice. Driveways mostly clear.
- Sidewalk only on one side of street, less slippery on Fairlane, more packed snow (maybe due to Buchanan School foot traffic?). Street signs for school zone.

Figure 18: Shopping cart tracks lead toward Unicity Mall from Portage Avenue

- No sidewalks on smaller residential streets – bays, crescents. Minimal traffic, so can walk on road. Very few cars passed, but gave considerate berth.
- Very clean neighbourhood, little physical disorder.
- Wide curbside boulevard on Hamilton. Sidewalks on both sides. No shelter at bus stops, some uneven ridges, mixed snow and ice terrain to board bus.
- VERY cold on Hamilton, no shelter from wind and snow. Adapted route and used a snow-drifted catwalk to turn off Hamilton onto Normandy for more protection. Side streets were more pleasant to walk along.
- Signs warning for "children playing."
- Saw some pedestrian tracks along my way, but very few people out walking.

- Re-joined Hamilton via Cavalier, but adapted route a second time to escape cold exposure again to walk along Bellavista Crescent.
- Sidewalk only on north side of Voyageur – same side as Voyageur Elementary School located (like Fairlane and Buchanan School).
- Sturgeon Creek on east side of Crestview Park Drive, sidewalk on west side. Creek side has paths from pedestrians and dogs, benches approximately every 100 m, garbage cans an estimated 200 m apart and marked with signage indicating dog owners must pick up after pets.
- Sidewalk on Crestview Park quite level with combo of pedestrian use and plowing. Dry concrete some places, alternating with ice, snow, grit, as witnessed in all neighbourhoods.

Post-Walk Analysis:

Crestview was chosen as an example of a car-dependent neighbourhood with low walkability. The neighbourhood is predominantly residential, with single-family, detached homes and apartment buildings located along the main roads. With the exception of a Food Fare located at Cavalier Drive and Hamilton Avenue, commercial destinations are exclusively located along the neighbourhood's southern periphery of Portage Avenue. Furthermore, restaurants, grocery stores, retailers, coffee shops, pharmacies, liquor stores and banks, are localized around Unicity Mall or at a small strip mall at Portage and Cavalier, rather than along the length of Portage Avenue. Public parks and school are plentiful throughout the neighbourhood, and the area is very clean and well kept, with minimal physical disorder. My observations took place on a cold and snowy Friday morning, which is assumed to have reduced the number of pedestrians visible. While I did see several people (or evidence of people in the way of footprints) walking near or along Portage Avenue, pedestrians were scarce.

Wide sidewalks exist on both sides of Portage Avenue. Similar to in West Broadway and Crescentwood, they have been plowed, but path condition suffers with snow, ice, grit, and driveway crossovers. However, despite the sidewalk, and commercial and public destinations, Portage Avenue is not walkable. The distance between Cavalier Drive and David Street is over 600 metres. In this space, there are no non-residential destinations and no access to the rest of the neighbourhood. Unicity Mall is just west of David Street, though to reach the many box stores, pedestrians need to walk further distances of up to 500 metres from Portage Avenue. Along Portage Avenue, trees exist mainly between the sidewalk and the residential buildings, providing little shelter from wind along the eight-lane highway. Most bus stops along the street do not have shelters. Furthermore, pedestrian crosswalks exist only at intersections with traffic lights, resulting in lengths over 400 metres with no opportunity to cross Portage without jaywalking.

The layout of Crestview is not gridded, but comprised of predominantly lower-capacity bays and crescents. Away from the main streets, sidewalks exist on one or neither side of the road. Where they do exist, similar problems regarding condition and maintenance occur as they did in the other neighbourhoods. There are fewer desire lines than were observed in Crescentwood, likely as a result both of fewer dead-end paths, and a lower volume of traffic allowing pedestrians to walk more safely on the road. Despite the lack of sidewalks, the walk was more pleasant on the narrower side streets that provided more protection from the wind and snow. Vehicles that passed me on the street always provided a wide berth as they went by, and were driving slowly enough I could see drivers nod or make eye contact with me. Away from Portage Avenue, paved shortcuts or “catwalks” between streets provided more pedestrian connections through the neighbourhood. These shortcuts were often found linking a school field or park to nearby streets. In the instance of my improvised route away from the cold and windy

Hamilton Avenue, I used one such catwalk to seek the shelter of a more protected crescent. Beyond narrowing streets with denser houses and trees, there were no destinations for a pedestrian to seek shelter in throughout the neighbourhood.

Access to public transit is good throughout the neighbourhood, with routes running along several main roads through the neighbourhood. Many stops have benches, but no shelter.

5.4 Summary of Observations

This chapter included the field notes transcribed from voice recording and/or hand-written following the analysis of each neighbourhood. Due to technological difficulties experienced while using my iPhone in the cold weather, the format of each subsection varies slightly. I endeavoured to record thorough observations about each neighbourhood with immediate written reflection after each survey. Observing three diverse neighbourhoods was intended to inspire critical examination regarding the ability of current auditing tools to assess urban walkability under winter conditions.

When considering such common aspects of walkability as pedestrian infrastructure, land-use integration, social environment, environmental aesthetics, public amenities, and safety, the resultant walkability of the three neighbourhoods assessed would likely rate predictably; West Broadway is very walkable and Crestview is not. While the literature provided some understanding of both the parameters of walkability and possible issues that may be encountered, direct walking experience and first-hand observation provided a better sense of climatic issues. Many of the same climatic issues were encountered in every locality, regardless of their various strengths and weaknesses concerning walkability. As a result, several themes arose from these

observations, including issues of public transportation infrastructure and the provision of comfort features, as well as issues around maintenance and safety (particularly in relation to sidewalks).

In every neighbourhood, sidewalks faced issues of maintenance. Snow, ice and grit were frequent problems to varying degrees, affecting both the condition and the smoothness of paths. Driveway crossovers often exacerbated issues of inconsistent terrain creating slippery grooves of varying depths. Sidewalk width was regularly affected by encroaching snowbanks. In some places, paths were shaped by repeated pedestrian use; this was observed both where sidewalks existed, but had not been plowed, and where sidewalks lacked continuity.

Transit stops in each neighbourhood also consistently suffered identical problems. The absence of shelters became more apparent in the face of cold winter winds. This was particularly problematic along main routes such as Broadway Avenue (West Broadway), Stafford Street (Crescentwood), and Hamilton Avenue (Crestview), where wider streets provide even less protection from wind exposure. Furthermore, the increased foot traffic at bus stops combined with the alternate thaw and freeze resultant of fluctuating winter temperatures causes changes in the condition of the path. Many of the paths at bus stops were extremely icy and/or uneven.

While most of the questions asked by auditing instruments are still pertinent in a winter climate, it is clear there are obvious gaps regarding some of the most serious challenges faced by pedestrians. The intent of these unobtrusive observations was to highlight some of those climatic gaps through the first-hand documentation of my own pedestrian experience in three diverse neighbourhoods. This preliminary exploration provided a sense of some of the issues a pedestrian may experience in the winter as they navigate the city. These issues are explored further, directly in relation to seven walkability auditing tools, in the following chapter, wherein

the instruments are systematically reviewed to assess their strengths and weaknesses regarding winter conditions.

6.0 SYSTEMATIC REVIEW

Walkability auditing tools enable systematic observation of environmental features thought to affect physical activity. More specifically, they are useful for collecting data on aspects of the physical environment not typically included in GIS databases (e.g., sidewalk condition), or better assessed through direct observation (e.g. path obstructions) (Brownson et al., 2009). The detailed data garnered from in-person observation can be of particular use to those interested in better understanding how people interact with spaces, such as city planners and urban designers. Researchers will typically walk or drive through a neighbourhood, in order to code features according to the specific item definitions and standardized form of the auditing tool. *Street segments* are generally accepted as two opposing sides of one block, and are often used as a unit of observation when completing neighbourhood audits. A random or purposeful sampling of segments is often used to represent a neighbourhood when auditing an entire area is not feasible (Brownson et al., 2009). Purposeful sampling was used in this thesis, when routes were drawn through Crescentwood, West Broadway, and Crestview to ensure important environmental features, such as parks, differing roadways, and land-use variation were observed.

In *Measuring the Built Environment for Physical Activity,* Brownson et al. (2009) comprehensively reviewed key characteristics of twenty audit tools. From this collection, seven audits were selected for assessment, based on their broader relevance and usability. The instruments reviewed can be found in Appendix C; they include the Systematic Pedestrian and Cycling Environmental Scan (Pikora, Bull, Jamrozik, Knuiman, Giles-Corti, & Donovan, 2002), Neighbourhood Active Living Potential (Gauvin et al., 2005), the Walking Suitability Assessment Form (Emery, Crump & Bors, 1998), the complementary Analytic Audit Tool and Audit Checklist Tool (Brownson et al., 2004), the Sidewalk Assessment Tool (Williams, Evans,

Kirtland, Cavnar, Sharpe, Neet & Cook, 2005), the Active Neighbourhood Checklist (Hoehner, 2011), and the Pedestrian Environmental Data Scan (Clifton, Smith & Rodrigues, 2007). Published between the years of 2001 and 2008, the tools originated in the United States or Canada, with one emerging from Australia. Despite the variance of the Australian to Canadian climates, the *Systematic Pedestrian and Cycling Environmental Instrument* (Australia, 2002) was one of the earliest auditing tools, and was still reviewed in this research (Brownson et al., 2009).

This chapter discusses the *background* associated with each of the seven tools, including such things as goals, inspiration, testing, and authors; *content*, including number of items, subsections or organization of questions, and response type; and *climatic gaps*, including blatant shortfalls, as well as items that may prove useful in assessing winter conditions as they are or with minor adaptation. This review also reflects on how the design of walkability audits may be improved in order to better address issues faced by winter cities in Canada.

6.1 Systematic Pedestrian and Cycling Environmental Scan Instrument

Background

With the knowledge that environmental factors can have a very direct effect on physical activity participation, the Systematic Pedestrian and Cycling Environmental Scan (SPACES) was born out of a desire to develop a tool to reliably collect, organize, and examine data on the physical environment (Pikora, Bull, Jamrozik, Knuiman, Giles-Corti, & Donovan, 2002). Through literature review, interviews, and a three-phase Delphi process, Pikora et al. identified factors of the physical environment that may affect walking and cycling behaviour (2002, 2006). The iterative Delphi method involves a panel of experts attempting to achieve group consensus on a topic when information is not readily available through systematic approach (Pikora et al., 2002). In this case, the panel rated factors of the environment regarding their importance

influencing walking and cycling behaviour. In generating the Systematic Pedestrian and Cycling Environmental Scan, a panel of experts rated environmental factors in terms of the importance relative to walking and cycling behaviour. These results were then used to construct four models of factors potentially important toward the influence of active transportation behaviour in local neighbourhoods. The four frameworks consist of *features* that summarize the physical environment, *elements* that form the components of features, and *items* that can be modified to better elements (Pikora et al., 2002 & 2006). The auditing tool was developed through the use and testing of these four models to determine which attributes were most relevant to the local environment.

The SPACES tool was widely tested during development, with a total of 1987 kilometers of street audited. It is, however, important to note development took place in Western Australia, in the city of Perth. While high reliability of items was generally observed, the location of development results in obvious limitations regarding climatic issues. A lack of variation in the segments audited further suggests the need to repeat reliability studies in other neighbourhood environments. Regardless, the tool was one of the first comprehensive auditing tools developed and tested. It is widely referenced by subsequent instruments, and is important to include in this review.

Content

The 39 items on the SPACES auditing tool guide the user in assessing various types and features of buildings, path characteristics and location, road and crossing aid infrastructure, and neighbourhood maintenance and security. Response types are varied, including checklists, yes/no questions, and Likert and rating scales, whereupon response is specified on a symmetric scale of

agreement or disagreement. Four subjective items ask the auditor to rate the attractiveness and the physical difficulty of the segment for walking and cycling, respectively.

As the instrument was first used to audit nearly 2,000 kilometres of road network in Western Australia, assessment of each segment was intended to be quick and efficient, with auditors collecting data for approximately two kilometres of data in 40 minutes. The SPACES Observation Manual was created to help the auditors familiarize themselves with the tool, and begins by defining a segment as a section of street between two intersections. Brief, but explicit guidelines for completing the form describe details such as map use, starting point, which side of the street to walk on based on the existence of paths, and instructions for recording answers. Each question is explained in brief, with instructions for how best to answer. Photographs often accompany the explanation. For example, when considering *path condition and smoothness*, definitions of what constitutes a poor, moderate, or good path are further illustrated with a photo of each designation, respectively.

Climatic Gaps

As one of the earliest auditing tools developed, having served as an important basis for several subsequent audits, the Systematic Pedestrian and Cycling Environmental Scan is a valuable resource to consider in this thesis (Brownson et al., 2009). However, as development and testing of the SPACES audit took place in Perth, Australia, there are certain predictable climatic gaps concerning northern hemisphere winter conditions. While there is no mention of snow, ice, slush, grit, wind, or shelter, several of the items assessed would still be relevant to communities worldwide, if attention is paid to seasonal changes. For example, while the rating scale in relation to *path condition & smoothness* references the existence of "bumps, cracks, holes & weeds," winter sidewalks can still be assessed using the poor to good designation, with

some modification to the scale definitions. Similarly, *path obstructions* could be expanded to include snowbanks, slush, or standing water, and questions of segment *slope* may highlight potential problem areas if ice is present during the winter.

Certain other items would provide useful insight, as they currently exist on the SPACES audit. An item regarding *path location* assesses the distance between the sidewalk and the curb, on a scale from "next to road" to "more than 3m from kerb." In a winter city, a buffer between the road and the sidewalk allows for snow to be cleared from the road, without reducing the width of the sidewalk. Questions regarding the existence of streetlights, whether lighting covers the path, existence of destinations, and ease of wayfinding will all contribute to a neighbourhood that encourages walking, regardless of seasonal variation.

In relation to the other auditing tools compared in this thesis, several items are of particular note, not only due to their irregular occurrence, but because of the issues they may highlight in a winter climate. In any climate, *driveway crossovers* are important to consider, based on the increased attention needed by both drivers and pedestrians to navigate safely. However, in a winter city, these crossovers can also cause dramatic path inconsistencies, when snow and ice have not been cleared to the concrete (Figure 14). This was a common issue encountered in Crescentwood, in particular, where a high volume of residential driveways often resulted in serious differences in path condition, levelness, and slope throughout the neighbourhood. The checklist item "*other routes available"* evaluates the presence of lanes, access lanes through cul-de-sacs, through-roads, and paths through parks. Similarly, "*continuity of path"* is important to enable easier pedestrian transportation. In the winter, pedestrian desire lines may be more clearly visible through parks and along curbsides where sidewalks do not exist during warmer months. As noted by Ariffin & Zahari, these improvised paths can provide important indications

regarding residents' desires for certain destinations, as well as where they are willing to walk (2013). These *other routes available* – or forged by repeated use when continuity is poor, may provide useful insight into maintenance and/or further development of pedestrian infrastructure.

Finally, the subjective assessment regarding the physical difficulty of walking each segment would provide particularly useful information when addressing climatic issues, as the level of difficulty is likely to change seasonally, including throughout the course of the winter. While the format of the SPACES audit does not allow for any additional comments to be made, the method of completing the checklist per segment is effective in highlighting problematic areas and specific issues based on location. Furthermore, because researchers have estimated observers can audit approximately two kilometers in 40 minutes, significant neighbourhood samples may still be comfortably audited in a short period of time during cold winter months.

6.2 Neighbourhood Active Living Potential

Background

Neighbourhood observation is becoming a more popular method with which to measure environments, as it helps to increase our understanding of those observable properties that cannot be captured by the census (Fuller & Muhajarine, 2010). However, considerable variability exists regarding the method of collecting and reporting such observations, making it difficult to compare studies (Fuller & Muhajarine, 2010). The development of standardized auditing tools and user manuals may allow for better observational comparison between neighbourhoods and cities.

Neighbourhood Active Living Potential "may be defined as aspects of the neighbourhood that regulate the likelihood of active living in individuals and populations" (Gauvin et al., 2005,

p. 127). A study intended to replicate the Montreal Neighbourhood Active Living Potential (NALP) observation measure in Saskatoon, Canada found the consistency of the audit's domains was high when inter-item and inter-observer variability were controlled (Fuller & Muhajarine, 2010). This level of control was achieved through three-day training sessions for observers and coding of the Montreal NALP domains. The consistent findings in Montreal and Saskatoon suggest, "separate research teams in different cities can successfully replicate the NALP, thereby demonstrating the stability and utility of the NALP measure" (Fuller & Muhajarine, 2010, p. 366).

Content

The NALP observation method considers three issues in its effort to develop environmental measures, including settings that may encourage physical activity, attempts to encourage the social cohesion of spaces, and incorporating individual and population perspectives to promote physical activity (Gauvin et al., 2005). Consisting of the three fundamental dimensions, activity friendliness (AF), safety (SAFE), and density of destinations (DD), NALP scores neighbourhoods on a spectrum ranging from having a very low to a very high potential for integrating physical activity into daily routines. Evaluating the physical characteristics of a neighbourhood, low AF hinders human-powered activities, while high AF encourages physically active engagement. In reference to the physical and social traits of a neighbourhood, low SAFE scores evoke in people a feeling of threat or unease, while areas with high SAFE feel secure. In direct assessment of the physical and social qualities of a neighbourhood, high DD indicates the locality has a diverse array of destinations where people may engage in meaningful personal or communal pursuits.

Climatic Gaps

Varying on a continuum from low to high potential for integrating physical activity into daily routines, NALP can consider both individual-level and population-level indicators of activity (Gauvin et al., 2005). While there are no climatic issues directly addressed on the auditing tool, the purview of the audit is greater than some instruments, considering human agency as a key factor in the outcome of interactions between people and environments. With the audit split into the three dimensions previously mentioned, the subset Activity Friendliness has particular potential to consider winter conditions. Assessment topics such as "pedestrian system has limits to pedestrians" and "effort to walk around" could be elaborated to discuss such issues as snow and ice affecting path condition, and availability of shelter for windbreak. The item "number of people-oriented destinations" under the Density of Destinations subset is useful when assessing winter walkability if elaborated upon to include such shelters as bus stops and warming huts that may allow for people to find momentary shelter, in addition to open shops and cafés.

6.3 Walking Suitability Assessment Form

Background

The Walking and Bicycling Suitability Assessment Form was developed by James Emery MPH, Carolyn Crump PhD, and Phil Bors MPH in 1998, with the goal of identifying and developing methods with which communities could assess the pedestrian suitability of their streets (WABSA Project, 2007). The development of the walking suitability tool included literature review to identify key variables of the pedestrian environment. Priority and weight of designated variables was assigned based on published pedestrian audits. An algorithm was

developed to calculate sidewalk suitability, and reviewed for improvement by the UNC-Chapel Hill Highway Safety Research Center.

Content

The Walking Suitability Assessment tool is a one-page form composed of 11 factors that measure characteristics of the pedestrian environment including traffic volume and speed, curb ramps, street lighting, and continuity, width and condition of sidewalks (James, E., Crump, C. & Bors, P., 2003). Each factor is given a numeric score based on pedestrian friendliness, with a lower number indicating greater walkability. For example, if the sidewalk is continuous on both sides of the street, a score of "0" is recorded, while if a partial sidewalk exists on one side only, a score of "4" is recorded. If no sidewalk exists for a road segment, the audit assigns an automatic minimum score of 99 to designate travel on foot or wheelchair is not comfortable or safe (James et al., 2003). Scores are totalled to provide the walking suitability score for each road segment, and assigned a correspondent grade ranging from "Poor" to "Very Good". Several dichotomous questions help to further identify the existence of supportive amenities such as marked crosswalks and pedestrian "Walk" signals. In addition, space is provided to record details about specific intersections, problem spots and suggestions for design improvements.

Climatic Gaps

The numeric scoring scale of the WSAF allows for climactic issues to be better addressed with this auditing tool. In particular, surface condition, width and continuity of sidewalks and/or paths are of note, with the potential for road segments to be scored more accurately should snowfall, ice, and snow removal affect the quality of the pedestrian environment. Variables regarding road buffers, curbs and lighting will also help accurately portray winter environments. The space allocated for comment on specific problem spots and quality of intersections is also of

particular use and may help to highlight areas requiring attention based on pedestrian volume or routes between residential areas and popular destinations.

Further factors requiring address based on a winter climate include frequency of destinations, possible shelter, and windbreak that may allow for reprieve from the cold as needed.

6.4 Analytic Audit Tool & Audit Checklist Tool

Background

Ross C. Brownson et al. (2004) created two versions of an audit tool with the goal of developing reliable methods of measurement to better understand the correlation between rates of physical activity and the street-scale environment (Brownson, Hoehner, Brennan, Cook, Elliott & McMullen). The "analytic" version of the tool uses a Likert scale and ordinal response choices, while the "checklist" version offers dichotomous response choices. The research team reviewed 36 audit tools for mode of administration, number and type of items per instrument, lens of assessment (e.g. transportation, health), and scoring style. Indicators of the community environment were grouped to help develop audit items for the analytic and checklist tools, and a multidisciplinary panel reviewed the final instruments for comprehensiveness and suitability of response scale. The intended use of the two auditing tools varies slightly, with the checklist being more accessible to lay community members and public health practitioners for a quick overview of a street segment or area, while the additional detail of the analytic instrument is more useful to researchers (Brownson et al., 2004).

Content

The two auditing tools are made up of six major domains, including land-use environment, transportation environment, recreational facilities, aesthetics, signage, and social environment. Protocol for data collection with the walkability audits was developed to address concerns of safety, methods of use, and clarification of the audit tool item language. The Analytic tool contains 144 items requiring scaled or open responses. The checklist tool contains 129 items requiring a dichotomous response of "Yes/No" or "Visible/Not Visible" regarding various physical features of the environment. The Checklist auditing tool is easier to complete and displays reasonable reliability, however a lesser degree of detail is captured than when the analytic auditing tool is used. Conversely, the Analytic audit may be unsuitable for some uses given the more intensive training requirements and the need for standardized categories and definitions (Brownson et al., 2004). Furthermore, the Checklist auditing tool can be completed using pencil and paper, while the handheld devices used to complete the analytic version may be too expensive for many projects.

When tested, items regarding transportation, land-use environment, and facilities showed high reliability, while questions of aesthetics and signage showed moderate reliability, and those regarding social environment revealed the lowest agreement between the two instruments. Besides an accurate reflection of low reliability, possible reasons for lower reliability include daily changes in the physical and social environment, differences across types of neighbourhoods, and the auditor's perception of the environment (Brownson et al., 2004).

Climatic Gaps

With 144 and 129 items, Brownson's Analytic and Checklist Audit Tools are the most detailed instruments reviewed in this work, respectively. While neither tool directly addresses

winter issues, both include items that may be seasonally affected. Both tools consider presence of sidewalks and their connectivity, availability of transit stops, street lighting, and "comfort features." In cities such as Winnipeg, where snowfall can be swift and substantial, the basic assessment of sidewalk existence becomes a relevant issue, as existing paths on one or both sides of the street may temporarily disappear prior to plowing. Comfort features may include such things as shade from trees, benches, and other such amenities. When considering winter conditions, the concept of comfort features may be redefined to include windbreak from trees or buildings, and warming huts. The tools thoroughly assess the presence of signs, including traffic signs, athletic and social event signage, and advertisement billboards. Any form of signage that contributes to ease of wayfinding becomes especially important during winter months when pedestrians generally intend to expedite trips. Asking, "are people visible?" may also provide seasonal insight based on the social environment observed through the winter. The final section of each version of the tool is for open comment, allowing for the elaboration of items, or for highlighting climatic problems.

While the checklist version of the tool is more practical for site observation and completion during cold weather months, the increased detail of the analytic tool includes a greater number of items that become relevant during winter. For example, several items specifically regarding sidewalks exist only on the analytic tool. Such items include continuity, width, obstructions, and levelness and condition of sidewalk. Question of sidewalk width or levelness becomes useful as indicators of snowfall and/or snow clearance during winter months. While the question regarding levelness and condition of sidewalk provides "heaves, alignment, cracks, broken sections, weeds" (Brownson et al., 2004) as possible causes for unevenness, an auditing tool with a winter focus may also include ice, packed or loose snow, and slush. Examples of possible obstructions

to the sidewalk include both artificial (i.e. cars and construction debris) or natural (i.e. trees and rocks) could be expanded to include snowbanks. Additionally, open water or puddles that flood sidewalks during later winter and spring thaw could also be considered. In addition to the presence of transit stops assessed by the checklist tool, the analytic tool also questions the presence of shelters at stops, which is important in winter cities.

Finally, while the dichotomous response style of the checklist tool expedites administration, the rated response of the analytic tool would allow for a better overall assessment of the items of particular importance when considering winter issues. For example, rated answers such as “a little,” “some,” or “a lot” explain sidewalk obstruction more constructively than answering “yes.”

6.5 Sidewalk Assessment Tool

Background

While studies have shown land use features such as sidewalk design have a great impact on walking behaviour, issues such as quality and maintenance of sidewalks have received less attention (Williams, Evans, Kirtland, Cavnar, Sharpe, Neet & Cook, 2005). Based on literature review, Williams et al. found sidewalk characteristics to be an important factor in walking as a means of transportation (2005). In a review preceding development of their auditing tool, the team found people who reported that sidewalks in their neighbourhood were well maintained were twice as likely to achieve recommended levels of physical activity than those in neighbourhoods who reported poor sidewalk maintenance. Using Internet searches for related pedestrian-friendly infrastructure guidelines, a tool was developed for assessing sidewalk maintenance.

Tool development took place in Sumter County in central South Carolina where the mean annual temperature is 17.8 ˚C. Of the sidewalks compiled for the database and assessed by the team, 92.9% were located in the city region (Williams et al., 2005). Residents of the sidewalk-dense downtown neighbourhood were consulted to check sidewalk map accuracy, ensuring valuable feedback from community members as well as greater map accuracy from those most familiar with the area.

Content

Consisting of five items, the final version of the Sidewalk Assessment Tool considers levelness, surface condition, artificial and natural blockages, and cleanliness (Williams et al., 2005). Contributing to a more standardized administration of the audit, guidelines to explain the rating scale are attached to the one-page tool. The guidelines explain how to score each item on a scale of 1-3, or "not at all maintained," "somewhat maintained," or "well maintained," respectively. Scores are based upon the presence, absence, magnitude, or quantity of specified sidewalk traits. For example, the item "rate the existence of natural items on or in the walkway" is to be scored a 1, "not well maintained" if major obstruction exists due to overgrown vegetation, grass, leaves, snow, or ice; 2, "somewhat well maintained" if the path is partially impeded (half the path or less); or 3, "well maintained" if there is no path blockage.

Climatic Gaps

The shortest auditing instrument analysed in this thesis, the Sidewalk Assessment Tool assesses five items with exclusive regard to sidewalk maintenance. This narrow scope limits the usefulness of the tool for those who are interested in examining multiple dimensions of a street segment, and is acknowledged as a limitation by the research team (Williams et al., 2005). Given the restricted focus, gaps exist with regard to assessing climatic issues. However, sidewalk

maintenance is one of the most important issues facing winter cities, and while only one of five items specifically mentions ice and snow, the other four remain topical concerns when assessing a sidewalk during the winter season. One consideration that may need to be paid when using this tool in a winter city is in regard to the definition of "sidewalk." For example, the third item asks for the condition of the sidewalk surface to be graded. Generally defined as a paved path, sidewalks in a city such as Winnipeg may not be cleared bare to the paved surface. Condition of the path remains a major issue, however "cracks, broken sections, grass and weeds growing through the concrete" may not be specific issues during winter. In addition to exposed cracks or broken sections of pavement, the space allotted for open comment allows for adaptation of the item with consideration to (for example) surface ice, snow or slush, and loose gravel that may be problematic.

In winter months, unforeseen detours become even more inconvenient to pedestrians, making the issue of both natural and man-made blockages especially pertinent. When considering the Sidewalk Assessment Tool, a slightly adapted division of certain issues would be required to use the instrument in a winter city. For example, the tool suggests the existence of ice be rated as a natural blockade to a sidewalk. However, in a city such as Winnipeg, icy paths are not automatically seen as cause for detour, but rather caution. Therefore, when using the SAT in a winter city, I would consider ice as an issue of path condition, rather than path blockage. The item asking for a rating on natural blockages does include "snow" in its list of possible problems, which is an appropriate issue to suggest when rating natural blockages. Unplowed snow, encroaching snowbanks and loose ice should all be considered when looking at sidewalk blocks in a winter city.

In a compact auditing tool such as this one, certain obvious gaps exist when assessing climatic issues. Land-use diversity, access to alternative transportation and shelter or windbreak are not mentioned anywhere on the items for assessment. The wording of the item regarding manmade blockages is of additional note, as it asks, "Rate the sidewalk with respect to absence of items blocking the walkway" (Williams et al., 2005). While it is important to examine manmade blockages such as dumpsters, cars, and construction, the language suggests absence of blockages is the exception rather than the rule. An alteration in phrasing would help make a clearer statement to say blockages should *not* be the norm.

While the brevity of the checklist may limit the detail with which a street segment may be analysed, it also simplifies the administration process. Using this tool, an auditor may assess more sidewalks, or a greater portion of any given neighbourhood in a shorter period of time. If the tool is being used in the winter season, shorter auditing tools are practical in assessing greater areas while keeping auditor comfort in mind. Furthermore, the accompanying guidelines for how to use the rating scale help to decrease subjectivity and increase reliability when being used by different people in a variety of settings.

6.6 Active Neighbourhood Checklist

Background

Developed by Christine Hoehner et al. in 2007, the Active Neighbourhood Checklist is an audit tool that considers street-level features of the environment and their connection to physical activity behaviours (Comstock et al., 2016). When tested, the tool was found to be reliable across a range of environments. The format, terminology, specificity and one-page length were all intended to contribute toward the tool's user-friendliness (Hoehner et al., 2011). In 2011,

Version 2.0 of the Checklist and Protocol was created to adopt minor additions and revisions to improve clarity and function of both the instrument and the auditing process.

Content

The Active Neighbourhood Checklist evaluates five areas, including land use, availability of public transit, street characteristics, quality of the environment, and pedestrian and cycling infrastructure. Each of the five sections provides space for additional comment to elaborate on perceptions, specific problem spots, and gaps in assessment if need be. The instrument is the first reviewed in this thesis to include optional items. Items designated optional include specifics regarding non-residential land uses and shoulders. In the ANC's instructional protocol, rationale for the optional items states land-use information may be time-consuming to assess and potentially available from other data sources. Optional items regarding shoulders are due to their inconsistent existence, low-priority status within some communities, and lower reliability of assessment (Hoehner et al., 2011).

The protocol accompanying the tool provides instructions for use, as well as more than a page of definitions for key concepts and terms used in the Checklist. An approximate 2-hour training session, with possible opportunity to complete practice audits and engage in group discussion is also recommended prior to use of the tool. Instructions include choosing an area or route to audit, choosing a sampling approach (i.e. all segments on route, random sample, stratified sample based on land-use), and identifying street segments, as well as some general rules for auditing (Hoehner et al., 2011). The list of operational definitions is unique to the ANC, when considering the auditing tools reviewed in this thesis. Terms defined are not listed alphabetically, but in sequential order as read when administering the audit. The list is all-inclusive, clarifying each auditing item as needed for proper segment evaluation. For example,

"E8. Major bumps, cracks, holes, weeds" explains any cracks or weeds that will not affect an individual's ability to walk or wheel do not count as "major" (Hoehner et al., 2011, p. 2).

The two-page tool is formatted in part with a checklist of land-uses, and mainly dichotomous questions requiring a yes or no response. Items regarding tree shade and steepest slope have a scaled response with three possible answers. In addition, sections B and E, regarding public transportation and sidewalks build upon the yes or no response by offering two options for the affirmative answer. For example, when asking whether sidewalks are present, the options for answer include "no; yes, one side; yes; both sides."

Climatic Gaps

Purposes of the Active Neighbourhood Checklist include raising community awareness regarding the ability of the environment to enable or discourage physical activity, generating needs assessment data, and organizing advocacy efforts for needed change (Hoehner et al., 2011). While none of the items addressed on the checklist pertain directly to winter issues, the goals of the tool can be pursued and achieved year-round. Furthermore, pursuit of these goals is especially important during cold-weather months, given the dearth of information regarding winter city pedestrian needs.

The first of the five areas analysed in the ANC considers land use. Mandatory subsections to be completed evaluate predominant land uses, as well as presence of various residential, parking, and recreational uses and facilities. Section A.6 is designated as "optional" and reviews non-residential uses and destinations present in the neighbourhood. If conducting the ANC during the winter season, the completion of this section becomes more important as variety of neighbourhood destinations will support the completion of shorter trips by active transportation

means. In addition, the list of public recreational facilities present could be adapted to include an outdoor skating or hockey rink.

Section B is concise, questioning the presence of transit stops. While this item is important regardless of season, the ANC increases its winter relevance by addressing the presence of covered shelter at the stop. In Section C, the ANC asks whether any stoplight does *not* have a walk signal. In contrast to the Sidewalk Assessment Tool, this language places the emphasis on pedestrian infrastructure, suggesting presence of walk signals should be the norm. Stop signs or lights for crossing street segments encourage physical activity by creating a safer pedestrian environment. In winter months, walk signals likely mean pedestrian crossings that have been cleared of snow, ensuring safer passage across the street. Furthermore, if pedestrian "Walk" buttons are available, the intersection may be fitted with actuated signal controls, alerting the system to pedestrians and reducing wait time (Gan, 2015). Intersections without walk signals may be highlighted in the area for notes at the end of the section.

Pedestrian amenities are reviewed in Section D, with the specification of pedestrian-scale lighting being important to create a more welcoming outdoor environment during dark winter months. An item regarding tree on a scale of none to a lot could be revised in the area for comment to recognize the ability of trees to create shelter or wind break. This checklist also asks for a grade of "flat, moderate, or steep" with regard to the steepest slope along the walking area. If steep slopes exist within the neighbourhood, these spots may be highlighted in the comment section if they become problem areas due to ice during winter months.

The fifth and final section on sidewalks is fairly comprehensive, with all items able to provide useful information during the winter season as well. One adaptation to this section that

would increase seasonal relevance would be the addition of an item regarding temporary obstructions. Examples of temporary obstructions may include ice blockage, open water, or unplowed snow. Alternately, such problem areas or obstacles could be addressed in the area for notes on sidewalks in the segment. As mentioned, the language used in this auditing tool places the emphasis on pedestrian infrastructure. A second example of this supporting language exists in item E.6, which asks the auditor to if the sidewalk is less than three feet for "*any part"* of the sidewalk (Hoehner et al., 2011). This phrasing suggests sidewalks that are three feet or greater is the standard, with paths less than three feet proving unacceptable.

6.7 Pedestrian Environmental Data Scan Tool

Background

Research regarding the connections between health outcomes, the environment, and levels of physical activity has highlighted the need for the development of appropriate environmental measures in order to better understand the elements of our surroundings that encourage or deter walking as a mode of transportation (Clifton, Smith & Rodriguez, 2007). Pedestrians are exposed to a variety of environmental features that drivers are not, and while this data is more difficult to attain, it is crucial in the effort to discern behavioural patterns. In 2006, Kelly Clifton, Andréa Smith and Daniel Rodriguez developed and tested the Pedestrian and Environmental Data Scan in an effort to develop a reliable and efficient auditing tool. The one-page instrument was designed to balance detailed data collection with concise administration, and modelled some of its format off the Australian Systematic Pedestrian and Cycling Environmental Scan (SPACES), with adaptation for more accurate use in the United States (Clifton et al., 2007).

Content

The PEDS auditing tool includes 40 items, with a total of 83 measures assessed. The four areas of evaluation include environment, pedestrian facility, road attributes and walking/cycling environment. In addition, four items of subjective evaluation exist to rate the environment "in recognition that the overall quality of the walking (and cycling) environment may not be adequately reflected by the sum of the individual parts" (Clifton et al., 2007, p. 98). Response type is varied, including checklists, rating scales, yes or no items and numeric answers. In contrast to most of the auditing instruments reviewed, no space is allocated for additional comment. However, the PEDS tool is intended for use with specified segment(s). Each checklist completed will include a defined study area and segment number, corresponding with a more localized area of the community. In this way, problems that arise will be pre-emptively targeted.

A mandatory two-day training procedure was developed in conjunction with the PEDS instrument for any auditors to complete prior to data collection. The training consists of two parts, including a presentation explaining and reviewing, in detail, the segmentation of streets of pedestrian networks, followed by a tailored agenda based on the location and conducted *in* the field (Clifton et al., 2007). In-field training sessions are continued until all auditors have a thorough grasp of every audit item. An audit protocol complements the PEDS training to provide guidance for data collection in the field. The formation of the protocol was iterative, with auditors adding information as it was discovered and deemed necessary.

Climatic Gaps

When comparing items assessed on the auditing tools reviewed, the Pedestrian Environment Data Scan is particularly comprehensive, containing the greatest number of items recurring on one or more audits (6.9, Table 3). As with the other instruments, issues of climate

are widely overlooked, and similar problems exist regarding items that skirt proper winter evaluation. For example, Section B evaluates “Pedestrian Facility,” considering path maintenance, obstruction, and width, among other items. Path condition is graded on a scale of poor to good, with “under repair” as an additional option. While this scale may be used to assess a sidewalk in the winter, the auditor is encouraged to evaluate based on evidence of bumps, cracks and holes, when in actuality, greater consideration may be needed with regard to snow, ice, gravel, or water that may worsen path condition. Potential path obstructions are listed, including poles, parked cars, garbage cans, and greenery, however no seasonal obstructions are given as options. The list of obstructions contains the option to check “other,” however as previously stated, the PEDS tool does not provide space for comment, so no clarification of specific obstruction may be made if it exists outside the list provided. An item of sidewalk width provides three scale options. Sidewalk or path width is applicable regardless of season, though may be subject to notable changes due to snow, ice, and/or slush.

In addition to the important, but more common item regarding sidewalk continuity, this instrument is the only one reviewed to consider connectivity to other sidewalks, asking the number of connections be specified. Significant to perennial community walkability, this item is of specific note, as the number of sidewalk connections may change in the winter season. In a city with heavy annual snowfall such as Winnipeg, the timeline of sidewalk clearing efforts is based on resources available and time required to clear great volumes of snow. Various city policies also differ on whether sidewalk and back lane snow removal is the responsibility of the municipality or of resident homeowners. With snow clearance, roads are prioritized over sidewalks, and the number of sidewalk connections may suffer for indefinite periods of time (“Senior trapped inside for 3 days”, 2017).

In Section C regarding Road Attributes, the PEDS tool asks another unique question: "Must you walk through a parking lot to get to most buildings?" For pedestrians, parking lots tend to be isolating, decreasing feelings of security. The orientation of buildings closer to sidewalks helps to foster a sense of safety in neighbourhoods. When considering seasonal effects, parking lots are often maintained by smaller contractors with diverse guidelines to control snow and ice clearance, and are therefore subject to unpredictable surface conditions that may increase pedestrian slip-and-fall risk (Kamal Hossain, Liping Fu, & Law, 2014). Further, the open expanse of parking lots provides little to no shelter for pedestrians during inclement weather. For these reasons, this item is of even greater relevance during the winter season.

Items in Section D (Walking/Cycling Environment) regarding building height and design, and tree shading will all give some indication of wind exposure. Assessing the presence of wayfinding aids is also relevant year-round, helping to encourage and expedite trips during cold weather.

Finally, a brief section of subjective assessment concludes the audit, asking for ratings regarding perceived level of attractiveness, and of safety. When considering safety, interpretation could be based on safety from traffic or from crime and may require further explanation. Regardless, given the reduced pedestrian activity typical during winter months, these subjective questions could provide interesting insight that might be useful to expand on.

6.8 Language of Auditing Tools

Throughout analysis of the auditing tools, the language used by each author was considered with regard to what messages were conveyed through vocabulary and tone. For example, the Sidewalk Assessment Tool was the only audit to specifically mention "ice" and

"snow." When considered in such simple terms as relevant language, the climatic gaps become glaringly obvious.

The fourth item addressed on the Walking Suitability Assessment Form asks about the existence and continuity of the sidewalk; if there is no sidewalk present, the segment is given an automatic fail and the auditor is provided instructions to stop assessment and move on to the next segment. In this instance, the rubric for assessment score states "when there are no sidewalks, travel beside the road on foot or wheelchair is not safe or comfortable" (Emery et al., 2003). While not all tools have this automatic fail mandate, the message conveyed to planners, policy makers, and politicians when using this audit is that existence of sidewalks provides the most basic level of walkability necessary for pedestrians to travel safely.

Similarly, the Active Neighbourhood Checklist asks whether "any part" of the sidewalk is less than three feet in width, suggesting a basic standard of expectation. The tool always holds pedestrian welfare in the highest regard, asking, "If a sidewalk is not present on any part of the segment, do you have another safe place to walk" (Hoehner et al., 2011)?

The language of the walkability audits was not the focus of analysis for this work. Nevertheless, these samples help to illustrate why the design of an auditing tool should take both vocabulary and tone into consideration in order to better communicate possible strengths and weaknesses of an environment to the necessary audience.

6.9 Summary of Auditing Tools

Seven walkability auditing tools were chosen for review in this thesis. The Analytic and Checklist versions of the 2004 auditing instrument developed by Ross Brownson et al. were both considered and assessed in Chapter 6.4 and Chapter 6.9 (Table 3), but regarded collectively as

one tool for the purposes of this project. The tools were selected from an article summarizing audits used to measure the observable environment for physical activity (Brownson et al., 2009). Reasons for selection included reliability of the tool, location of development (primarily U.S. and Canada), method and time required for completion, relevance to the greater population, and access to original instrument.

Themes

Research on the links between the environment, levels of physical activity and various factors of health has underscored the importance of developing appropriate measures in order to understand those aspects of our surroundings that can discourage or enable active transportation behaviours (Clifton et al., 2007). The reason for development of every tool reviewed in this document was based on the common goal of better understanding the relationship between street-scale features of the environment and levels of physical activity. The instruments intend to explicate observable factors related to physical activity that cannot be captured by other data collection methods, such as the census.

Seventy-seven observable items were compiled (Table 3) across the seven instruments, with most of the audits measuring one or more items on topics such as land use integration, landscape and architecture, paths and sidewalks, streets and traffic, pedestrian amenities, and safety measures. Other aspects of the physical environment were observed less frequently, depending on the scope of the tool. The Pedestrian Environment Data Scan contained the most common observable features, with 47, while the Sidewalk Assessment Tool contained the least, with 6. However, each audit contained strengths and weaknesses, as well as lessons learned that could be applied to a more comprehensive audit for all seasons.

Climatic Gaps

As realized in Chapter 5, many of the same climatic issues were encountered in all three neighbourhoods assessed, regardless of standard walkability rating. When considering the design of current auditing tools, it is these common issues missing from the instruments, thus creating flaws in their ability to properly assess walkability in winter cities, such as Winnipeg.

Certain gaps exist in the consistency of items addressed by tools. For example, while the majority of the tools reviewed addresses sidewalk continuity, only two audits consider connectivity to other sidewalks (Table 3). In a winter climate, both of these items become especially important when trying to enable walking as a form of transportation. As noted in Chapter 2.2, walking behaviour shows increases in relationship to availability and accessibility of public transit (Morency et al., 2011; Villanueva et al., 2008). Transit availability becomes even more of a necessity during the winter season when public transportation may supplement walking as a mode of transportation. However, less than half of the audits reviewed consider transit availability, or transit shelter. Items regarding sidewalk condition and smoothness, sidewalk width, slope, and permanent or temporary path obstruction are addressed by some of the audits, but despite the appropriateness of these factors, some of the gaps regarding climate are due to response options. For example, a checklist of possible path obstructions could be easily adapted to include "snowbank" in apt consideration of winter cities. A question that regards levelness and condition of sidewalk on a rating scale based on the existence of "heaves, alignment, cracks, broken sections, weeds" (Analytic Audit Tool) could be adapted to include snow, ice, slush, grit.

Categories for Improvement

This thesis focused on identifying the existing climatic gaps in walkability auditing tools that hinder the instrument's ability to properly assess walking conditions in winter cities. In order to adapt tools to accurately evaluate the reality of urban winter living, developing standard metrics of assessment is an important next step in the progression of this research. The walkability factors for assessment that may contribute to an improved pedestrian experience through lessening of climatic issues fall into three broad categories: sidewalks, comfort and transportation. Preliminary notes on possible measures of assessment are as follows:

1. **Sidewalks:** Do they exist? – On both sides of the street? Does the neighbourhood have good connectivity? Are there any dead-end paths – if so, how many and where? How wide are the sidewalks? Have they been plowed of snow? Have snowbanks reduced the width of the path? Are ice, slush or snow impeding the path? Are any seasonal obstructions (e.g. snowbanks, ice) causing detours? Are snow windrows or ice preventing easy or safe access to crosswalks? Are driveway crossovers causing inconsistencies in the smoothness of path? How many driveway crossovers exist per segment?
2. **Comfort:** Are buffers present (separating the street and the sidewalk) to enable snow clearance from the street and protect from vehicle splash? How wide are buffers? Are snowbanks creating visibility problems for pedestrians and/or drivers? How high are snowbanks? How many streetlights exist per segment? How many trees line the buffer?
3. **Transportation:** Is public transit available in this neighbourhood? – How many transit stops exist per segment? / How many segments separate transit stops? Do transit stops have shelter? Do they have lighting? Are there opportunities for pedestrians to seek

shelter if needed? How many public buildings exist per segment? Are pedestrians required to walk through empty parking lots to reach commercial destinations? – How many per segment? Percentage within neighbourhood?

Table 3: Comparison of Items found on Walkability Audits

	SPACES	**NALP**	**WSAF**	**AAT**	**ACT**	**SAT**	**ANC**	**PEDS**
Air pollution				x	x			
Alternate paths in lieu of/as well as sidewalk	x						x	x
Annual average daily traffic			x					
Attractiveness	x	x		x	x			x
Average tree height	x							
Benches				x	x		x	x
Bicycle facilities	x	x						x
Boulevard maintenance	x							
Boulevard trees	x							
Buffer maintenance	x							
Buffer present							x	x
Buffer width	x		x	x	x		x	
Building design uniformity	x							x
Connection to other sidewalks							x	x
Construction (temporary)							x	
Continuity of path	x		x	x	x		x	x
Crossing aids	x		x	x	x		x	x
Curb cuts	x		x	x			x	x
Curb type	x		x	x	x			
Data collection method							x	
Destinations present / Land use diversity	x	x		x	x			x
Driveway crossovers	x							x
Enclosure								x
Exclusive of people		x						
Garden maintenance	x							
Inclusive of people		x						
Intersection type								x
Land use integration	x			x	x		x	x

Lane markings on-street							x	
Lighting covering path	x		x				x	x
Median or pedestrian island							x	
Neighbourhood legibility/Signage (wayfinding)	x	x		x	x			x
Noise pollution				x	x			
Number of lanes on road	x		x	x	x		x	x
Open comment			x	x	x	x	x	
Overwhelming		x						
Parking facilities	x						x	x
Parking lots between sidewalk and destinations								x
Parking restriction signs present	x							
Path condition and smoothness	x		x	x		x	x	x
Path location (in relation to curb)	x			x	x			x
Path material	x		x					x
Path obstructions - permanent	x		x	x	x	x	x	x
Path obstructions - seasonal						x		
Physical difficulty for walking	x	x						
Physical disorder/Cleanliness (litter, graffiti, etc.)	x			x	x	x	x	x
Picnic tables				x	x			
Posted speed limit			x	x	x		x	x
Power lines								x
Public art							x	
Public recreation facilities/equipment				x	x		x	x
Public telephones				x	x			
Restrooms				x	x			
Road condition	x							x
Safety (i.e. perceived crime threat)		x						x
Sidewalks present	x			x	x		x	x
Sidewalk width				x	x		x	x
Slope	x					x	x	x
Social environment (i.e. are people visible?)				x	x			
Streetlights	x		x	x	x			x
Surveillance	x							
Threat of traffic to pedestrians		x		x	x			x
Traffic calming devices							x	x
Traffic control devices	x		x	x	x		x	x
Transit availability				x	x		x	x
Transit bench				x	x		x	x
Transit shelter				x	x		x	x
Trash bins				x	x			x
Tree shade				x	x		x	x

Trees in buffer	x						x	x
Type of buffer								x
Type of buildings (i.e. residential, commercial, etc.)	x						x	x
Type of crossings	x		x					
Type of path	x		x	x	x			
Type of views (urban, nature, water, etc.)	x	x		x	x			
Vending machines				x	x			x
Water fountain (drinking)				x	x		x	x

TOTAL	**39**	**11**	**17**	**38**	**36**	**6**	**35**	**47**

7.0 CONCLUSIONS

7.1 Summary of Findings

When selecting an auditing instrument for use, researchers must consider various factors, such as features observed, data collection method, sampling, reliability of the tool, and ability to compare outcomes with other studies (Brownson et al., 2009). However, there is a lack in the ability of existing tools to properly assess climatic issues in winter cities, such as Winnipeg. Throughout this document, I have attempted to address gaps in the literature on winter walkability and the capacity of auditing instruments to assess climatic issues, reflect on my research process and answer my research questions, as well as make some suggestions regarding how to better design walkability audits for all seasons.

Through examination of the three research sites, Chapters 4 and 5 informed **1. To what extent do current walkability audits reflect the realities of urban winter living?** Overall, the audits assessed failed to properly address the winter issues encountered at each research site. Important factors such as path maintenance and seasonal obstructions, consistent sidewalk connectivity, and availability of transit shelter were addressed by less than half of the auditing tools examined. The fundamental questions of path smoothness and condition were missing from the Neighbourhood Active Living Potential instrument and the Audit Checklist Tool. When people consider walking as a practical mode of transportation, attributes of the route rather than the destination appear to matter most (Clifton et al., 2007; Srinivasan, 2002). While the audits reviewed reliably provide an accurate quotient of walkability, crucial factors of street-level convenience and comfort are not properly addressed with regard to urban winter conditions.

Chapter 6 addressed **2. How can walkability audits be better designed to address walkability issues residents in Canadian winter cities face?** In order to more accurately assess walkability in Canadian cities, I recommend auditing instruments incorporate key factors related to urban winter living, including, but not limited to:

[1. Sidewalks]

- Do sidewalks exist? On both sides of the street?
- Sidewalk condition and maintenance – existence of snow, ice, slush, grit?
- Sidewalk width – are snowbanks reducing path width?
- Sidewalk continuity – are sidewalks complete? Are there any dead-end paths?
- Sidewalk connectivity – are sidewalks connected to each other for path continuity?
- Seasonal obstructions – has snow been cleared? are snowbanks causing detours?
- Curb ramps – are snow windrows or ice preventing easy or safe access to crosswalks?
- Driveway crossovers – are they causing inconsistencies in smoothness of path?

[2. Comfort]

- Buffers – present to enable snow clearance and protect from vehicle splash?
- Buffer maintenance – are snowbanks creating visibility problems for pedestrians and/or drivers?
- Streetlights – is adequate lighting present?
- Trees in buffer – are they providing any shelter from wind?

[3. Transportation]

- Is public transit available?
- Do transit stops have shelter?
- Do transit stops have lighting?
- Variety of destinations – are there opportunities for pedestrians to seek shelter if needed?
- Parking lots – must pedestrians walk through empty lots to reach destinations?

7.2 Limitations and Assumptions

Foremost, this thesis assumes winter walkability is an issue Canadian cities hope to improve upon. While research has shown clear links between health outcomes, street-level environmental factors, and walking behaviour, there are gaps in the literature related to winter conditions. Furthermore, this research assumes adapting auditing tools to reflect winter living is a useful starting point in the challenge of improving walkability in cities such as Winnipeg.

Characteristics that contribute to the concept of "walkability" are continually being analysed. Theoretical complications exist when considering the concept given some elements of the pedestrian environment can be measured simply and objectively, while others are more subjective in nature (Clifton et al., 2007). Studies have used different indicators of what defines a community as walkable, as reflected in the diversity of auditing tools used in a collective, but varied effort to assess the natural and built environment.

Analysis took place in three different neighbourhoods with varying street-level attributes and degrees of walkability in an effort to increase generalizability to other locales. However,

given variant winter conditions across Canada, and other northern climates, certain locale-specific climatic issues may have been overlooked.

In addition, the reality of winter conditions proved to be a limitation. Observations were conducted during March of 2016, with cold temperatures and precipitation created complications with equipment, disrupting continuous use, or affecting quality of voice recorded notes. As a result of fluctuating weather patterns and the time constraints of completing observations during the winter season, each neighbourhood was only observed once, limiting the depth of information collected. Further, site observations were conducted at varying times of day. Routes through each neighbourhood were predetermined, in a deliberate effort to be thorough in my analysis, without spending an extensive amount of time outdoors. However, complete analysis of all segments was not plausible, given outdoor conditions. Fluctuating conditions throughout the season, as well as annual differences, may reveal further gaps in the auditing tools that could not be assessed with site observations taking place over the course of three days and variant times. As a result of these limitations, observations may not necessarily reflect all pedestrian experiences. I must also recognize the inherent limitations in developing recommendations based on this restricted data set.

Finally, it must be noted that as the sole participant in this research, my perception of the environment, and how it affects walkability differs from others. As a relatively advantaged person, my relationship to walking, physical activity, and the built environment may differ vastly in comparison to disadvantaged groups (Adkins, Makarewicz, Scanze, Ingram & Luhr, 2017). Analysis of the auditing tools was also built around my own personal experience with the environment. A more rigorously outlined standard measure of analysis would strengthen future analysis.

7.3 Implications for Planning Practice

In Winnipeg, the hierarchy of street clearing features three levels: Priority 1, or regional streets, include all major routes; Priority 2, or collector streets, include non-regional bus routes based on traffic counts; and Priority 3 streets include all residential roads. The plowing of back lanes is often expedited for reasons of accessibility and garbage collection. The plowing of sidewalks is determined by Clauses C-1-4 of the City's Policy on Snow Clearing and Ice Control, as approved by the Works & Operations Committee. Sidewalks on Priority 1 and 2 streets are generally plowed based on inspection following a 5 cm snowfall, and maintained to a compacted snow surface. All Priority 1 and 2 sidewalks within the Downtown are to be plowed to the pavement when conditions allow, however minor snowfalls or fluctuating temperatures may affect this stipulation and result in a compacted surface of ice or snow. Sidewalks on Priority 3 – or residential streets – will generally be maintained to a compacted snow surface following an accumulation of 8 cm of snowfall. Those sidewalks in Priority 3 areas near senior citizen complexes, or such high volume areas as near schools shall be plowed to the standards of Priority 1 and 2 (maintained after 5 cm of snowfall), and logically routed toward the nearest Regional street. In Priority 1 and 2 areas, and on those Priority 3 streets near senior citizen complexes, snow plowing is to be completed within 36 hours following an average storm. However, in Priority 3 areas, the snow plowing is to be "completed within five working days following the commencement of work", as approved by City Council in 1993 (City of Winnipeg, 2011, p. 10).

While the actual resources for managing Winnipeg's abundant annual snowfall may be limited, the current standards of sidewalk maintenance (as described above) do not seem capable of properly ensuring safe pedestrian travel throughout the city. Planners play an important role in

the circulation of information, amongst politicians, engineers, architects and the public, alike. The data collected through the use of auditing tools will aid planners in their role as communicators and advocates. With issues of infrastructure and maintenance providing the main barriers to winter walking behaviour, planners can use data collected from walkability audits to evaluate current winter snow clearing policies and advise more effective maintenance policies and procedures. Recognizing the need for technical considerations in planning, auditing tools can also provide insight into infrastructure needs that can be communicated to civil engineers to assure cost-effective and sustainable land use that will create better urban spaces in which to live, year-round. Further, walkability audits provide a very useful and comprehensible source of information that planners can use for pedestrian advocacy and public engagement.

This research views improving urban walkability as an intervention that can support community health. It has looked at attributes of the street-level environment that may help to improve the walkability of Winnipeg, but have been overlooked or neglected during the winter season. Improving community health is multidisciplinary work. Planners, however, are often in a position to help effect change. With appropriate use of auditing tools, planners may be better positioned to adapt, direct and implement policies and regulations that may promote active transportation in their cities.

7.4 Directions for Future Research

Although this thesis has concentrated on assessing audit tools, it bears stating that in the process of doing the research, some lessons around winter walkability have emerged. Having acknowledged the limitations of this work, there are several directions for how research on these issues may be expanded in the future.

Expanding the Research

The development and evaluation of standard metrics for climatic elements will be necessary to ensure reliability when conducting audits. Research should be conducted at different times of the day, week and year to create a more thorough understanding of varying winter conditions. In addition to increased observation, a consistent schedule of daily observation times would ensure further rigour. Do issues vary from day to night? Does time of day impact the liveliness of the neighbourhood? Do seasonal perceptions of walkability change with varying levels of liveliness? Can maintenance issues be prioritized earlier in the season to help alleviate challenges later? Does the spring thaw create any unique difficulties? Further, research could continue in other Canadian cities in order to create a more thorough representation of the nation's diverse winter weather.

Consistency in Audit Deployment

While content of auditing tools must accurately reflect the components of the environment they intend to measure, it is also important to consider the people completing the audits as active players in the assessment process. As evidenced by the Neighbourhood Active Living Potential replication study in Saskatoon, greater consistency of audit domains was observed when inter-observer variability was controlled through training sessions (Fuller & Muhajarine, 2010). Future research should consider the role education and training could play in improving the reliability of tools with greater consistency in audit deployment.

Built Environment and Socioeconomic Status

While the capacity of this project was limited to observing walkability in relation to built environment terms, further research should be conducted to expand on the relationship between

socioeconomic status and the concept of walkability. There are multiple directions wherein such research may progress. As noted by Adkins et al. (2017), the relationship between the built environment and walking as a form of physical activity likely varies by socioeconomic context. As such, can walkability audits be used as tools to identify aspects of the built environment that may be strengthened to support disadvantaged groups?

Environmental Supports for People with Disabilities

According to Spivock, Gauvin & Brodeur, "the nearly 20% of North Americans living with a disability are even less likely to be active than the general population" (2007, p. 224). Beyond individual risk factors, these lower levels of physical activity may be related to the accessibility of neighbourhood environments, which may be further exacerbated by winter conditions. For example, issues with respect to sidewalk surface, curb cuts, and snow clearance may all create greater problems for disabled persons. While issues of snow clearance affect all pedestrians, challenges become even greater for disabled persons attempting to navigate sidewalks using mobility devices. Further research should focus on the environmental supports necessary to make winter transportation more accessible to people with disabilities.

Taking Action

With suggestions having been made on how to better assess baseline walkability, the natural next step will be to consider how to improve upon street-level issues identified in the pedestrian environment. Investigation about how best to adapt and implement policies and regulations regarding snow removal and pedestrian infrastructure will be an important next step in addressing walkability challenges in Winnipeg.

7.5 Final Thoughts

Through literature review, site auditing, unobtrusive observations, photographic documentation and systematic review, I have endeavoured to identify climatic gaps that exist in current walkability auditing tools. This final chapter has revisited my original research questions, recommending possible design adaptations that would help walkability audits more accurately reflect winter living in Canadian cities. It has recognized the limitations of this research, considered implications for planning practice, and suggested directions for the work to be enhanced or expanded in the future.

I believe in the ability of urban planning to help support community health. However, in order to effectively contribute to the growing dialogue on population health and active transportation, an important first step is the proper identification and measurement of street-level attributes that can help to improve walkability in cities such as Winnipeg. Given the growing wealth of literature on walkability, and the disparate dearth regarding winter conditions facing pedestrians, my hope is that this research has shown improving walkability in Canadian cities is not as far out of reach as it may sometimes seem; my hope is that this is a beginning rather than an end.

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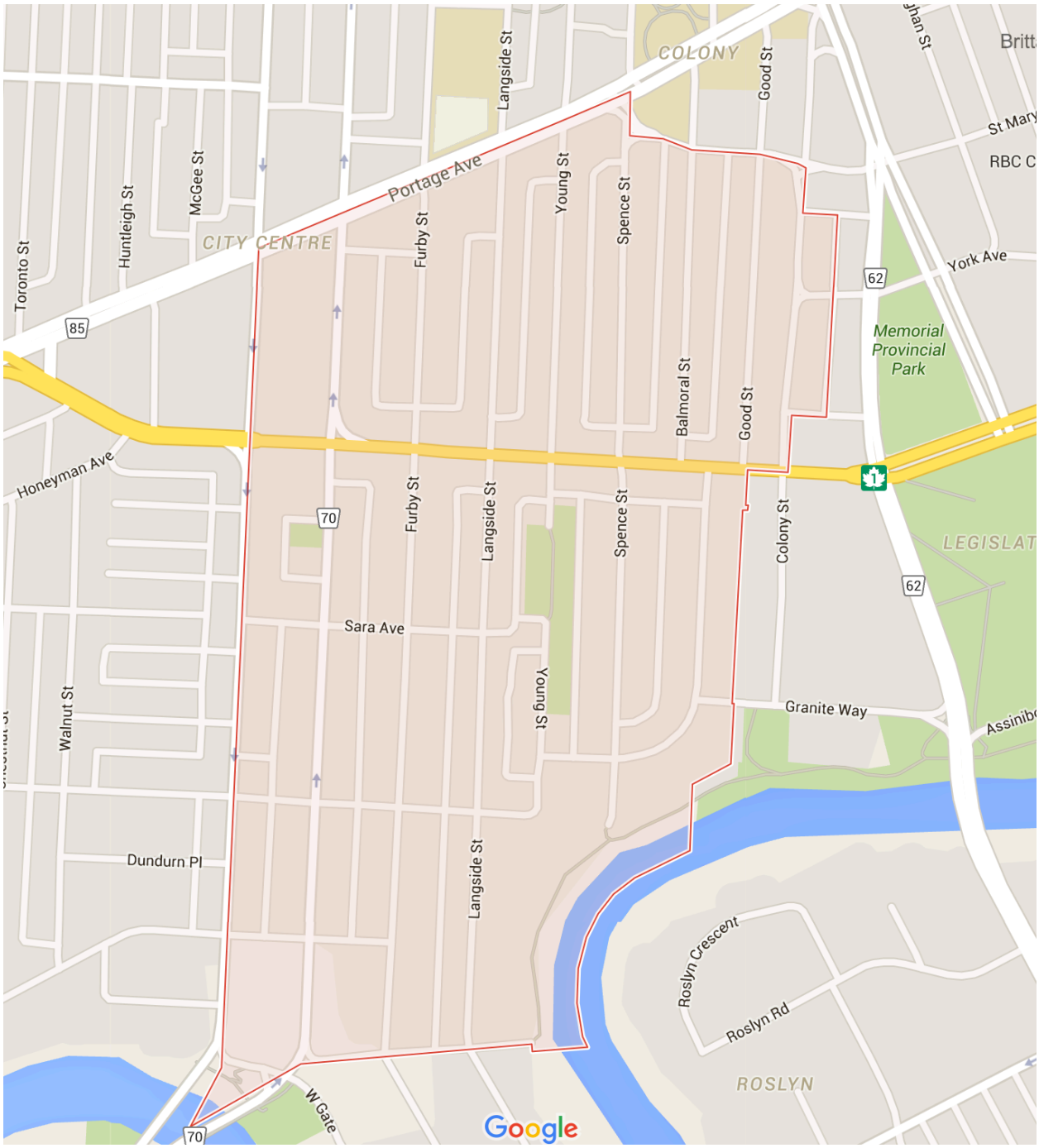
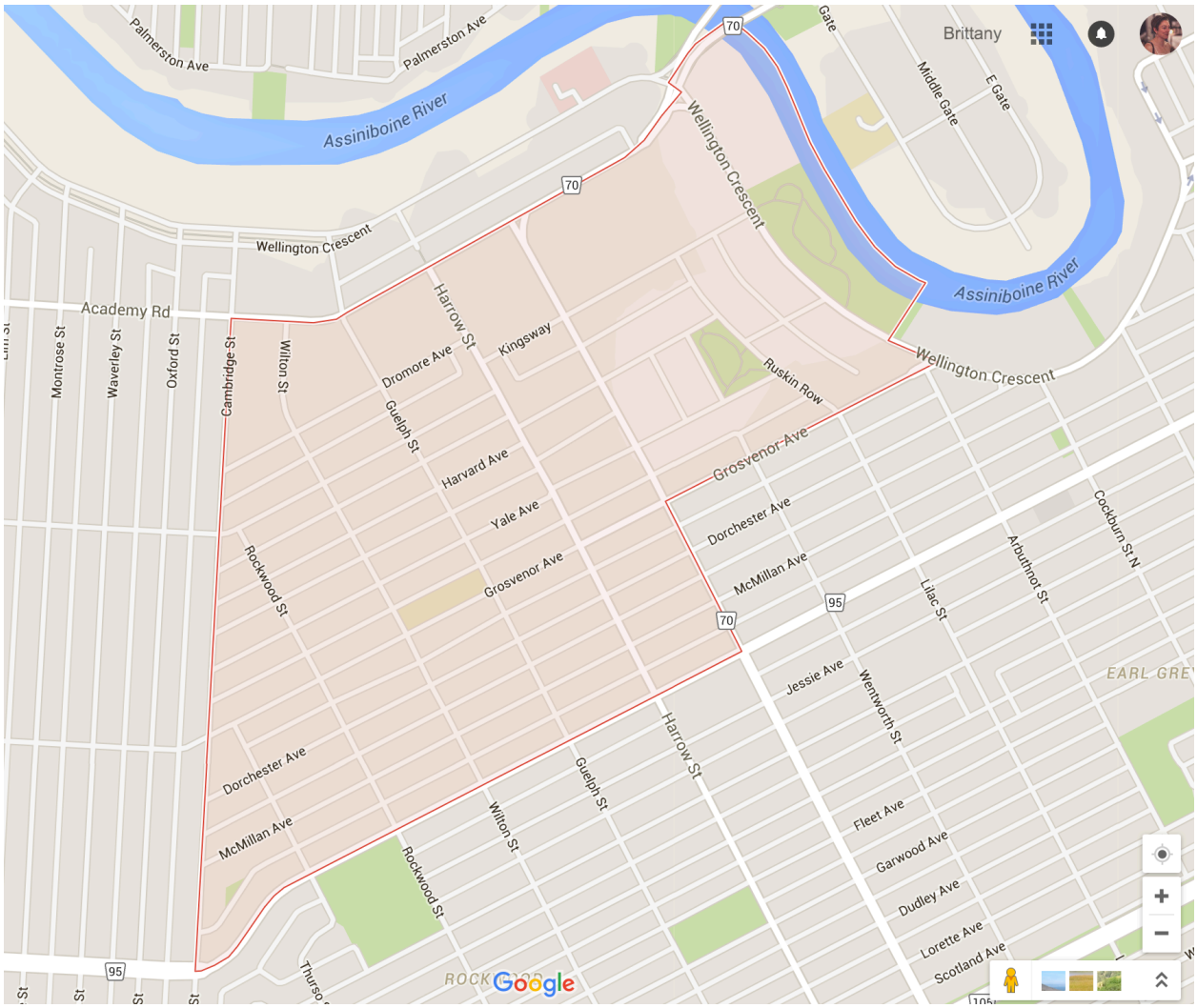
APPENDICES

A. Neighbourhood Boundary Maps

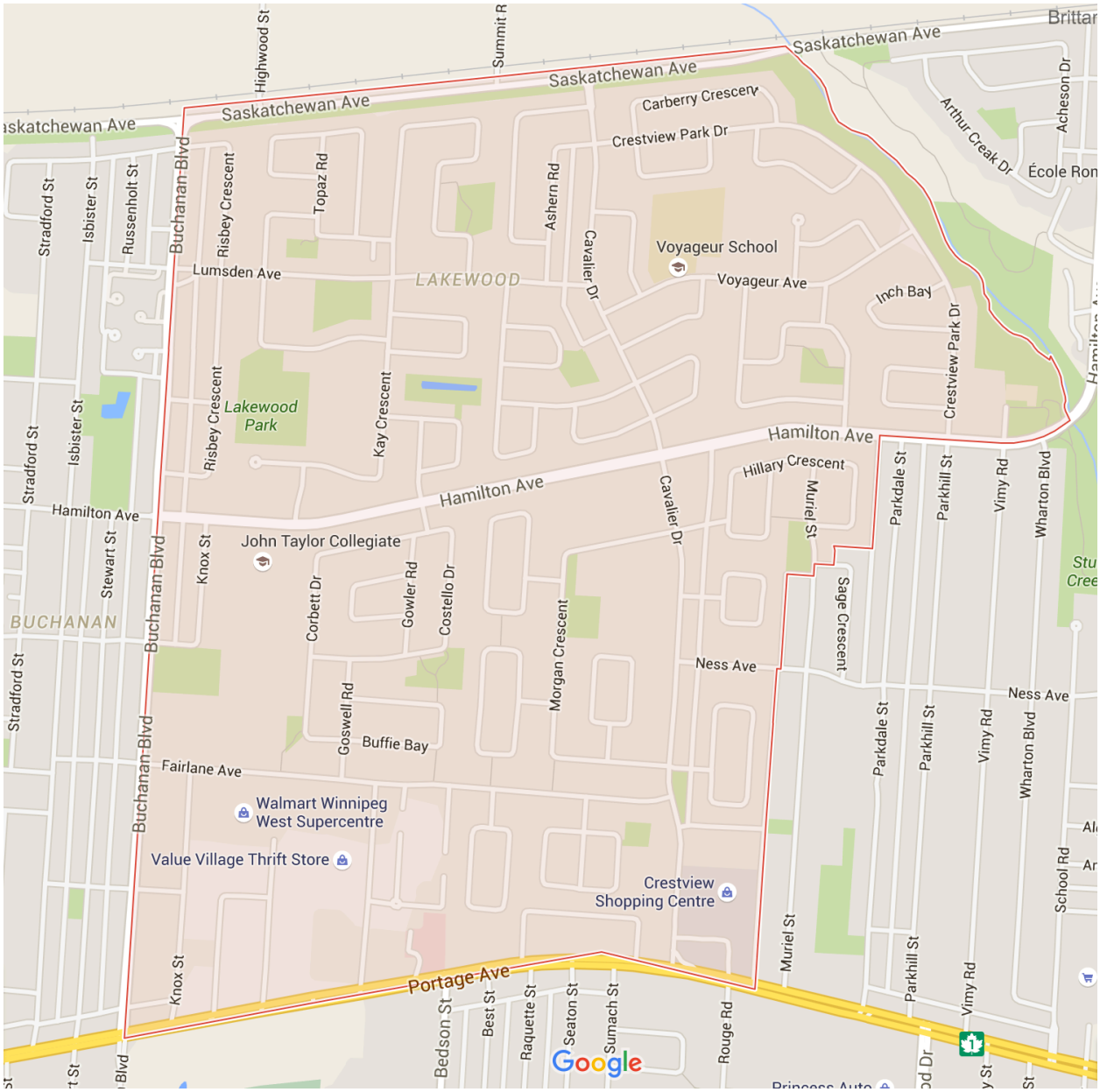
[1] West Broadway, Winnipeg



[2] Crescentwood, Winnipeg



[3] Crestview, Winnipeg

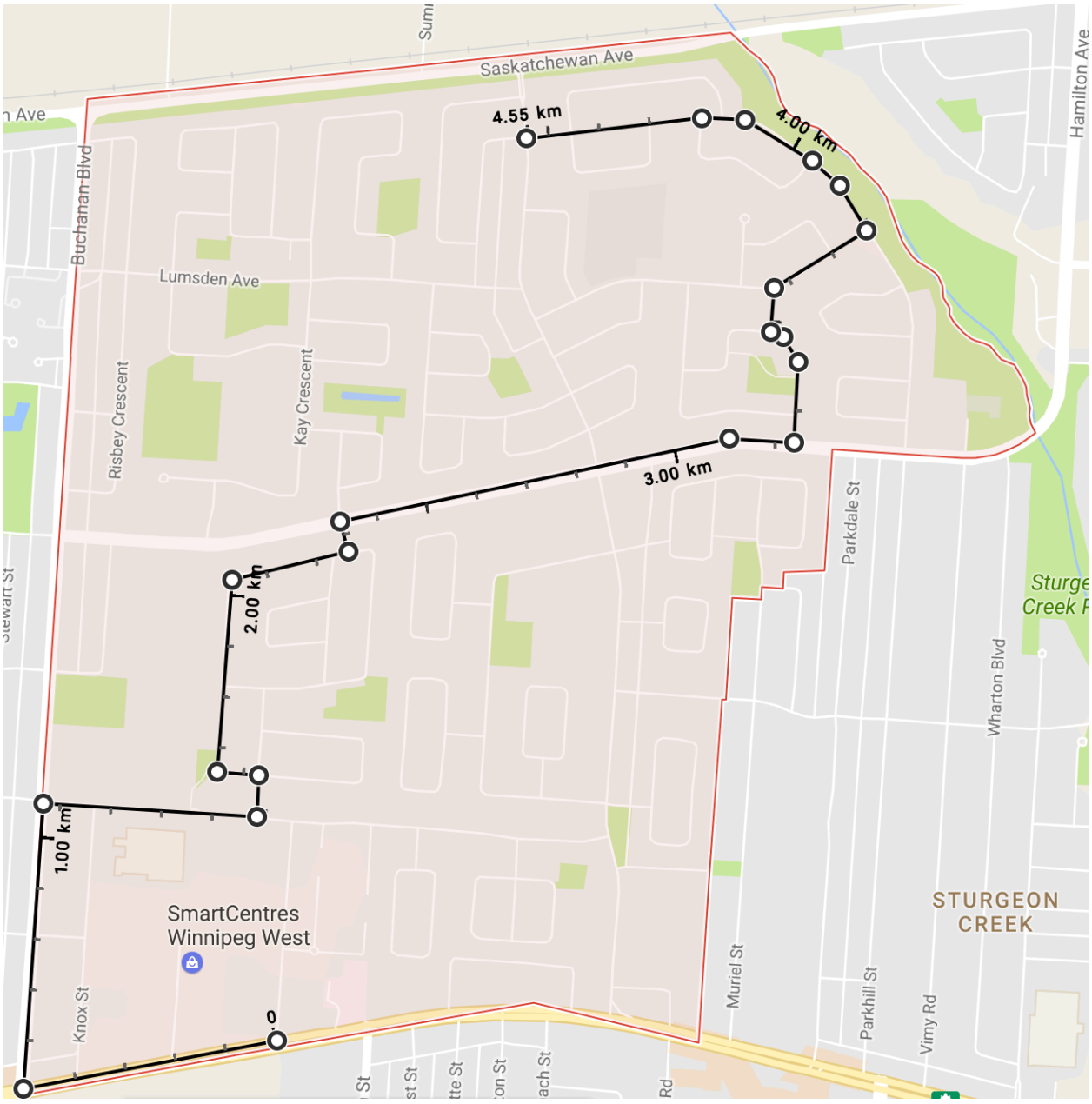


B. Route Maps

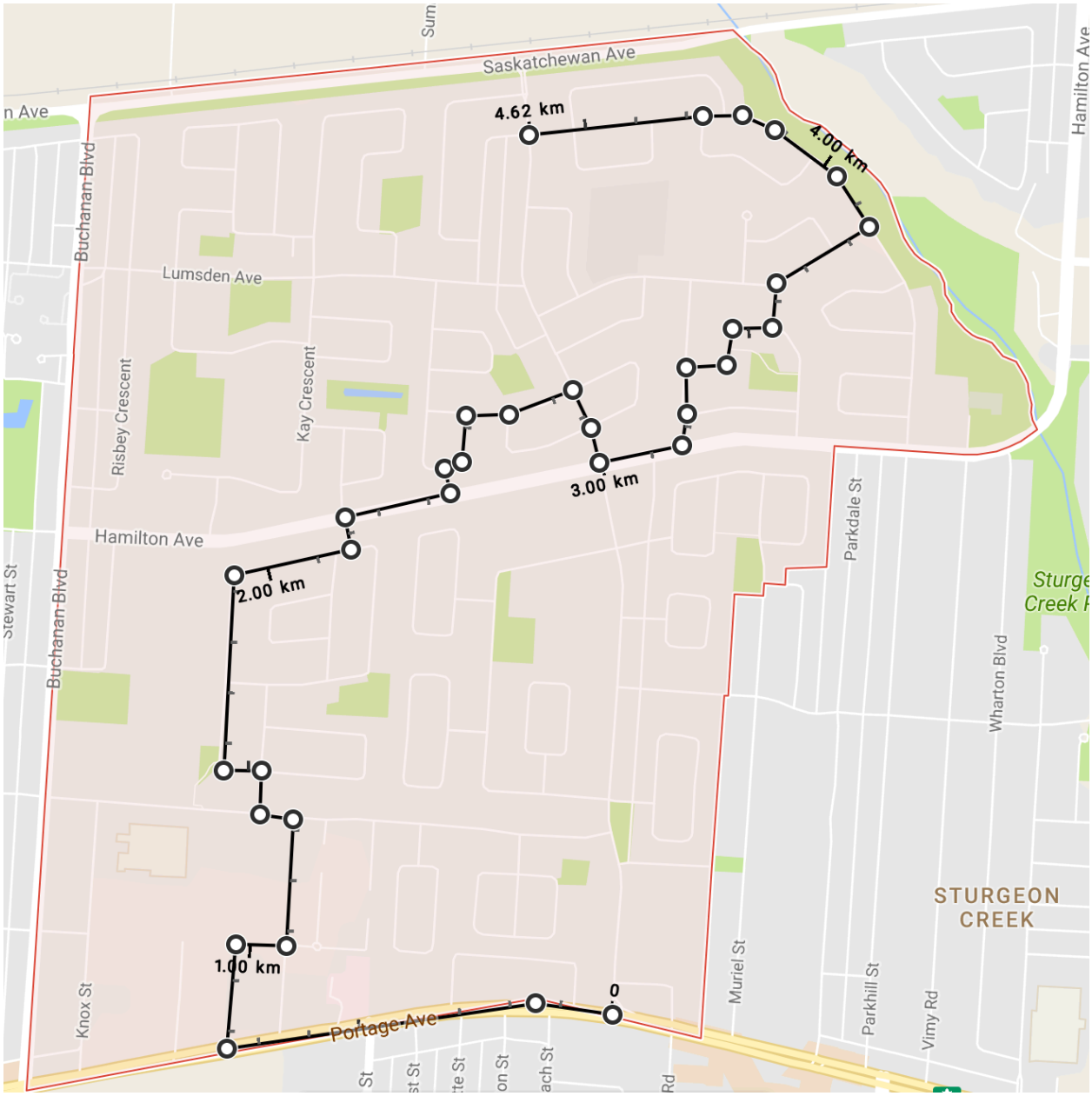
[4] Route through West Broadway: 3.88 km

[5] Route through Crescentwood: 3.34 km

[6] Proposed route through Crestview: 4.55 km



[7] Finalized route through Crestview: 4.62 km



C. Walkability Audits

[8] Systematic Pedestrian and Cycling Environmental Scan

SPACES	Item	Response Type
	Type of buildings/features	Checklist
	Predominant buildings/features	Response options
	Uniformity of buildings/features for both sides	Y/N
Path for Walking and/or Cycling	Type of path	Response options
(only if path is present)	Path location (in relation to curb)	Rating scale
	Path material	Response options
	Slope	Rating scale
	Path condition and smoothness	Rating scale
	Permanent path obstructions	Checklist
On-road	Path type (regarding cycle lane markings)	Response options
(all segments)	Slope *(only assess on-road if no path is present)*	Rating scale
	Condition of road	Rating scale
	Number of lanes on road	Response options
	Vehicle parking restriction signs present	Y/N
	Curb type	Response options
	Traffic control devices	Checklist
	Other routes available	Checklist
	Type of crossings	Response options
	Crossing aids	Checklist
	Streetlights present?	Y/N
	Lighting covering path?	Y/N
	Destinations present?	Y/N
	Number of car parking facilities at destinations	Rating scale
	Bike parking facilities	Checklist
	Driveway crossovers	Rating scale
	Surveillance	Rating scale
	Garden maintenance	Rating scale
	Boulevard maintenance	Rating scale
	Boulevard trees	Rating scale
	Average tree height	Rating scale
	Cleanliness	Rating scale
	Type of views (urban/commercial/nature/water/etc.)	Checklist
	Building design uniformity	Rating scale
	Level of attractiveness	Likert scale

	Level of physical difficulty for walking	Likert scale
Overall Assessment	Continuity of path	Response options
	Neighbourhood legibility (ease of wayfinding)	Likert scale

[9] Neighbourhood Active Living Potential

NALP	Item	Response Type
Activity Friendliness	Pedestrian system has limits to pedestrians	Rating scale
	Effort to walk around	Rating scale
	Bicycle system has limits to cyclists' needs	Rating scale
	Pedestrian system addresses pedestrian needs	Rating scale
	Effort to cycle around	Rating scale
	Bicycle system addresses cyclists' needs	Rating scale
Safety	Safety/feeling threatened with the potential for crime (pedestrian)	Rating scale
	Threat of traffic to pedestrians	Rating scale
	Safety/feeling comfortable with the potential for crime (cyclist)	Rating scale
	Threat of traffic to cyclists	Rating scale
Density of Destinations	Exclusive of people	Rating scale
	Inclusive of people	Rating scale
	Number of people-oriented destinations	Rating scale
	Environmental stimuli	Rating scale
	Socially dynamic/static	Rating scale
	Visual interest	Rating scale
	Variety of destinations	Rating scale
	Overwhelming	Rating scale

[10] Walking Suitability Assessment Form

WSAF	Item	Response Type
	Annual Average Daily Traffic	Numeric score
	Posted Speed	Numeric score
	# of Thru Lanes	Numeric score
	Sidewalk/Path Continuity	Numeric score
	Material	Numeric score
	Surface Condition	Numeric score
	Sidewalk Width	Numeric score
	Buffer Width	Numeric score
	Curb Ramps	Numeric score
	Adequate Lighting	Numeric score
	Isolated Problem Spots?	Numeric score
	Do any busy intersections need marked crosswalks?	Y/N
	Do any busy intersections need traffic signal lights?	Y/N
	Do any busy intersections need pedestrian "Walk" signals?	Y/N
	Do any wide intersections need a refuge island for safer crossing?	Y/N

[11] Analytic Audit Tool

AAT	Item	Response Type
Land Use Environment	Level of integration of diverse land uses	Rating scale
	Types of residential destinations	Enter #
	(seven listed, e.g. single-family home, apartment building)	
	Types of commercial destinations	Enter #
	(twenty-one listed, e.g. gas station, supermarket, coffee shop)	
	Types of public or government destinations	Enter #
	(thirteen listed, e.g. post office, library, schools)	
	Types of recreational facilities/destinations	Enter #
	(ten listed, e.g. indoor fitness facility, park, outdoor pool)	
	Other types of destinations	Enter #
	(five listed, e.g. parking lot or garage, vacant lot, railroad)	
	Types of natural features	Enter #
	(four listed, e.g. large body of water, small body of water)	
Transportation Environment	Availability to alternative transportation modes	Rating scale
	Presence of sidewalks	Response options
	Location of sidewalks	Response options
	Continuity of sidewalks	Rating scale
	Sidewalk width	Rating scale
	Levelness/condition of sidewalk	Rating scale
	Obstructions	Rating scale
	Type of curb	Response options
	Bikability - six related items	
	Availability of transit - presence of transit stops	Response options
	Presence of transit stop bench or shelter	Response options
	Presence of multi-use trails or paths	Response options
	Width of multi-use path	Rating scale
	Marked for multi-use	Rating scale
	Levelness/condition of trail	Rating scale
	Obstructions to trail	Rating scale
	General speed limit posted	Note limit
	Special speed limit posted	Note limit
	On-street parking	Y/N
	Street type (lanes)	Rating scale

	Connectivity	Rating scale
	Street design characteristics to reduce volume or speed	Rating scale
	Traffic calming devices	Rating scale
	Aggressive drivers	Rating scale
	Crossing aids	Rating scale
	Street lighting	Rating scale
Facilities	Availability of public recreational facilities	Rating scale
	Availability of public recreational equipment	Rating scale
	Type of public recreational equipment	Enter # per item
	(three listed, e.g. playground equipment, sports equipment)	
	Types of service amenities available	Enter # per item
	(eight listed, e.g. equipment rental, sports stands, restrooms)	
Aesthetics	Attractive features present	Rating scale
	Comfort features present	Rating scale
	Air pollution	Rating scale
	Noise pollution	Rating scale
	Physical disorder (litter, discarded items, graffiti, broken glass)	
	(eight listed, e.g. broken glass, garbage, graffiti)	Numeric scale
Signage	Types of signs present	
	(fifteen listed, e.g. "share the road" sign, athletic event)	Numeric scale
Social Environment	Are people visible?	Numeric scale
	Are there any children visible?	Numeric scale
	Are there any children engaging in active behaviours?	Numeric scale
	Are there any teenagers or adults visible?	Numeric scale
	Are there teenagers or adults engaging in active behaviours?	Numeric scale
	Are there any older adults visible in this segment?	Numeric scale
	Are they older adults engaging in active behaviours?	Numeric scale
	Are there people stopping to talk or green one another?	Numeric scale
	Are there people fighting, acting hostile or threatening?	Numeric scale
	Are there stray dogs or animals in the segment?	Numeric scale
Open Comment		

[12] Audit Checklist Tool

ACT	Item	Response Type
Land Use Environment	Land use integration	Y/N
	Types of residential destinations	Visible/Not
	(seven listed, e.g. single-family home, apartment building)	
	Types of commercial destinations	Visible/Not
	(twenty-one listed, e.g. gas station, supermarket, coffee shop)	
	Types of public or government destinations	Visible/Not
	(thirteen listed, e.g. post office, library, schools)	
	Types of recreational facilities/destinations	Visible/Not
	(ten listed, e.g. indoor fitness facility, park, outdoor pool)	
	Other types of destinations	Visible/Not
	(five listed, e.g. parking lot or garage, vacant lot, railroad)	
	Types of natural features	Visible/Not
	(four listed, e.g. large body of water, small body of water)	
Transportation Environment	Availability of alternative transportation modes	Y/N
	Presence of sidewalks	Y/N
	Presence of bus stops or transit stations	Y/N
	Presence of paths or trails	Y/N
	General speed limit posted	Note limit
	Special speed limit posted	Note limit
	On-street parking	Y/N
	Street type less than or equal to two narrow lanes	Y/N
	Good connectivity	Y/N
	Street design characteristics to reduce volume or speed	Y/N
	Traffic calming devices	Y/N
	Aggressive drivers	Y/N
	Crossing aids	Y/N
	Street lighting	Y/N
Facilities	Availability of public recreational facilities	Y/N
	Availability of public recreational equipment	Y/N
	Type of public recreational equipment	Visible/Not
	(three listed, e.g. playground equipment, sports equipment)	

	Types of service amenities available	Visible/Not
	(eight listed, e.g. equipment rental, sports stands, restrooms)	
Aesthetics	Attractive features present	Y/N
	Comfort features present	Y/N
	Air pollution	Y/N
	Noise pollution	Y/N
	Physical disorder	Y/N
	Types of physical disorder visible	Y/N
	(eight listed, e.g. broken glass, garbage, graffiti)	
Signage	Types of signs present	Visible/Not
	(fifteen listed, e.g. "share the road" sign, athletic event)	
Social Environment	Are people visible?	Y/N
	Are there any children visible?	Y/N
	Are there any children engaging in active behaviours?	Y/N
	Are there any teenagers or adults visible?	Y/N
	Are there teenagers or adults engaging in active behaviours?	Y/N
	Are there any older adults visible in this segment?	Y/N
	Are they older adults engaging in active behaviours?	Y/N
	Are there people stopping to talk or green one another?	Y/N
	Are there people fighting, acting hostile or threatening?	Y/N
	Are there stray dogs or animals in the segment?	Y/N
Open Comment		

[13] Sidewalk Assessment Tool

SAT	Item	Response Type
	Levelness of the sidewalk	Rating Scale
	Comments	
	Absence of items blocking the walkway	Rating Scale
	Comments	
	Condition of the walking surface	Rating Scale
	Comments	
	Cleanliness of the sidewalk	Rating Scale
	Comments	
	Existence of bushes, trees, weeds, leaves, snow, ice that block sidewalk	Rating Scale
	Comments	

[14] Active Neighbourhood Checklist

ANC	Item	Response Type
General	How were data collected?	Response options
	Is the segment under construction?	Y/N
Land Uses	Are residential and non-residential land uses present?	Rating scale
	What is the predominant land use?	Response options
	Type of residential uses present	Checklist
	Functioning parking facilities present	Checklist
	Public recreational facilities and equipment present	Checklist
	Non-residential uses present	Checklist
	Open comment	
Public Transportation	Transit stop	Y/N
	Bench or covered shelter present	Y/N
	Open comment	
Street Characteristics	Posted speed limit	Note limit
	Special speed zone	Note limit
	Number of lanes on street	Enter #
	Marked lanes?	Y/N
	Median or pedestrian island?	Y/N
	Turn lane?	Y/N
	Stop sign or light for crossing this segment?	Y/N
	Any stoplight without a walk signal?	Y/N
	Crosswalk for crossing this segment?	Y/N
	Traffic calming device?	Y/N (if Y, specify)
	Cul-de-sac?	Y/N
	Sidewalk cut-through in cul-de-sac?	Y/N
	Open comment	
Quality of the Pedestrian Environment	Commercial buildings adjacent to the sidewalk?	Y/N
	Bench (excluding at transit stop)	Y/N
	Drinking fountain	Y/N
	Pedestrian-scale lighting	Y/N
	Other pedestrian amenities	Specify
	Public art	Y/N
	Graffiti or broken/boarded windows	Y/N
	Litter or broken glass	Rating scale
	Tree shade on the walking area	Rating scale

	Steepest slope along walking area	Rating scale
	Open comment	
Sidewalks and Shoulders	Sidewalks present	Y/Y/N
	Buffer between curb and sidewalk along most of segment	Y/Y/N
	Trees in buffer	Y/Y/N
	Sidewalk continuous within segment	Y/Y/N
	Sidewalk continuous between segments at both ends	Y/Y/N
	Width >3 ft. for *most* of the sidewalk	Y/Y/N
	Width <3 ft. for *any* part of the sidewalk	Y/Y/N
	Alternate safe place to walk if sidewalk not present:	
	Street or shoulder (if safe)	Y/Y/N
	Unpaved pathway	Y/Y/N
	Other	Y/Y/N
	Open comment on Sidewalks	
	Section for bicycles on shoulders (OPTIONAL)	

[15] Pedestrian Environmental Data Scan

PEDS	Item	Response Type
Segment Type		Response options
Environment	Land uses in segment	Checklist
	Slope	Rating scale
	Segment intersections	Checklist
Pedestrian Facility	Type of pedestrian facility	Checklist
	Path material	Checklist
	Path condition/maintenance	Checklist
	Path obstructions	Checklist
	Buffers between road and path	Checklist
	Path distance from curb	Rating scale
	Sidewalk width	Rating scale
	Curb cuts	Rating scale
	Sidewalk continuity	Y/N
	Sidewalk connectivity to other sidewalks/crosswalks	Enter #
Road Attributes	Condition of road	Rating scale
	Number of lanes (minimum/maximum)	Enter #
	Posted speed limit	Enter #
	On-street parking	Y/N
	Off-street parking lot spaces	Rating scale
	Must you walk through a parking lot to get to most buildings?	Y/N
	Presence of med-hi volume driveways	Rating scale
	Traffic control devices	Checklist
	Crosswalks	Rating scale
	Crossing aids	Checklist
	Bicycle facilities	Checklist
Walking/Cycling Environment	Roadway/path lighting	Checklist
	Amenities	Checklist
	Wayfinding aids	Y/N
	Trees shading walking area	Rating scale
	Degree of enclosure	Rating scale
	Powerlines along segment	Checklist
	Overall cleanliness and building maintenance	Rating scale
	Articulation in building designs	Rating scale
	Building setbacks from sidewalks	Rating scale
	Building height	Rating scale

	Bus stops	Checklist
Subjective Assessment	Attractive for walking	Rating scale
	Attractive for cycling	Rating scale
	Feels safe for walking	Rating scale
	Feels safe for cycling	Rating scale