Winter Cycling
Reflections from a South End Commuter - Revision 1

Prepared for Bike Ottawa Advocacy Working Group

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Disclaimer: The views and opinions expressed in this paper are those of the author and do not necessarily reflect the policy or position of Bike Ottawa or its agencies. The information is based on the author's specific experiences and his particular circumstances, therefore is not intended to be interpreted as providing sanctioned or authoritative recommendations.

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1.0 AIM

This paper expands on winter cycling commuting thoughts and experiences presented to the Bike Ottawa Advisory Working Group on 17 Dec 2019. Based on experiences garnered while cycling to work along a route largely composed of areas with no cycling focused winter road maintenance, this paper aims to provide helpful information and otherwise outline issues that need attention in order to promote and facilitate the growth of cycling as a broadly accepted, year round primary commuting option. Diving into the subject matter does result in some technical analysis and detailed descriptions that do not make for light reading. The table of content is intended to offer a convenient option to navigate directly to sections of interest.

2.0 BACKGROUND AND CONTEXT

2.1 Global

Understanding that there are no great revelations in the following, it bears repeating that a wider adoption of cycling has the potential to improve overall quality of life for society by reducing the expense, pollution, waste and stress associated with traffic congestion, while improving population health through active transportation. In addition, within the context of global environmental concerns, few readily available alternatives can be as quickly and relatively inexpensively adopted to provide a greater reduction to commuting related impacts, especially in large urban centres. Although other options to meet commuting needs have varying advantages, none appear able to provide the broad range and magnitude of societal benefits available from an expansion to cycling. Given the focus of this paper, it is worth noting that the aforementioned facts transcend the seasons of the year.

2.2 Local

In Ottawa, wintery conditions can reasonably be expected from Nov to end Mar, which represents over 40% of the calendar year. Sometimes this period is even longer e.g. 8.8 cm of snow fell on 9 Apr 2019. Unlike recreational outings, going to work, for most, cannot be scheduled around the seasons.

According to 2016 Statistics Canada Census data on commuters in the National Capital Region (NCR), 2.6% use active transportation, while the remaining 97.4% use a combination of public transit (19.7%) and cars (77.7%). In actual numbers the last two categories represent a potential of well over half a million commuters from which additional cyclists could be drawn. The Statistics Canada data retrieved did not discuss seasonal impacts on the active transportation figures, but other sources estimate that the amount falls to about 0.7% under wintery conditions. This would indicate that winter conditions in the NCR represent an aspect that requires specific attention if active transportation growth is to be maximized. Other local factors such as a relatively flat topography, and a high percentage of the population living within a 20 km radius of the city core, provide excellent fundamentals on which to grow the numbers participating in cycling as a means of active transportation. It stands to reason that leveraging these factors year round would better realize the potential benefits. As detailed further in this paper, there are some elements in the design phase of cycling infrastructure that can have an important impact on facilitating all season use.

2.3 Individual

Having moved to Ottawa in the summer 2018 from a smaller community with much less traffic, and after evaluating commuting options, cycling was selected for a variety of reasons. Principally, these included the parking expenses and traffic headaches associated with using a car or motorcycle to commute to/from downtown during rush hour, the expense and inconvenience (schedule limitations) of taking public transit across the river to Gatineau along a particular North-South corridor not as well served as other areas of the city and finally, a true appreciation for the simplicity, convenience and efficiency that cycling brings to city commuting. In the context of the author's particular commute and job location/schedule, cycling provides for self-reliance and flexibility on par with taking a personal motor vehicle, without the negative elements mentioned. It offers autonomy and freedom from traffic jams as well as city transit disruptions.

When cycling was originally selected as the method of choice, there was no real expectation of winter use. In fact, as is the case for many, winter cycling was not a familiar concept. Discovery of winter cycling information on the city's web site in the fall of 2018 changed this. Given the disposable nature of the bicycle being used, and the continuing compelling applicability of the original reasons to select cycling, it was decided to give it a try one day at a time. Once the snow hit, through adaptation, one day led to a week, then a month and ultimately to the end of the winter season. To be clear, some days were missed due to the challenges associated with the unplowed portions of the commute. After some experience, for the most part, when the forecast called for more than 10 cm of snow through the overnight or for a given day, commuting plan B (i.e. Bus) was reluctantly invoked.

As the cold snowy winter of 2018/19 went on, it became clear that the only change required in order to permanently retire plan B, would be for the city to better integrate cycling requirements as part of its approach to existing winter road maintenance operations. This aspect is further explored throughout this paper, as is the fact that all other challenges were found to be manageable at the individual cyclist level.

3.0 INTRODUCTION

Although experienced in motorcycling, the author does not claim expertise in any aspect of cycling. The winter of 2018-19 in Ottawa was a first experience with winter cycling. Although the 310+ cm total snowfall was above average, thereby providing ample exposure to a variety of conditions, more seasoned cyclists riding other types of bicycles may consider some of the information contained herein to not reflect their more comprehensive exposure.

The experiences are drawn from a daily commute originating in Ward 9 (Knoxvale-Merivale, formerly part of Nepean) and stretching approximately 14 km one way (i.e. 28 km daily round trip). 2/3^{rds} of the route to the Gatineau destination takes place on Prince of Wales Dr in Ward 9 (Knoxvale-Merivale) & Ward 16 (River) where winter cycling road maintenance appeared mostly absent. The remaining 1/3rd is mostly on plowed multi-use pathways and bicycle lanes through Ward 14 (Somerset) & across the Portage Bridge to Gatineau. As of the end of the 2020 winter cycling season, the author's total commuting distance logged during the Nov – Mar time frames since Nov 2018 stood at well over 3500 km. On average, duration of the winter commute was just under one hour (one way), compared to about 45 mins in the summer. Although this could decrease slightly or increase significantly depending on surface conditions, both average timings are lower than the time required under ideal conditions using city transit and slowdowns due to weather delays were no worse than those experienced by motor vehicles.

Although the content of this paper includes some generic aspects and touches upon the existing winter cycling network, the majority is focused on the more challenging portions of the commute along Prince of Wales Dr. Much of this information is likely to be applicable to other busy roads which do not benefit from winter cycling maintenance. Throughout this document, the term "contamination" refers to substances such as water, snow, ice, salt, dirt, grit, etc… which tend to accumulate on road surfaces primarily during wintery periods resulting in messy conditions and reduced traction.

4.0 DISCUSSION

4.1 Bicycle choice

A broad range of bicycle types can be seen in winter use, from purpose built “fat” bikes to road bikes and virtually everything in between. Factors worthy of consideration while pondering a winter commuter include increased wear and tear due to rough surfaces, the city’s liberal use of road salt, as well as the innate ability of slush/snow to retain dirt and small gravel particles. As the entire mess tends to splash onto the bottom portion of the bike, sticking to the drivetrain in particular, a sparkling new bike is unlikely to remain as such after some winter duty.

The author’s commuting bicycle (figure 1) was selected based on what was already available. The bicycle is assumed to be from the 1980s. It was purchased for the token sum of $5 from someone who no longer had use for it, circa 2009. At the time, no winter or even commuting use was planned.

The bike consists of a rigid steel frame, mountain bike tires 26” x 1.75”, 5 speeds (14 x 28 freewheel rear gears) and rim brakes. Fenders, rear luggage rack, bell, cyclometer, side view mirror and removable lights were added for a total capital investment of $125, to create a more practical commuter. Overall, this low budget bicycle performed well in a variety of sometimes extreme conditions with a reliability comparing favourably with that of some newer billion dollar city transit systems.


Figure 1: Author’s winter commuting bicycle

4.1.2 Features

4.1.2.1 Fenders: The relatively cheap universal option purchased managed to help reduce the common winter road splash and a loose fit provided clearance for buildups of sticky wet snow on the tires.

4.1.2.2 Rear luggage rack: Basically this is a flat metal rack with a spring loaded clamp. Another universal fit option, this made for practical load carrying capacity. As one can imagine, this area does get dirty in spite of the rear fender. An easy and economical way to keep work related goods such as a briefcase, backpack, laptop, lunch bag, etc… clean and dry proved to be as simple as inserting the cargo in a large garbage bag. The resultant package could be secured on the rack with bungee cords, which in turn allowed a rear light to be added on easily. Opting for the orange coloured garbage bags shown also contributed to visibility. The bags used were found to last a few weeks and were several orders of magnitude cheaper than anything purpose built that was considered. They were easy to store at destination and are not particularly attractive as items to steal. Also, they did not require cleaning; once worn, replacement was easy and in the spirit of reusing, the retiring bag was typically still sufficiently fit to move on to a second career more in line with its original calling. Although saddle bags (panniers) were not trialed, they would contribute favourably to lower the center of gravity.

4.1.2.3 Lights: With shorter days and changing road conditions, seeing and being seen was a top priority. The typical winter commute is likely to be conducted in the dark, at least one way. Removable lights were convenient, as the bike mostly slept outside. Bringing the lights indoors limited their time in the cold to the commute itself, avoiding having the batteries cold soak overnight. USB rechargeable lights offered the benefit of more lighting power over conventional batteries, which was especially useful for the front light. It should be noted that as temperatures plunged, they required nightly recharging. At night, a steady white front light with slight downward aim provided adequate short range visibility and was generally appreciated by oncoming cyclists and motorists over the hypnotizing blinding effect of a 2000 lumens strobe light. In areas devoid of streetlights, getting a look at the terrain further downrange was more challenging, but periodically possible by taking advantage of the momentary added illumination provided by the headlights of passing cars. A rear light with conventional batteries provided an economical option, effective especially when coupled with visible clothing (see visibility section). The useful life of the CR2032 coin type batteries used was found to be reduced to about 3 to 4 weeks due to the cold temperatures. As performance could drop rapidly, carrying spare lights enables a quick change.

4.1.2.4 Mirror: As changing surface conditions required attention to be on the road ahead and often fully focused on the surface, a quick glance in the mirror proved less disruptive than turning one’s head. This was especially significant given the limited peripheral vision provided by ski goggles. The ability to have easier awareness of traffic coming up from behind proved convenient when approaching obstacles, such as a snow induced choke point (see figure 2).

Figure 2: Photo dated 20 Mar 2019. Looking southbound on Prince of Wales Dr at the Intersection with Colonnade Rd. The green path represents the unobstructed summer trek along the paved shoulder. The red path illustrates the diversion required due to the snowbank not being sufficiently pushed to the side by the plows resulting in a choke point (purple arrows). Intersections like this one were often the site of similar choke points. These result in cyclists having to carve out some space in the vehicle lane, in this case, on a road where the 60 km/h posted limit appeared at times converted to mph as some drivers would race through the intersection in an effort to beat the red light.

4.1.2.5 Brakes: This is an area where an upgrade from the tired '80s technology would be most significant. The stock side pull single pivot rim brakes (even after adjustment) are no match for more modern rim or disc brakes, even in ideal dry conditions. Although cold temperatures do harden materials such as those used in brake pads, moisture was found to have a far greater impact and this was evident whether in winter or summer. Starting at "very good" under dry conditions, braking efficiency was found to deteriorate notably under wet conditions. The difference could be noticed after a relatively short travel distance through some wet or melting snow. As such, maintaining constant awareness of overall available braking power was useful, helping to avoid resorting to an emergency boot brake technique. Road salt's ability to melt snow, although contributing to improved traction, did nothing to improve brake pad performance, as it simply added to the instances of wet conditions.

An innocuous condition unique to winter, illustrating the need for constant awareness of the potential for rapidly changing brake performance, involves encountering a significant change of temperature, for example, after entering a heated underground garage. Following a dry pavement commute at -20C, the garage's warm moist air contacting the very cold wheel rims would result in condensation which could almost instantaneously reduce braking efficiency. It was therefore important, especially after a tense commute, to fight the tendency to relax and let the smooth concrete surface and "tropical" air lull the mind into summer mode. Any hopes of arresting the momentum of a high speed descent built up along the garage ramp with an "endo" at the bicycle parking rack, was doomed to end unpleasantly.

4.1.2.6 Wheels: Mountain bike type wheels with a conservative 26" diameter feature fairly robust spokes that resisted well to the rough surfaces encountered throughout the winter.

4.1.2.7 Tires: Mountain bike tires with a width of 1.75" (44.5mm) turned out to be suited to tackle a wide range of surface conditions, providing a good compromise between low rolling resistance, damping, and adhesion to slippery surfaces, while also appearing to help minimize getting drawn into snow and ice ruts. The thread pattern (see figure 3), includes a useful smooth "road ridge" in the center, again a compromise on a wide variety of surfaces. Having the better of the two tires up front was found to be optimal given the importance of avoiding front wheel skids. The various offerings of winter/ice/studded tires currently available, although not tested undoubtedly come with their own plus and minuses. Studded tires in particular have been reported by some as making a world of difference in avoiding falls due to ice hidden under snow.

Figure 3: 26" x 1.75" Mountain bike tire

4.1.2.8 Drivetrain: The 5 speed configuration provided more than adequate flexibility for winter commuting, where speeds tend to be lower. Although lacking the precision offered by an indexed shifter, the old style “friction” lever gear shift made for easy use even with ski mitts. The robust chain and typically looser space tolerances of a 5 gear freewheel set-up compared with an 8 or 9 gear modern cassette, may be better at dealing with the frequent gritty contamination splashed onto the drivetrain.

4.2 Bicycle winter maintenance

<u>4.2.1 General</u>: Expecting more wear and tear should be a given. One particularly significant consequence of the harsh winter environment is the corrosion of steel, aka rust. Although virtually unavoidable, it’s useful to understand that certain practices can aggravate the situation. Moisture is a catalyst for the formation of rust and road salt greatly improves the efficiency of the process. Condensation and melting of salty snow on the bike will accelerate corrosion. Leaving the bike outside minimizes exposure to the large fluctuations in temperatures which contribute to this cycle thereby slowing rust.

As a winter commute is likely to include some cold miserable days, unscheduled maintenance can be considerably more inconvenient and unpleasant than during the summer. Minimizing these occurrences is therefore a worthwhile endeavour, especially if a breakdown could result in having to walk several kilometers along a desolate frozen landscape, or alongside a roadway flanked by a tall snowbank on one side and fast moving traffic on the other. Performing a pre-return to service inspection and tune up in the fall is a good start to the season. It’s a lot easier to make adjustments at the outset on a clean bike, possibly indoors, rather than later outside after a series of messy commutes. Awareness and monitoring of serviceability issues through regular inspection coupled with routine / preventative maintenance and adjustments throughout the winter were found to be good practices to ward off serious unscheduled maintenance.

In spite of all precautions, having a portable tool kit on board is never a bad idea. Typically small and relatively cheap ($30), these can make a real difference in a pinch. A typical kit will include a mini pump, multi-wrench, multi-tool hex set, glue-less patches with scuffer, spoke wrenches, and tire levers. Adding a few extras such as mini portable chain tool and spare pins to enable a quick chain repair, some Zip Ties, a set of thin disposable nitrile/vinyl gloves and a paper towel or two, does not take any more space and can be particularly useful. Although these gloves don’t keep fingers from freezing, they can keep them clean and dry, which makes warming up easier and avoids having to stick greasy wet paws into clean mitts after a repair. To deal with simpler situations, tucking a grocery size plastic bag under the seat not only makes for a convenient seat cover if parked outside, it also provides quick access to something that can be draped over the chain or other greasy parts to manipulate them, keeping hands and mitts clean without having to break open the tool kit.

In cases where a repair is to be performed at home, having room indoors to bring in a slushy, salty bike to thaw out, dry up and work on, is ideal. If that’s too much of a mess, or otherwise not an option, an alternative can be to keep a nearby exterior area clear of snow throughout the winter for such an eventuality. A porch or back deck can work well, enabling bringing in removed parts to be cleaned and repaired inside as applicable or simply allowing one to quickly duck inside periodically during the repair to thaw out frozen fingers and recover dexterity.

At the end of the season, a thorough clean to remove all dirt and salt can help keep the “rusties” at bay during storage or summer use. A clean bike will also allow for an easier inspection to determine what needs to be planned as work before the start of the next winter season.

4.2.2 Drivetrain maintenance: As one of the systems that can cause issues, this is worthy of some discussion. An accepted approach to drivetrain routine maintenance includes a careful cleaning of all parts followed by a conservative application of chain lube to each roller/pin. In the summer, even with daily use, this may only be required a few times over the entire season. However, as mentioned earlier, winter brings with it a high rate of surface contamination which literally coats the bottom portion of the bike so the drivetrain can be filthy and covered with dirt and salt after as little as one day. Under such conditions, a little more attention is required to prevent the drivetrain from exhibiting that rusty orange glow in short order. In addition, under certain conditions, snow and ice were found to build up and eventually freeze the derailleur mechanism, causing skipping between gears and subsequently leaving only one or two of the slowest gears as usable, making a long commute even longer.

Although a daily full system clean and lube would likely be ideal, this was not deemed practical. The approach chosen, although still evolving, included a monthly chain wipe and lube (with chain lube). This was supplemented, when the drivetrain had gotten wet the previous day or if snow was in the forecast, by a morning pre-departure application of spray can lube to the derailleur pivot points and any related areas that appeared to be turning orange, while obviously keeping lube away from the tires, wheel rims and brake pads. This was used as an opportunity to use up old stock, so a variety of types of sprays were used and all appeared to get the job done. Applying used old motor oil with a squirt can is another option reported to be effective and economical. Ultimately, minimizing the moisture on the moving parts reduced corrosion and prevented snow and ice build-up on the rear derailleur from causing malfunctions. While this worked, the drivetrain looked filthy most of the time and the stuck on grime was likely contributing to faster wear than in the summer. The good news is that these systems are easy to work on and, especially for ‘80s bikes, the parts are inexpensive.

Last but not least, regular chain wear monitoring especially if winter usage is high, is a good way to avoid bigger problems. A chain measuring tool is a few dollars and provides a quick and easy way to measure chain stretch. Replacing a chain worn beyond limits in time will prevent the rest of the drivetrain components from being rapidly chewed up.

4.2.3 Tire maintenance: One of the most common causes of breakdowns is literally where the rubber meets the road. Tire pressure is affected by ambient air temperature and given the wild swings in temperature possible during a typical Ottawa winter, monitoring of tire pressure can help avoid both over and under pressure situations. A quick visual before departing and applying weight to the bike to see how the tires respond usually provided a good idea of whether the pressure gauge should be brought out for a more formal check. Detecting an issue before leaving could prevent having to deal with it on route.

In spite of the most religious preventative maintenance routine, flat tires can happen unexpectedly. The best course of action is likely situation (location / weather) dependent, but here are some thoughts. An immediate action option is to simply try adding air to see if the leak is slow enough to get to destination; this worked on one occasion. Failing that, walking to somewhere dry and/or warm, for example to a parking garage or if the weather is acceptable, getting to a safe open area with some “clean” space to work. At times, walking back home may be the most efficient way to go. In one instance this meant walking 5 km+ along a snowy shoulder. Alternatively, trying to fix one of these on the shoulder presents special challenges. Thankfully, no first-hand experience with this one and the walking alternative would likely have to be fairly extreme for this rider to attempt a repair in the snow along a busy road. First, the wheel is likely going to be filthy so removing it from the bike then the tire from the rim is going to be messy, expect wet, slimy, frozen fingers and needing to be careful not to lose the wheel nuts, washers or tools in the snow. Planning to find the location of the puncture in the tube and gluing a patch in sub-zero temperatures with no dry surface around, possibly in the dark, is the next challenge. An easier alternative would be to carry a new or previously repaired tube as a spare and simply swapping it out. Just doing that while trying not to get dirt, grit and slush inside the tire/rim/bead during reinstallation, with frozen fingers, possibly in the dark, next to passing cars will be challenging enough. Although nil first-hand experience using tires with puncture protection, it's assumed these might provide a good line of defence.

4.3 Apparel

Those who have never cycled in winter often assume the cold to be the major concern. Compared to other challenges, this one was quite easily managed such that zero commuting days were missed due to temperature. The coldest morning temperature recorded was -27C (wind chill not factored) and this did not feel like a physical limit. As a note, colder temperatures are typically accompanied by clearer skies therefore less precipitation, contributing to much cleaner roads and plenty of sun, an advantageous trade-off for the most part. Cycling on most winter days, and especially on those sunny days, was more enjoyable than summer cycling on a rainy day. Further, by comparison, the standing around associated with waiting for the bus and the temperature fluctuations from going in and out of a heated environment could leave one feeling much colder.

While looking for winter gear, there are so many purpose designed accessories that it's easy to get carried away and fall into the fashion police or pro gear trap. This can be a waste, especially before making a solid commitment to winter cycling as a regular commuting option. Also, the post purchase realization that this pricy gear will get covered with winter road grime may damper enthusiasm.

Here are some apparel related thoughts, summarized as "4C4T3F" (due credit here to other members of the Bike Ottawa Advisory Working Group for the "T" portion):

4Cs

Cheap – Part of the goal was for the commute costs to be lower than the next cheapest available option i.e. monthly transit pass. As such, the solution was made up mostly of apparel currently in the home inventory. An old raincoat with a couple of layers underneath provided excellent protection against wind, cold and external moisture. Keeping in mind that most of the outer layer of clothing from the boots to the jacket was routinely prone to be splashed with dirty, salty and slushy water, this 1st "C" was a good guiding principle. Given the recurring abuse, the outer layer was kept consistent throughout the winter while the inner layers were the ones adjusted to deal with the changing temperature.

Common sense – Just as expecting to get by with a T-Shirt and shorts is not realistic, neither is simply anticipating donning a snow suit for the duration. There are a range of temperatures to contend with, and cycling generates body heat so some thought needs to be put into sourcing a variety of apparel and combining them to meet the changing conditions, but as per the 1st "C", this need not break the bank.

Core – Core temperature is important, however, proved relatively easy to manage with loose layers. In contrast to the extremities, preventing core overheating was often the greater challenge. Struggling to prevent one area of the body from overheating while managing others to prevent frostbite became one of those interesting winter cycling ironies. See the 4Ts for more on management of body temperature during the commute and 3Fs for frostbite information.

Chart – Building a "Temperature vs Apparel Chart" (see figure 4 sample at the end of this section) made it easy to record with checkmarks, what individual pieces of apparel had worked for a given temperature or temperature range. This enabled optimization of clothing combinations. Eventually, having this info as a reference, made it quick and easy to figure out what to wear for the day based on the morning forecast.

4Ts

Time – The duration of the commute dictates the time of exposure and time of cycling effort. Combined with the other factors, this can either reduce or increase clothing requirements. More time typically will mean more body heat generation therefore a need to go with fewer layers.

Tempo – The effort required during the commute will result in more or less heat generation. If effort is high, choosing clothing that can be easily and gradually vented/opened up to improve cooling can help prevent overheating before arriving at destination.

Temperature – Obviously the actual temperature is important, but so is noting wind. Over the 14 km commute, fighting a headwind would eventually result in more core body heat generation, which could require venting, sometimes even at the extreme end of the cold scale i.e. -25C. Meanwhile, the added cooling effect on the face and extremities still needs to be managed, especially over the first few kms.

Tolerance: As one's own sensitivity to temperature will affect clothing requirements, recommendations from others may be a good place to start, but building one's own chart will provide more effective results.

3Fs

Fingers – Typically the first to freeze, wearing something that keeps fingers together such as ski mitts worked best as temperatures plunged. For that awkward temperature zone barely above the freezing mark when cold rain could soak into mitts, a set of thin wool gloves inserted into some thick, loose fitting rubber gloves worked to keep hands dry and thereby less likely to freeze. Ensuring a loose fit made a big difference to help fingers stay warm.

Face – Appropriate covering of exposed skin helps prevent frostbite. To address the wide range of temperatures, various combinations of headband, balaclava, ear muffs, scarf, sunglasses, and ski goggles were used. It's worth noting that lenses can be prone to fogging, especially in the absence of airflow, for example, waiting at a stoplight when breathing rate may be high from recent exertion. Prescription glasses inside goggles will exacerbate the fogging problem. Ensuring good external airflow around the lens and being mindful of where one's exhaled air is directed via a scarf or other covering of the face helped manage the effect. As a note of caution, entering a heated underground garage after a ride out in the cold was found to result in rapid fogging of lenses such that being ready to quickly flip them out of the way was useful. Freezing rain/drizzle could cause a buildup of ice on goggles, resulting in gradual and eventually significant reduction in visibility. Pedaling faster in the hopes that generating more body heat would defrost the lens proved counterproductive. A low tech solution found to be effective involved periodically scraping the ice from the lens using fingernails to avoid a buildup. As the goggles used were old, concerns about causing scratches was low. In the milder range of sub-zero cold conditions i.e. above -10C, simply moving the goggles out of the way e.g. on to forehead was often the best solution to ensure visibility. Anti-fogging sprays were not trialed but may be worth considering, especially if prescription glasses are part of the combination used.

Feet – This area is also prone to getting cold. In addition, inherently exposed to a stream of salty water/snow/slush made waterproofness an important footwear consideration. Wool socks inside a pair of old style zip up rubber overshoes/boots provided excellent salt water resistance. As these are made of a relatively thin rubber (including the sole), they were light, very flexible and always kept feet dry with a loose fit. It should be noted that walking 5 km in this type of footwear following a flat tire was less than comfortable. Good old fashion rubber boots are another alternative that likely provides the same resistance to the elements. Although not tested, the concern with summer fabric type cycling waterproof shoe covers, would be their resistance to the harshness of the salt. Similarly, as lower legs will also be the targets of liberal splashing, an old / cheap pair of wind/rain pants may be preferable to high dollar Gore-Tex. Having said that, if you have some extra funds in the budget to spend on apparel, this is reportedly a good area to invest, understanding that you will likely have to trash the pants after a few seasons.

Apparel / Temp	Shorts	T-Shirt	Long Sleeve Shirt	Light Jacket	Wind Pants	Sweat Pants	Head Band	Scarf	Balaclava	Rain Jacket	Rubber Gloves	Wool Gloves	Mitts	Shoes	Winter Overboots	Light Goggles	Ski Goggles
>=20																	
19 to 15																	
14 to 10																	
9 to 5																	
4 to 0																	
-1 to -4																	
-5 to -9																	
-10 to -14																	
-15 to -19																	
-20 to -24																	
-25 to -29																	
<=-30																	

Figure 4: Sample of a Temperature vs Apparel recording chart.

4.4 Visibility

Lights have already been discussed, but the apparel section is appropriate to further consider the overall importance of visibility. To emphasize the previous mention, the ability to be seen is just as important as seeing, and when sharing the road with motor vehicle traffic in reduced visibility conditions, standing out can make the difference. A typical commute along the 9 km portion along Prince of Wales Dr involved being overtaken by approximately 250 vehicles. Accounting for the return trip, that's 500 potential interactions per day, 2500 per work week, etc... Reflective strips, such as those commonly available to stick on to utility trailers are a cheap but effective way to improve visibility, especially from the sides. However, viewed from the rear, bikes provide a very narrow visual signature to a driver expecting car sized traffic moving at a faster speed. In addition, some drivers are prone to tunnel vision such that anything beyond a certain narrow lateral distance from their immediate trajectory becomes part of an inconsequential blur. The good news is that, all things being equal, when presented with the option, most drivers will elect not to hit a cyclist. Properly leveraging this involves being easily detectable in spite of the challenges. Opting to dress like a snowman during the day and/or a ninja at night places a high level of reliance on the bike itself to ensure visibility. Other than reflectors, this leaves lights, which can malfunction due to a dead battery or poor contact from corrosion due to salt water intrusion or simply detach themselves, falling off the bike. A rear red light going out halfway through a commute is unlikely to be noticed by a rider focused on looking ahead for the next icy patch and can quickly render the bike all but invisible to cars approaching from the rear. In such conditions, a speed bump sensation may be a motorist's only belated indication of a cyclist's presence.

Although perhaps scoring low on the smart winter fashion scale, high visibility clothing such as a workman's orange mesh vest featuring a large reflective "X" at the back was found to provide a cheap and easy way to increase contrast with the winter landscape both at night and during the day, in an effort to avoid becoming a hood ornament.

4.5 Route features

As mentioned, 2/3[rds] (9 km) of the route is on Prince of Wales Dr. Specifically, from the intersection with Amberwood Cres to the Trillium Pathway's southern link (just West of Preston St). For cyclists, Prince of Wales Dr is comprised mostly of a paved shoulder as well as elevated multi-use pathways, elevated bike lanes, and some floating lanes. As mentioned, winter cycling road maintenance appeared absent throughout, as such, any snow clearance benefiting cyclists was incidental, varied and unpredictable.

The remaining 1/3rd (5 km) of the route starting at the southern link to the Trillium Pathway is on the winter cycling network and comprises multi-use pathways and bicycle lanes including across the Portage Bridge to Gatineau. Overall, the contrast between this portion and Prince of Wales was striking and comparatively relaxing. Even the most severe storm of 2019 was manageable on the Trillium Pathway.

The following sections provide some additional observations and photos of certain portions of the route. It is worth emphasizing that photos provided were taken in daytime, mostly at the end of March 2019, long after the winter's peak had receded.

4.5.1 Paved shoulder: The quality of the pavement on the shoulder of Prince of Wales Dr was observed to often be poor and more prone to cracking and degrading than the roadway. To make matters worse, in many areas, the shoulder appears to have been added after construction of the roadway, resulting in a seam in the area of the white line. This seam was prone to cracking and water accumulation which developed into potholes, a particular night hazard. Not surprisingly, an already rough surface compounded the effect of slippery contamination.

At times, certain shoulder areas were fully cleared down to the pavement. At other times, this could degrade to the point of having a snowbank, formed on the white line, preventing any access to the shoulder. In general, the conditions encountered riding on the shoulder were at best similar to, but most often worse than those existing on the adjacent roadway for motorized four wheel traffic.

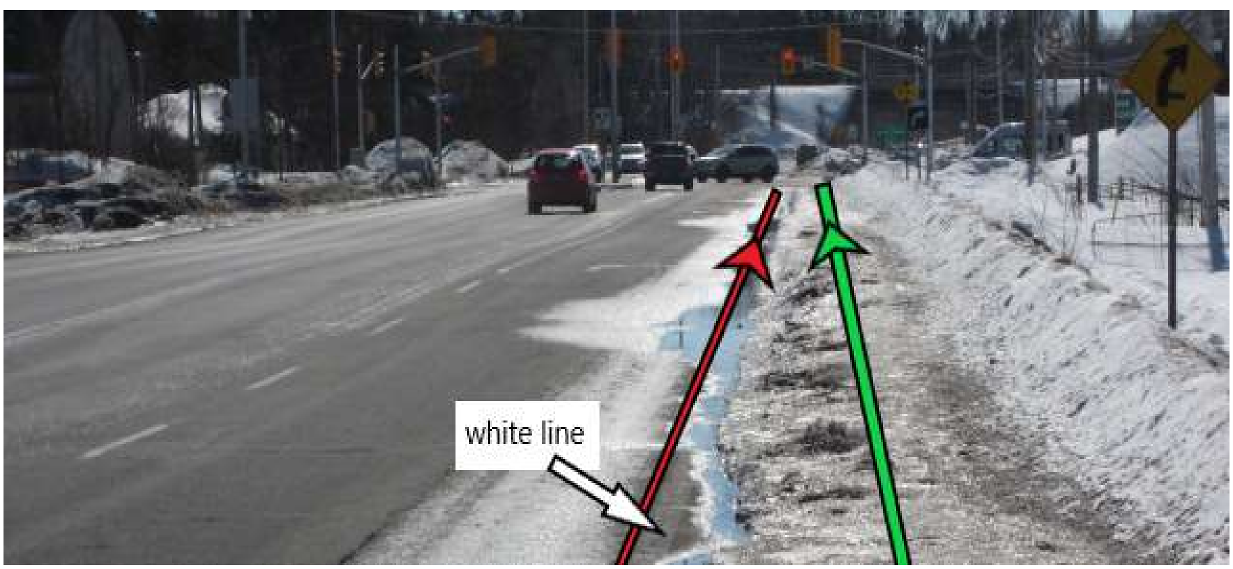

Figure 5: Photo dated 20 Mar 2019. Looking southbound on Prince of Wales approaching Colonnade Rd. The green path represents the unobstructed summer trek along the paved shoulder while the red line illustrates the path on the roadway required due to the poorly plowed shoulder. Although the snow bank is low following some melting, the rough and laterally angled surface render this surface impractical. Note the white line separating the roadway from the shoulder. The standing water in this area is not only messy, it is also very effective at hiding potholes.

Figure 6: Photo dated 20 Mar 2019. Looking north on Prince of Wales at the curve after the Kochar Dr Intersection. Although not perfect, this type of plowing leaves sufficient space for cyclists to circulate to the right of the white line and therefore off the roadway.

Figure 7: Photo dated 20 Mar 2019 Northbound Prince of Wales approaching Hartwell's Locks Lane showing a fully cleared shoulder surface. This portion of the route typically benefitted from better plowing than others. Note the significant (ideal) distance available between the snowbank and the white line separating motorized traffic from the shoulder.

<u>4.5.2 Elevated multi-use / shared pathways</u>: Along Prince of Wales, these were used for snow storage during the 2018/19 winter period (figure 8). However, during the 2019/20 season, some were partially cleared. Although not perfect, the opening of these gauntlet areas reduced the instances of cold sweat experienced along the route.

Figure 8: Photo dated 20 Mar 2019. Unplowed newly built (2018) shared pathway next to two lanes of southbound Prince of Wales traffic near the Deakin St intersection. Note elevated concrete curb separating roadway from impassable shared pathway leading to a small cleared bus stop area. This forced cyclists onto the two lane roadway which does not have a shoulder so the cyclist must ride in the lane with traffic, right next to a high curb. Also note the snowbank spilling over the curb and onto the roadway, further reducing space for cyclists.

Figure 9: Photo dated 20 Mar 2019. Looking north on Prince of Wales between the Carillon Housing Co-operative entrance and Nesbitt Place. The type of plowing seen on the northbound side often left sufficient space for cyclists to circulate to the right of the white line and therefore off the roadway. Although hard to see, the southbound side of this stretch did not benefit from this type of plowing, even though the amount of space available is the same.

<u>4.5.3 Elevated bike lanes</u>: As a favourite destination for snow pushed from the roadway on one side and from the sidewalk on the other, this newer infrastructure was the first to disappear, becoming unusable in the fall and the last to clear, late in the spring.

Figure 10: Photo dated 20 Mar 2019. Prince of Wales, northbound side showing impassable newly built (2018) elevated bike lane located to the north of Maryland Ave. The corresponding bike lane across the street, located mostly in the shade, was not usable until late Apr 2019.

<u>4.5.4 Floating lanes</u>: Often used to provide cyclists with a corridor to transit major intersections which feature turn lanes, these have the cyclist travelling between two car lanes separated only by paint markings on the pavement (see figure 11). Ironically much maligned in the summer, as they are easy for cars to transgress, these were the only areas which could be counted on to be plowed on par with the roadway, at all times. They offered a temporary respite, especially during an active snowfall, unfortunately they had a tendency to be capped at both ends by snowbanks.

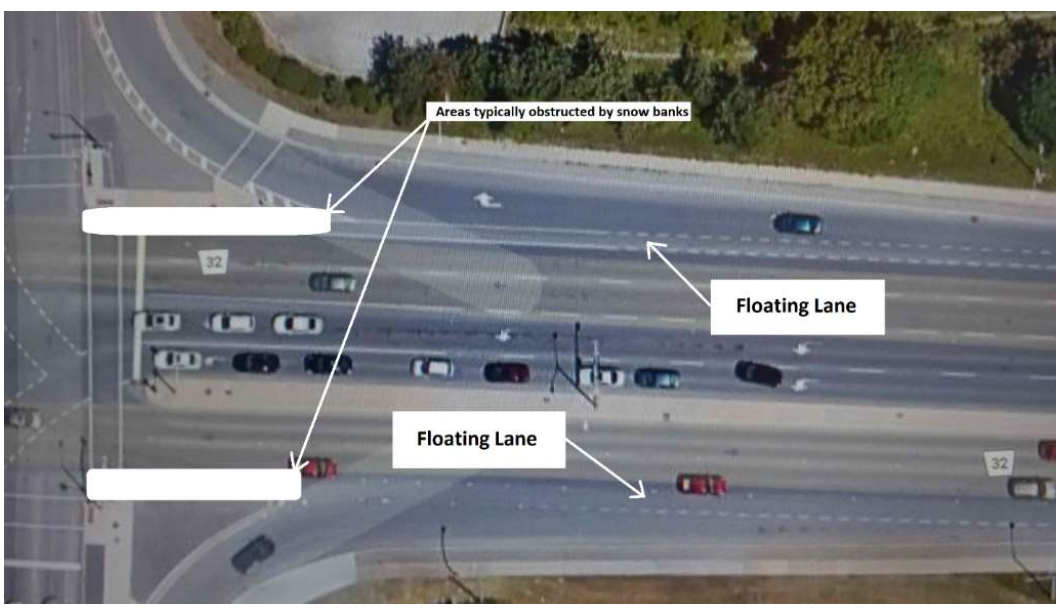

Figure 11: Top view showing a typical floating lane configuration. As the snowplows move through the intersection, they often would leave a significant snow bank in the locations shown, covering the ends of the floating lanes thereby creating choke points. This would force the cyclist to merge into the car lane both when entering as well as when exiting the intersection. As these are typically major intersections where the attention of drivers is taxed watching for other traffic and focused on the status of the lights, having to share a lane is not ideal.

4.5.5 Winter network: The Winter Network portions of the Trillium Pathway appeared mostly well maintained. The same could not be said for certain protected bike lanes along city streets. Although it's hard to complain here given there are areas which don't benefit from any plowing, it did appear that protected bike lanes did not enjoy the same priority as the adjacent streets or sidewalks and one of the main challenges seemed to be a lack of space to push the snow. Both on the Trillium Pathway and shoulder areas along Prince of Wales Dr in locations with sufficient "overflow" space to push the snow, earlier and more frequent plowing was noted, resulting in increased riding surface quality. Plowing the area during a snowfall followed by a final pass thereafter appeared to better avoid the build-up of a rough surface layer. Conversely, areas where snow could not be completely pushed away from the surface, required a post snowfall, more time consuming and likely more expensive use of snow blowing machinery and trucks to take the snow away. This often left a rough snow and ice covered surface. Although only a few cm thick, this could be unusable until a significant warm spell. It is worth noting that plowed surface quality is more critical for cyclists than it is for cars and pedestrians. As such, the types of snow clearance operations that will be possible are important factors to consider as part of cycling infrastructure design. Based on observation of snow bank sizes, a good rule of thumb to avoid the need for a secondary snow blowing clearance step after every significant snowfall is for the space available to push the snow to be as wide as the surface being plowed.

Figure 12: Photo taken 20 Mar 2019. This is the start of the southern link to the Trillium Pathway and, in spite of the excessive use of road salt, represents the winter cyclist's Holy Grail. No matter the weather, given the absence of motor vehicle traffic and the availability of safe manoeuvring room, this was always a welcome sight. The exhaust free air, quiet and picturesque setting would often have a calming effect on pulse rate, especially after a tense 1st portion of the commute.

During the winter of 2018/19, the Portage Bridge elevated bike path was used for snow storage. However, in the fall of 2019, fresh from a Jun 2019 widening and addition of a protection wall, it was plowed for the first time. Like the protected bike lanes, space to push the snow out of the way is a challenge, sometimes reducing the width to just over one lane as shown at figure 13.

Figure 13: Photo taken 21 Jan 2020. This elevated two way traffic bike lane is on the east side of the Portage Bridge. Even though it was often cleared as the last priority after the road and the sidewalk, it was great to see this newly plowed and no longer used for snow storage.

4.6 Winter riding techniques

4.6.1 General: As per the introduction, by far the most challenging weather related factor encountered relates to surface conditions. As the Trillium Pathway was well plowed, many of the conditions described below were either much less severe or not applicable to this area. Where they existed, they were completely manageable and could add just the right amount of spice to a routine commute. It is when encountered in areas of fast moving traffic with reduced riding space available to properly navigate the surface that spiciness could quickly go from hot to scorching. Accordingly most of this section is focused on handling contaminated surfaces in traffic settings, as they are the most challenging.

Unsurprisingly, the degree of difficulty associated with navigating a particular surface was found to depend on the thickness and type of contamination, the lateral space available (lane width) to manoeuver, as well as the distance to be travelled in the contamination in question. For thin coatings, say 1cm or less, the type of coating and the other factors were less of an issue. As thickness increased, the type of contamination and its physical properties gradually became more relevant on the level of difficulty and the best technique to use.

Broadly speaking, maintaining control when surface contamination was encountered involved reading and reacting to the changing conditions, potentially adjusting speed, generating sufficient torque, smooth and sparing steering / braking inputs as well as maintaining careful awareness of one's balance and weight distribution. Most of these are intuitive, perhaps with the exception of speed. Reducing speed would appear to always be the way to go, and it often was, however, certain slow speed conditions could result in more controllability issues due to a lack of forward momentum and ultimately degenerate into walking scenarios. A clear way to experience the importance of momentum is in thick snow. When starting from a stop, significantly more torque is required and balancing is more difficult until a certain speed is reached. Under all conditions, the key was finding the right combination of the aforementioned factors to suit the given situation. The more consistent and undisturbed the surface, the easier this was. Achieving the right balance established a controlled "snow groove" in which the weight distribution, torque and steering management would result in just the right momentum to effectively slice through a given snow thickness or skim a given surface roughness. Achieving the right balance was also found to reduce the sense of wear and tear on joints, especially knee joints, inherent with riding on rough and slippery surfaces. Biasing weight distribution on the rear wheel, which involved using the pedalling motion to keep one's weight towards the rear while avoiding leaning on the handlebars, turned out to be a useful technique for specific conditions which are discussed later under surface types.

It is worth noting, especially for anyone considering expanding their cycling commuting to the winter period that most winter riding does take place on pavement both wet and dry, no superhuman abilities are required, and the major difference with summer riding in those settings is the need for a heightened level of awareness. For surfaces with wintery contamination, "Practice makes perfect" is a good mantra. Parking lots, driveways, back yards, parks, quiet side streets, and unplowed bike paths can make for convenient areas to see how the bike reacts to various surface conditions. Building experience in the most extreme riding conditions in a benign environment is low stress and can pay dividends. This can also be a lot of fun. Exploring the infrastructure along the route to work on a weekend when traffic is lighter can enable a good assessment of the challenges and travel times. When ready, starting on fairer weather days and leaving plenty early can help ease into winter cycling.

4.6.2 Traction: Although a general concept, this topic is worthy of its own section. Given the simplicity of the bicycle as a single track vehicle, its dynamics can get surprisingly involved. For the purpose of this paper, it is worth understanding that the contact patch of the tire with the surface being ridden on, is where adhesion or traction is produced. The results are often illustrated with the aid of the traction circle (typically more of an ellipse in the real world) representing the traction available on a given surface. As the coefficient of friction between the surface and the tire decreases due to contamination and falling temperatures, the size of the circle or amount of traction available to make the bike do what is desired, including staying upright, is reduced.

The circle's real usefulness lies in helping visualize how a finite amount of traction available needs to be shared between turning, braking and accelerating. From a practical perspective, in winter conditions, this means smooth, gradual and overall sparing demands on traction. Importantly, the impact of lateral i.e. right/left slippage, especially if it involves the front wheel, can be the difference between remaining upright or going down and being swallowed up by a passing vehicle. As such, it was sometimes better to make light to nil use of the brakes in order to preserve the limited traction available for steering and remaining upright through a rough patch. With enough lead time, sequential use was sometimes an option e.g. first using the traction available to slow down in a straight line, then releasing the brake to use the traction to effect a turn or course correction. Ultimately, getting the feel for the available traction on a given surface and how to best use it without exceeding it came with increased practice and exposure, as opposed to an engineering analysis, but an understanding of the fundamentals proved useful.

The three circles at figure 14 provide notional representations of traction available on ice, wet pavement and dry pavement. As an example, the coloured arrows represent traction required for a cyclist, travelling at a certain speed, to slow down while turning to the right along a given trajectory. The green vertical arrow represents the traction required to slow down while the blue horizontal arrow represents the traction required to turn to the right. The amount of traction required to perform the individual parts of the manoeuver is represented by the length of the two arrows and is mainly a function of the bike's momentum and the rate at which the cyclist wants to perform each part. The diagonal red arrow represents the combined amount of traction needed to perform the overall manoeuvre. In this example, it is within the dry pavement circle limits which means that in such conditions, sufficient traction is available. If the cyclist were instead on wet pavement, he could use the available traction to slow down at the desired rate but would need to corner at a slower rate to avoid a slide. On ice, he would need to both slow down and corner at reduced rates to avoid sliding.

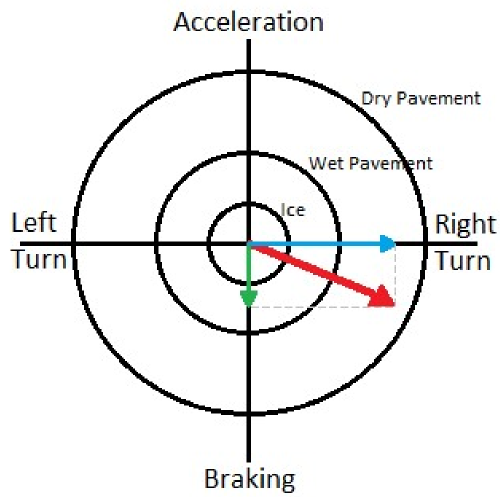

Figure 14: Traction Circle

4.6.3 Optimizing riding track: This is otherwise defined as finding the best place to ride at a given time based on factors such as surface conditions and traffic. Understanding the behaviour of the bike under various conditions helped in making the best track decision. Generally, the worse the surface conditions, the wider the lane width required to safely maintain control at a given speed as the width allows for steering manoeuvres to maintain balance. As such, riding a smooth wide paved shoulder covered with 5 to 10 cm of snow, typical at the start of the season, could feel quite manageable. Later in the season, if poor plowing reduced available width to a narrow strip around the white line, there was little margin left to maintain control such that a relatively small amount of precipitation could make it difficult to navigate.

Along similar lines, even though more separation from passing traffic is generally preferred, there are no absolute rules given the highly varied possible combinations. The right answer was often a balance which aimed for the best level of control available to stay within a comfortable distance from passing traffic and feel stable / safe. At times, this meant riding further to the right with more space from traffic but on worse surface conditions, while at other times it meant being closer to traffic with better surface conditions. This could result in being on the white line or even to the left of it, on the roadway. Under specific circumstances, for example if lateral space was very tight at intersections, moving into the middle of the lane, directly behind the car in front, helped avoid being squeezed against a snowbank by a vehicle trying to pass. Other similar circumstances could make claiming some space on the roadway essential. Regardless, making gradual movements onto the roadway, ideally before getting to an obstacle, avoiding sudden moves, having a predictable track, signaling intentions if appropriate, coupled with visibility, aimed to provide drivers as much information as possible and therefore the best odds of avoiding contact when in close quarters.

Having found the optimal track could be short-lived; maintaining awareness of upcoming conditions, remaining alert to deal with variations, including potential abrupt changes in surface conditions, was front and centre. Transitions to areas with higher contamination and typically lower traction were particularly challenging. For example, intersections with snowy side streets, parking lot entrances and driveways were observed to be locations prone to changing conditions due to motor vehicle traffic turning from those areas onto the roadway and their tires carrying and then leaving tracks of snow. Typically, for a few days after a snowfall, it was necessary to be cognisant that a clear track along the shoulder could be interrupted with 10+cm of mashed snow extending at least half of the width of an intersecting road and which could only be avoided by diverting onto the roadway, sometimes as far as the middle of the travel lane. During a typical rush hour commute, traffic often was not conducive to this type of manoeuver. This is where the side mirror was particularly useful in providing traffic related situational awareness, facilitating a quick assessment and decision on whether to try to outflank such an obstacle by going left into the roadway. Other factors such as the type and volume of surface contamination would dictate whether to adjust speed, to plow straight through or enter it further to the right, anticipating that the impact on controllability would require more separation from passing motor vehicle traffic.

Driveways specifically could also have ridges or snowbanks on either side resulting from the owner's plowing operations. These could extend as a barrier all the way across the shoulder and to the edge of the roadway, sometimes even merging at a right angle with similar ridges formed by the street plow. Certain areas were particularly prone to this such that increased vigilance became the norm when precipitation had fallen since the last commute.

At times, it was tempting to take advantage of a temporary traffic lull to move onto the roadway and enjoy the typically better surface conditions. The decision often rested on the anticipated duration of the lull and the challenge to laterally cross any contamination separating the current track from the roadway. The presence of a snow ridge, regardless of size, a line of frozen slush "rocks" or other vehicle road splash often made it unfavourable to break an established "snow groove" in a quest for temporary cleaner pavement. However, other situations were deemed worthwhile, for example during a long gap in traffic, or when making the move was easy. Once on the roadway, it became important not to get over zealous with the speed or lose track of the potentially changing shoulder conditions to avoid being shut out and left without an ability to duck back out of the way in a controlled manner when traffic resumed.

<u>4.6.4 Cornering</u>: This is another area worthy of more in depth review. Changes in direction such as turning, but also virtually any type of movement intended to change one's track, results in lateral forces. As already alluded to, traction or adhesion available is part of what helps keep a bicycle upright. Simply encountering surface roughness or surface contamination related obstacles imparts lateral forces which can jostle the bike laterally such that a slippery surface could result in a loss of control.

In general, a dramatic reduction in speed and maintaining the bike as upright as possible while carefully managing demands on traction proved to be effective on a wide range of surfaces. That said, this was not always optimal based on traffic conditions, for example, when this required a rapid reduction in speed and/or when a finite amount of time was available to clear an area, such as for a left turn across the road in the presence of traffic. In addition, as mentioned earlier, in heavy snow contamination, going too slow could result in getting bogged down, making it very difficult to get going again. In those situations, an optional technique that enabled higher speed cornering included extending the inner leg out "motocross style". The set up involved being off the seat, standing with one foot on the outer pedal, and letting the inner foot touch the ground upon entering the turn. With the inner foot effectively sliding on the ground, bending the inner knee in the direction of the turn and letting the bike gradually lean into the turn, the back end could then be coaxed to slide outwards (momentarily applying some rear brake did help initiate this if needed). The resultant rear wheel skid would cause the bike to swivel into the direction of the turn. As the bike pivoted to line up with the desired track, the inner leg could be gradually straightened until the bike returned to a fully upright position, stopped skidding and could resume rolling forward, enabling one to start pedalling again. The description likely makes the manoeuvre sound more complicated than it actually is; practice is the best way to learn how to make this work most efficiently. A few things to note; sufficient speed and a relatively slippery surface was required to make this work well. As such, this technique was particularly useful when coming down a hill and needing to turn on a snowy surface as part of proper coordination with surrounding traffic or when momentum was required to overcome thick surface contamination during or right after a turn. Although skidding the rear wheel is not essential, it does make for a more efficient turn, especially for 90 degrees or more and it does provide more points for artistic impression.

As a general technique, extending a leg out while keeping the foot simply hovering above the ground, ready to intervene to keep the bike upright could be used in any type of turn, even to simply change track when transitioning to an area of higher contamination where lower traction was anticipated.

4.6.5 Obstacles: As is the case for motorcycling, the rule of thumb was to avoid challenging an obstacle greater in height than the front axle. It was often effective to directly take on the smaller obstacles given challenges with evasive manoeuvers in slippery conditions. In general, facing obstacles squarely and getting weight off the front wheel when possible, helped maintain control. Under less ideal situations, if fully lining up at 90 degrees was not possible, as in a situation requiring a lateral move onto a curb, then hopping the front wheel over the obstacle was best. If a clean hop was not possible, at least getting the front wheel lined up as squarely as possible helped minimize the resultant lateral forces it would experience. It was always easier to manage some rear wheel skid induced fishtailing than a typically uncontrollable front wheel skid. In many situations when there was sufficient time to prepare taking on obstacles, rising off the seat and balancing oneself on the pedals created a stable base. This was particularly effective at absorbing the jarring of rough terrain type obstacles such as extended frozen ruts, and frozen / ice packed snow ridges, etc…

4.6.6 Surface types: Over and above the lessons already mentioned, comments focused on techniques used for specific surface contamination types are listed below. The surface types described are not exhaustive or official categories but represent a good cross-section of surface contamination experienced.

4.6.6.1 Wet snow: This represents a broad category of snow typical of milder freezing temperatures. Comparatively heavy, with a high moisture content, texture could vary from snowman construction grade all the way to watery brown slush. At one end of the spectrum, undisturbed snowman grade snow could respond well to tire tread imprint, resulting in good grip. When not over 10 cm in thickness, it generally provided a good riding surface, albeit resulting in additional effort.

When the surface was disturbed, such as by traffic, conditions deteriorated. The resultant soft ruts coupled with the contaminants mentioned earlier, would eventually produce a soft brown slippery texture. During this phase, the snow could stick to the tires, further increasing slipperiness. The buildup could remain stuck for some time, in particular to the tire edges. Under those conditions, even after having moved on to a dry surface, a turn could result in the contact patch moving from the clean rubber at the centre of the tire over to the still slushy/snowy edges suddenly reducing grip and causing a skid.

Over time, as traffic and salt further transformed the surface, the slush increasingly softened, traction would gradually improve and eventually under warmer temperatures, the slush became watery, easily parted and shed by the tires, resulting in good traction, especially when the tires were able to cut down to smooth pavement.

It is worth noting that potholes and cracks can be well hidden by watery slush and/or standing water, with the latter providing no damping of their impact. Selectively biasing weight distribution on the rear wheel helped throughout the range of wet snow types although became less important at the later wet slush stages.

4.6.6.2 Hard compacted snow: The roughness of the surface made the difference between a headache inducing ride and something akin to riding on a dirt path or even pavement. This type of surface would mostly offer low rolling resistance and typically meant a less messy commute. A balanced weight distribution on front and rear wheel was effective over smooth hard and icy sections while biasing weight on the rear helped over rougher portions.

4.6.6.3 Loose powder: This could be handled surprisingly well up to the height of the wheel axles, depending on surface quality underneath. Increasing thickness and density required added torque and speed was naturally reduced. A rearward weight bias helped traction and holding the front wheel straight minimized drag and helped avoid abrupt, snow induced steering inputs. This, coupled with adding torque to maintain momentum, helped power through thick sections, thereby avoiding getting bogged down.

4.6.6.4 Heavy "sand like" snow: The analogy with sand is used to refer to a category of snow which likely started its life as loose powder but was then manipulated in some way resulting in increased density. Such manipulation could be from the wind as in the case of some drifts of blowing snow or mechanical snow blowing as part of snow clearing operations. The resultant surface was similar to sand dunes but with less buoyancy and traction i.e. a heavy texture without enabling the tire the ability to imprint, both aspects made this slippery and very hard to push through. When able to build sufficient speed, it was possible to traverse isolated mounds. A rearward weight bias, patience, being ready to handle snow induced steering inputs and plenty of pedal effort became the order of the day.

4.6.6.5 Ice, including from freezing rain: Smoothness and side to side surface inclination were two key factors found to affect stability. Glare ice on a flat surface was easiest, going uphill was mostly OK while going downhill or encountering a lateral slope i.e. from the shoulder of the road angling down towards the ditch proved more challenging. Overall, an even weight distribution and focus on balance seemed to work best. This was definitely a situation to focus on smooth steering and braking inputs with particular attention on not locking up the front wheel. The summer mountain bike type tires proved adequate for most situations but this is undoubtedly where having a studded tire, at least on the front wheel, would be a good asset.

4.6.6.6 Frozen mounds and ruts: This hard, uneven and jarring surface was typically a result of compaction, hardening or freezing of disturbed snow. The cause could vary from footsteps, tire marks, or snow plows pushing or blowing snow, exacerbated by a freeze-thaw cycle. The result varied from assorted ruts, ridges a few inches high, all the way to snowbanks several feet in height. Whether made of hardened snow or ice, this was one of the most unpleasant surfaces to ride on. A heavy rearward weight bias, i.e. getting most of the weight off the front wheel and allowing it some ability to skim the surface while giving it some latitude to be jostled about by the roughness (i.e. resisting the urge to fight with the steering) helped avoid having the front wheel dig in and the potential for sharp, surface induced steering inputs. As mentioned in the general comments, a rougher surface typically would require a wider lane area at a given speed to safely maintain control and balance, so expecting to be bounced around and awareness of space available was helpful in determining the most effective and safe speed. At the extreme, this type of surface effectively becomes a snowbank, and the rough surface and density from the freeze-thaw cycle results in a mostly impassible surface (figures 5, 8 & 10).

4.7 Overall comments and way forward

4.7.1 General: Notwithstanding snow clearance frustrations, winter cycling had an overall positive impact on this rider's appreciation of the season. Learning new skills to overcome challenges added to the sense of accomplishment and the periodic shots of adrenaline could be an energizing way to start the day. Anecdotally, spending more time outside exercising appeared to contribute to good health as no commutes were missed due to illness during the reported timeframe. Some portions of the route, namely the Portage Bridge, provided for spectacular winter views of the river and the city, especially on crisp sunny mornings. As a bonus, thanks to its affordability and the commuting expenses related savings i.e. transit pass costs, cycling actually paid dividends. For a sport to financially pay off, without a need to take part in competition or even to be particularly skilled is an exceptional benefit.

4.7.2 Importance of closing the winter gap: Given the potential benefits associated with expanded use, and the city's 24 Apr 2019 climate emergency declaration, it would stand to reason that cycling be prioritized as one of the most important aspects of the city transportation system. The current 40% time period of wintery weather when cycling and related infrastructure is underutilized due to limited winter maintenance, is an untapped source, readily available for a fraction of the cost of other transportation solutions. In some cases, addressing the gap is as simple as adjusting existing maintenance practices taking place for the adjacent roadway to ensure a portion of the shoulder is cleared concurrently on a more consistent basis. In other cases, simple area specific plowing is required.

Addressing this gap would do more than simply provide current cyclists with safe year round access, it would place cycling on a more equal footing with other commuting options, all of which already benefit from winter maintenance. This could facilitate a wider acceptance of cycling as a primary commuting option. This is particularly important as a search for transportation solutions increases in light of climate concerns and traffic congestion issues. Cycling stands to obtain a greater share of the resultant investment pie if it is considered as a serious alternative that commuters, city wide, can access year round.

At best, a failure to address this gap could result in missing out on opportunity funding. At worse, cycling could be viewed as a discretionary recreational expense as opposed to a serious part of the transportation solution and left vulnerable to cuts, in the case of an unexpected constraint to city finances or a less cycling friendly city administration.

As such, cementing cycling as a primary commuting option, available year round, when coupled with the multiple advantages mentioned earlier, has the potential to result in a greater share of future transportation dollars as well as increasing its resiliency in the face of competition for funding.

4.7.3 Way forward: The convergence of a series of factors is such that the future of utilitarian cycling has seldom looked brighter. Accordingly, certain things are improving. Due credit to the National Capital Commission and the City or Ottawa for visible progress between the winters of 2018/19 and 2019/20. Specifically, the plowing of the Portage Bridge elevated bicycle lanes and partial clearance of two elevated Multi Use / shared pathways, on Prince of Wales Dr are welcomed steps.

The fact that a winter cycling newbie was able to handle a 28 km round trip commute, mainly along a high traffic route without the benefit of cycling winter maintenance, on a budget bicycle, is a good indicator that addressing the remaining obstacles could see winter cycling poised for significant growth over a large area of the city. The following are some thoughts to help capitalize on current circumstances and move the yard sticks forward.

4.7.3.1 An "All Season" approach: Achieving an equal footing with other transportation options should not be viewed as requesting special treatment or making unreasonable demands. At the core, this means ensuring that winter use is part of the base line approach to cycling and not a distinct or secondary element. Recent infrastructure appears not to reflect this approach. Figures 8 and 10 show new cycling infrastructure (opened in 2018). In both cases, traditional paved shoulders of the type shown at figures 6, 7 & 9, which provided some usability to winter cyclists, were removed and replaced with elevated bike lanes or shared pathways which were then used for snow storage. The situation diverted many winter cyclists onto the roadway where they must share a lane with motor vehicles, including trucks and city buses. At times, the snowbank built up on the elevated bike lane even spilled over the curb and onto the roadway, further reducing the width and creating a hazard particularly difficult to see at night (see “snowbank spillage” shown at figure 8). Under these conditions, Ontario’s 2015 rule requiring drivers who want to pass cyclists to leave a 1 metre cushion between them and the cyclist, when respected, could result in frustrating traffic delays which are not conducive to improving driver/cyclist relations.

Overall reductions in safety and usability undoubtedly run counter to the city’s intent and desired message but the situation could be interpreted as a two tier cycling transportation network. While those in the city core benefit from increased services, access by those on the outskirts is concurrently reduced. Under such conditions, drivers would not be faulted for concluding that cycling, in some areas, at certain times of the year, is not sanctioned by the city, therefore those taking part have no business on the road. This can reduce willingness to share the road and combined with the tension typical of rush hour traffic, can degrade safety. Also, other than for those who want their commute to consist of an extreme sport, increasing the level of difficulty to cyclists is unlikely to have a positive impact on an emerging winter cycling demand. The danger of a “less demand therefore less priority to improve access” spiral increases the importance of pioneering efforts to show a presence in spite of existing challenges, while advocating to address the obstacles.

In order to promote an outcome with year round viability, all cycling matters should benefit from a year round perspective at the outset. In particular, the development and review of planned infrastructure projects should ensure designs do not cause unintentional negative consequences to existing all season use and should anticipate increased winter use. The following are specific recommendations for the process:

- Design development should start with an assessment of the current winter cycling usability of the area, including input from current winter users to determine what aspects work and which ones need improvement. Adding consultations with fair weather cyclists would help understand the existing obstacles linked to their reluctance to cycle in winter;
- Designs need to improve the current situation. Reductions in winter cycling safety and usability of the area, including plans to use the new infrastructure for snow storage must be rejected;
- City road maintenance / snow clearing operations staff must be part of the design review process and their input should be sought in particular to optimise the design for winter maintenance effectiveness. Specifically, where possible, the design should leverage or complement existing winter road and/or sidewalk maintenance, carefully consider potential conflicts and avoid the need to generate inefficient, time consuming and maintenance intensive requirements.

4.7.3.2 Winter cycling network expansion: Advocating for outward expansion of the winter network, starting by targeting the winter obstacles on the existing major cycling corridors that connect large outlying areas to the city core, can provide a significant number of commuters with easier access to the downtown winter network. In the same way as adding more roads or lanes to existing roads encourages more people to drive, if cyclists know that main arteries are opened up enabling them to make it all the way downtown, without the need to top up their life insurance, usage of the entire network will naturally grow. Opening of other routes can follow to fully capitalize on the demand.

Simply opening up the existing network is a very modest but necessary first step. This is a long way from other winter cycling capitals such as Stockholm Sweden where they not only offer a broad year round cycling network, they also prioritize its plowing over the roads, recognizing the greater impact of snow on cycling. This has resulted in more cycling commuting and is one part of the effort required to balance out transportation options and put a dent in traffic congestion.

4.7.3.3 Winter cycling commuting awareness and promotion: The prevailing perception of winter cycling commuting amongst the general public and even many summer cyclists was observed by the author to still be a fringe activity, sometimes characterized as "crazy". None of the people (including cyclists) spoken with outside the advocacy community appeared to be aware of the city's website on winter cycling or efforts at supporting the practice. Although the advent of fat bikes may be softening current perceptions, much more remains to be done to move winter cycling into the mainstream. The situation provides an opportunity to achieve gains simply through increased awareness. Along with a better understanding of commuting options available, this could lead to improved driver attitudes towards cyclists out in winter conditions. Ultimately, looking for opportunities to raise awareness and specifically promote the practice, both to the cycling community and the wider commuting public can pay dividends.

4.7.3.4 Coexistence: According to open source data from 2019, the average car on the road in Canada is almost 10 years old. Given this, one simply needs to look at the rows and rows of new cars at the still expanding network of car dealerships in the city to realize that the automobile is not going away anytime soon. Although disruptive changes are predicted for this industry, it is safe to say that the need to share transportation infrastructure space and funding will remain a fact for the foreseeable future. Although the playing field remains far from equal, and efforts to right this situation must continue, it is useful to understand that certain types of gains for cycling can easily be perceived as frustrating losses by motorists. Needlessly compounding the sentiment with negative interactions on the road is unlikely to ease acceptance and help facilitate transition. The mere presence of cyclists on the road, especially in winter can be the source of resentment to some. Whether based on ignorance, preconceived notions or simply stress, doing one's part as a cyclist to project a positive image and avoiding perpetuating negative stereotypes can contribute to preventing resentment from turning to animosity. From peaceful coexistence to the ultimate goal of conversion as opposed to alienation, all cyclists can play a role as ambassadors both on and off the road. Remembering that many of us are or were also motorists, the ideal outcome of advocacy efforts is one that leaves all transportation users seeing the benefits of increased cycling. The agreement and cooperation of the majority of road users is an element that can greatly facilitate achievement of more balanced transportation options.

5.0 CONCLUSION

The potential for winter like conditions in Ottawa is a reality for a significant portion of the year. Winter cycling represents an aspect with tremendous potential. The primary obstacle to achieving accessibility and viability at least on par with summer cycling is improved winter maintenance of the infrastructure. In many cases, the efforts to make large gains are minimal and the costs low compared with other transportation solutions. Either way, this effort has the potential for an increased return on the existing infrastructure investment. Addressing the access issue would help place cycling on par with other modes of transportation as a year round option. In turn, cycling would be better able to capitalize on the growing momentum for transportation alternatives. Based on the usage of the winter maintained portion of the infrastructure, it is evident that if you plow it, they will come! Until then, pioneering efforts to be out, "showing the flag", nurturing a demand and advocating for improvements must continue, while being mindful to do so in a manner which projects a positive image of cycling.