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MICROMOBILITY IN MISSISSAUGA

Suitability analysis for a shared micromobility scheme

24/08/2023

TABLE OF CONTENTS

Tables

Figures

Appendices

1. INTRODUCTION

1.1 Context of micromobility in Mississauga

1.1.1 The City of Mississauga is planning to expand low-carbon transportation options by offering a shared micromobility scheme led by one or several private operators.

1.1.2 Micromobility encompasses small vehicles such as bikes, e-bikes and e-scooters. They have been increasingly popular for rent under shared schemes for short point-to-point trips[1].

1.1.3 Shared micromobility can serve a wide range of purposes: people use them to reach their place of work or education, to access shops and services, to visit friends or family, and for recreational purposes. Many people use micromobility to access transit stations, as a 30-minute walking trip can generally be done on an e-scooter or e-bike in under 10 minutes.

1.1.4 Cities across the globe are experiencing a paradigm shift in transportation patterns, driven by a growing emphasis on sustainable, accessible, and efficient mobility solutions.

1.1.5 The City of Mississauga plans to join other Canadian cities in enhancing its urban mobility infrastructure while fostering environmental sustainability with a shared micromobility system. A shared micromobility system could help residents connect to the Hurontario Light Rail Transit, the Mississauga Transitway, and reach destinations like Port Credit, Streetsville and the City's center[2].

1.2 Context of the study

1.2.1 Within the context set out above, the City of Mississauga commissioned Momentum to assess the suitability and profitability of a micromobility scheme scheme.

1.2.2 This report details the construction and findings of an ArcGIS suitability model aimed at identifying the optimal areas to implement a shared micromobility system within the city, and the locations of parking bays. The model used spatial analysis and data on Mississauga's population, employment, transit system and cycle infrastructure to assess the suitability for the micromobility scheme.

[1] National Association of City Transportation Officials, Guidelines for Regulating Shared Micromobility, 2019, consulted on 08/08/2023
NACTO_Shared_Micromobility_Guidelines_Web.pdf
[2] City of Mississauga, Introduction to Shared Micro-mobility Systems, consulted on 08/03/2023
Introduction to Shared MicroMobility Systems – City of Mississauga

1.3 Objectives of the study

1.3.1 This report aims to:

- Provide an in-depth understanding of the methodology used to develop the suitability model and profitability analysis
- Present areas with likely higher demand for micromobility
- Identify the density and location of micromobility parking bays
- Recommend the fleet size and service area that would make the scheme successful in terms of usage and attract private micromobility operators.

1.4 Contents

1.4.1 This section forms the introduction of the report. The next sections include:

- Chapter 2: Methodology
- Chapter 3: Site suitability analysis
- Chapter 4: Revenue and cost considerations
- Chapter 5: Parking locations
- Chapter 6: Summary
- Chapter 7: About the authors
- Appendices

2. METHODOLOGY

2.1 Overview of the methodology

2.1.1 Optimal locations for deploying a shared micromobility scheme within the city were identified thanks to geospatial data on the City's population, employment and infrastructure.

2.1.2 Current suitability for micromobility was estimated based on the most recent available data. The projection for 2031 considers forecast changes in population, employment, and new public transit.

2.1.3 The final output of the ArcGIS model is a suitability map that highlights the potential for deploying the shared micromobility system. The suitability model helped identify potential areas of service, and the number of trips required to make the system economically viable.

2.1.4 Profitability analysis then set out future revenue and costs.

2.1.5 A parking identification model was used to identify parking locations that would maximize user convenience.

2.1 Presentation of the inputs

2.1.1 The model uses the most recent data available provided by the City of Mississauga, at the smallest available geographical unit, to maximize the accuracy of estimates.

2.1.2 Research on the main factors influencing demand for micromobility services was conducted to guide input selection. The research for this section is provided in Appendix A: Literature review, providing rationale for the inputs presented below.

INPUTS CONSIDERED

Population density

2.1.3 Areas with higher residential population density generate more trips and are usually hotspots for a demand in micromobility services[3].

2.1.4 Census 2021 data was used for this input.

Distance from the cycling network, and quality of active travel infrastructure

2.1.5 The closer people are to safe cycling infrastructure, and the more likely they are to choose a micromobility mode for their journey[4]. How far people are willing to cycle to reach the cycling network depends on several factors: how comfortable they are riding a micromobility vehicle, their riding speed, the density, quality and the extent of the network they are accessing, whether they need to make a detour to access it, and the safety of roads and intersections to access the network.

[3] (Hosseinzadeh, Algomaiah, Kluger, & Li, 2021)
[4] (Zou, Younes, Erdogan, & Wu, 2020) (Sorkrou, et al., 2022)

2.1.6 In this model, the catchment of the cycle network was set at 900m. That is because Mississauga's network consists of off-road trails and protected lanes which people are likely to want to access from further away. Electric assistance is also likely to help make longer distances more acceptable. Beyond 900m, cyclists would typically go over several unprotected intersections and heavily trafficked roads, where they would typically feel more vulnerable to road traffic, so it was considered that beyond a 900m distance the impact of the network would fade.

2.1.7 Within the cycling network data, off-road or segregated cycle lanes were given a 6:1 weight – to reflect the fact they generate more micromobility demand than cycle routes which share road space with vehicular traffic. This is based on evidence that people riding micromobility vehicles have a marked preference for segregated cycle lanes.

2.1.8 Distances to the cycle network were calculated from the Open Data available in the Cycle Plan 2018[5].

Employment density

2.1.9 A higher density of jobs creates demand for micromobility modes, from people commuting, and workers making other trips, such as travelling to meetings or accessing services near their place of work[6].

2.1.10 Employment density was calculated through a cluster analysis, which identifies the average number of jobs within a set area. 900m was chosen as a set area based on willingness to walk to access transportation. Willingness to walk to a shared dockless micromobility vehicle depends on the city (people are willing to walk more in larger cities), the person, the journey people are looking to make, whether other modes are available, and the scheme – for example people will be willing to walk further if they can reserve a micromobility vehicle, and if the fees to reserve it are deemed reasonable. We considered that few people would walk over 900m to access an e-bike or an e-scooter and would be much more likely to make that journey by another mode of transportation.

2.1.11 The employment data provides information on the usual place of work but does not capture the demand arising from people working remotely. It is likely that the demand for micromobility in residential areas is higher than forecast as a result of remote working.

2.1.12 The employment data was provided by the City of Mississauga. Areas with a higher average number of employees within them have a higher score.

Student population

2.1.13 Micromobility vehicles are particularly popular among students, as they are less likely to own a car, and they make a higher number of daily trips[7].

2.1.14 Students are often underrepresented in public data since they change their home address frequently.

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[5] City of Mississauga, open data catalogue, consulted on 07/27/2023, Cycling Master Plan – City of Mississauga

[6] See (Raky & Monzon, 2022)

[7] See (Raky & Monzon, 2022) and (Smart & Noland, 2020)

2.1.15 The student data is sourced from the Transportation Tomorrow Survey ('TTS') 2016, downloaded from Data Management Group Website[8].

2.1.16 Students 18 years old and above were included in the model. The student data only includes students who live in Mississauga.

Public Transportation Accessibility Level

2.1.17 Micromobility is a popular mode of transportation to reach public transit, so transit stops generate demand to pick-up and drop-off micromobility vehicles[9].

2.1.18 The Public Transport Accessibility Level is a measure of transit connectivity used in the UK, and increasingly internationally, based on the distance to public transit and the frequency of services available at the nearest stop.

2.1.19 The variable was constructed considering the existing transit network in the city, to assess the distance from each point in the city to transit stations, and the frequency of services at that station.

2.1.20 High scoring areas are within walking distance of a transit stop with fast and frequent transit services.

2.1.21 The calculation assumes that people will walk up to 640m (approximately eight minutes) to a bus service and up to 960m (12 minutes) to a rail service. Services available at a longer distance do not affect the Public Transportation Accessibility Level of a selected location. If there is no public transit available within these distances, the location is rated as "0".

2.1.22 Scoring was adapted to suit the context of public transit in Mississauga.

Car-free households

2.1.23 Shared micromobility can be popular among both car-owning and car-free households, but people who do not have access to a car at home are particularly more likely to use shared micromobility systems, as it provides them with a door-to-door mobility solution. According to micromobility operator Lime, US Lime users are 40% more likely to live in zero-car households than their neighbors[10].

2.1.24 Data on car ownership was sourced from TTS 2016[11].

OTHER INPUTS CONSIDERED

2.1.25 The following inputs have been considered for inclusion but have not been considered necessary – either because they overlap with another input, or because they do not work well with a rating scale.

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[8] Data Management Group, Transportation Tomorrow Survey, consulted on 07/27/2023, Transportation Tomorrow Survey (utoronto.ca)
[9] See (Hosseinzadeh, Algomaiah, Kluger, & Li, 2021)
[10] Lime, Latest Data Show Lime Attracts New Riders To Active Transportation, Reduces Car Use And More, consulted on 08/10/2023, Latest Data Show Lime Attracts New Riders To Active Transportation, Reduces Car Use And More.
[11] Data Management Group, Transportation Tomorrow Survey, consulted on 07/27/2023, Transportation Tomorrow Survey (utoronto.ca)

Topography

2.1.26 Hilly terrain is much less of a consideration in the demand for e-bikes and e-scooters than their pedal-powered equivalents – and since the City of Mississauga features generally flat or gentle inclines, topography was not deemed useful to determine site suitability.

Household income

2.1.27 Household income data was not included in the site suitability model, for two reasons:

- Using higher income as an input could be misleading: for example, students would have a lower average income but could benefit from parental support for their transportation costs.
- It might also create a deployment bias reinforcing inequalities: the service area would be more likely to exclude people on lower incomes, who are also less likely to have access to a car.

2.1.28 Income data was still considered in the service area recommendation. This was to help ensure that a micromobility scheme would not disadvantage neighborhoods where lower-income households are more likely to reside in.

2.1.29 Income data was sourced from the City of Mississauga's Census 2016 Neighborhood Comparison Dashboard[12].

Propensity to cycle

2.1.30 Propensity to cycle is a composite indicator that was estimated based on 13 criteria that lead to a higher number of cycle trips. These are:

- Residential population density, by traffic zone
- Density of people aged 20-35, by traffic zone
- Proportion of zero car households
- Number of school trips over the age of 16 per traffic zone
- Number of walking and biking trips
- Number of transit trips made from or to the area
- Number of part-time and full-time workers
- Number of trips under 5km
- Meters of bike infrastructure within 1km
- Distance to MiWay Transitway and future Hurontario LRT (within 2km)
- Community centers within a 2km radius
- Post secondary institutions within a 2km radius
- GO stations within a 2km radius

2.1.31 Some of the variables used to calculate the propensity to cycle overlap with other inputs in the suitability model – such as Public Transportation Accessibility Level and the proportion of car-free households.

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[12] City of Mississauga, Neighborhood Comparison Dashboard. Income, consulted on 08/24/2023. https://mississauga.maps.arcgis.com/apps/MapSeries/index.html?appid=bff08f8c66d54463a3679aba79927579

2.1.32 The propensity to cycle is also a composite indicator, which offers a useful summary of inputs but dilutes each variable.

2.1.33 The propensity to cycle tool was used to compare and contrast findings with the suitability analysis undertaken.

Trips under 5km

2.1.34 The number of short trips is an excellent indicator of demand for micromobility, as these are more likely to be made on an e-bike or e-scooter.

2.1.35 The number of short trips is highly correlated with other variables above (such as the density of population and employment) and was therefore not included in the demand model.

2.1.36 That said, short trips offer a wealth of information on how residents currently travel. Short trips were mapped to help ensure that the recommended service area would accommodate the short journeys that people are currently making. Short trips are mapped in Figure 7.

2.1.37 The TTS 2016 was used to find out the origins and destinations of trips under 5km are currently made within Mississauga[13].

Walking and cycling mode share

2.1.38 The proportion of walking and cycling trips is a good prediction of trips that could be done with a micromobility mode, but this data was not included in the model as it overlapped with the public transportation accessibility, the population density, the student and the car-free populations.

2.1.39 Moreover, it was felt that this input would not reflect where short car trips were made, which could also be replaced by micromobility.

Age profile

2.1.40 Users of shared micromobility vehicles are more likely to be younger[14], but this was not included in the suitability model since it is highly correlated with the student population.

SUMMARY OF INPUTS

2.1.41 The table below shows the datasets which are included in the suitability model.

2.1.42 A correlation matrix was produced for selected inputs to ensure that inputs are as independent from each other as possible. This minimizes the risk of unintended compounding effects and improves the reliability and accuracy of findings, allowing for more robust conclusions and recommendations.

2.1.43 The Correlation matrix tables are provided in Appendix B: Correlation matrix.

2.1.44 Each input in the table below has been given an equal weight in the suitability analysis.

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[13] Data Management Group, Transportation Tomorrow Survey, consulted on 07/27/2023, Transportation Tomorrow Survey (utoronto.ca)
[14] See (North American Bike Share Association, 2019).

Table 2.1: Data inputs into the site suitability model

Dataset	Unit	Source	Year
Population density	Number of persons per km2 in each Census Tract	Census	2021 and 2031
Student population	Student population per Traffic Zone	Transportation Tomorrow Survey ('TTS')	2016
Employment density	Average number of jobs within a 900m area	Mississauga Business Survey	2021 and 2031
Public Transportation Accessibility Level	Score (based on walking distance to transit)	GTFS	2022 and 2031
Distance from cycle network	Distance from cycling infrastructure (off-road, segregated or shared)	Cycle Plan	2018 and 2031
Car-free households	Proportion of households that do not have access to a car	Transportation Tomorrow Survey ('TTS')	2016

2.2 Weighting

2.2.1 Each input in the table above has been given an equal weight in the suitability analysis.

2.2.2 Within the cycling network data, off-road or segregated cycle lanes were given a 6:1 weight – to reflect the fact they generate more micromobility demand than cycle routes which share road space with vehicular traffic. This is based on evidence that people riding micromobility vehicles have a marked preference for segregated cycle lanes.

2.3 Scoring

2.3.1 The data for each input is classed bands, with high scores indicating high suitability. High scoring areas are more suitable zones for the implementation of a micromobility system, lower scoring areas represent less suitable zones.

2.3.2 The suitability of an area is defined by the sum of the scores of the model inputs. For example, based on the model, a denser zone, with a reduced distance to the cycle network, with a significant proportion of employment and student population will be a highly suitable zone for the scheme.

2.3.3 Bands are defined by natural breaks, whereby similar values are grouped together to highlight significant differences between the areas. For TTS data, scores are applied at the scale of the TTS zones (also called Traffic Zones).

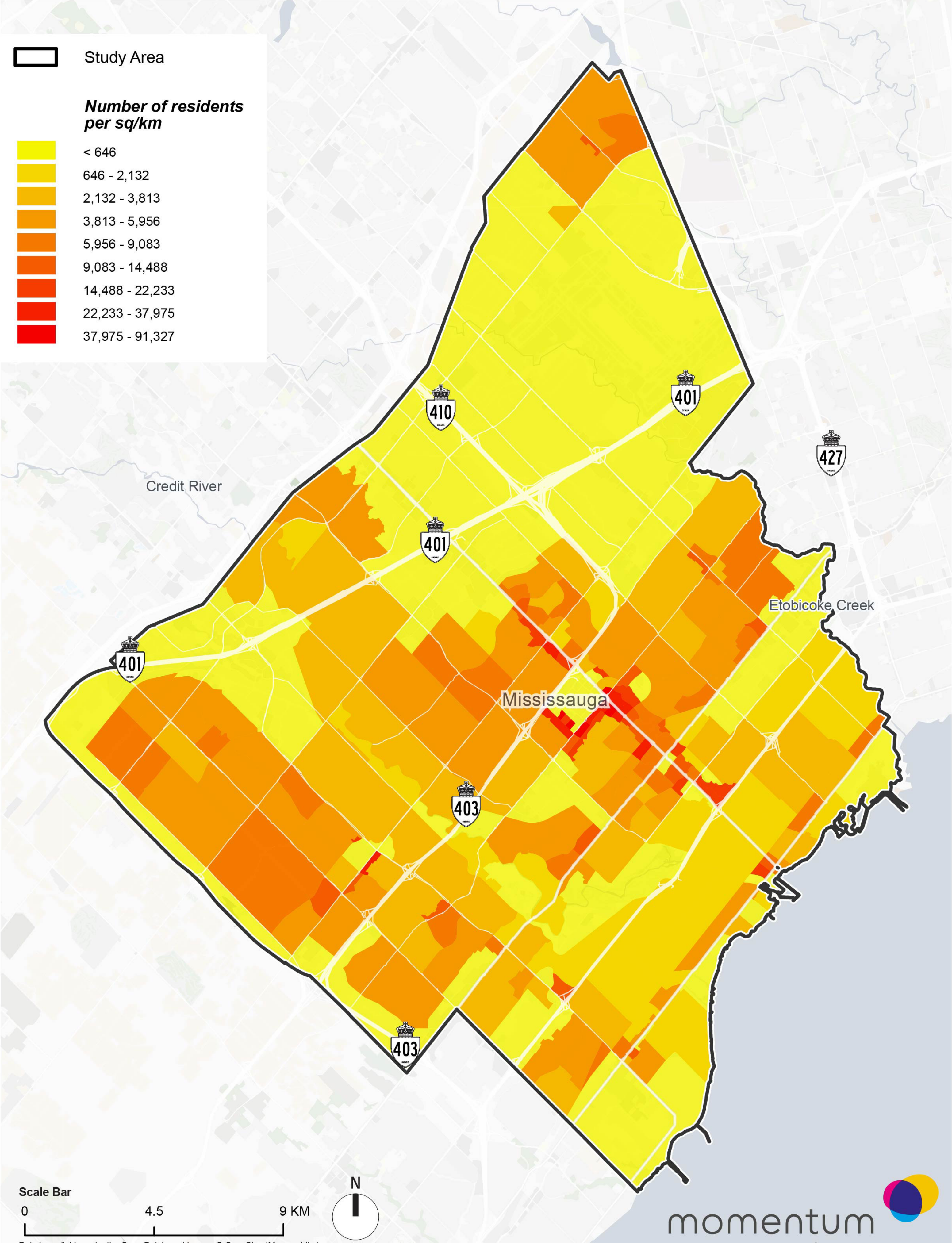
2.3.4 Thresholds for the current and the future models were kept the same to enable comparison.

SITE SUITABILITY INPUTS

2.3.5 This section presents maps of each input into the suitability model, and the scoring for each input.

MISSISSAUGA MICROMOBILITY PILOT

FIGURE 1 : RESIDENT POPULATION DENSITY



Data is available under the Open Database Licence, © OpenStreetMap contributors

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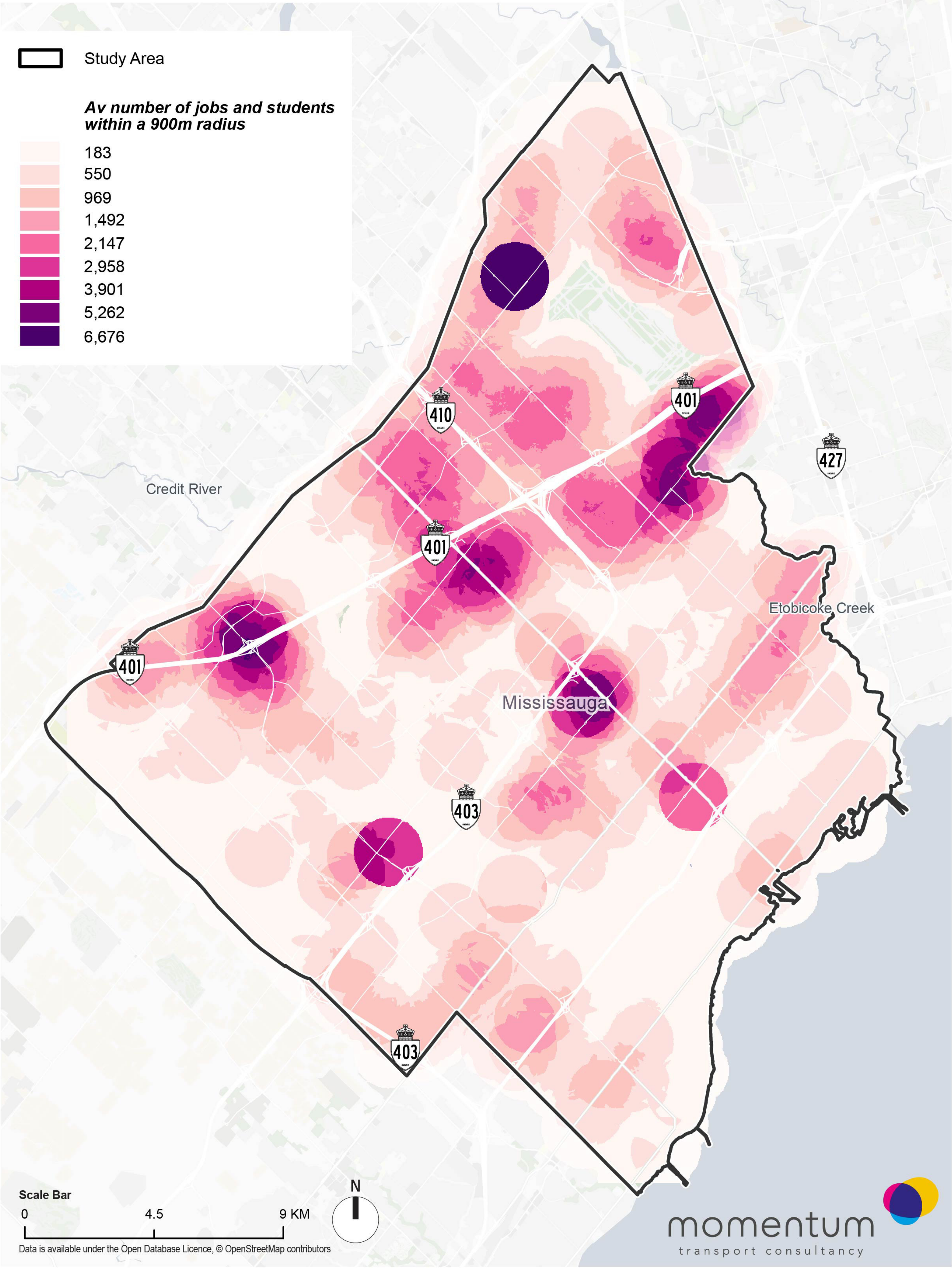
MISSISSAUGA MICROMOBILITY PILOT

FIGURE 2 : EMPLOYMENT DENSITY



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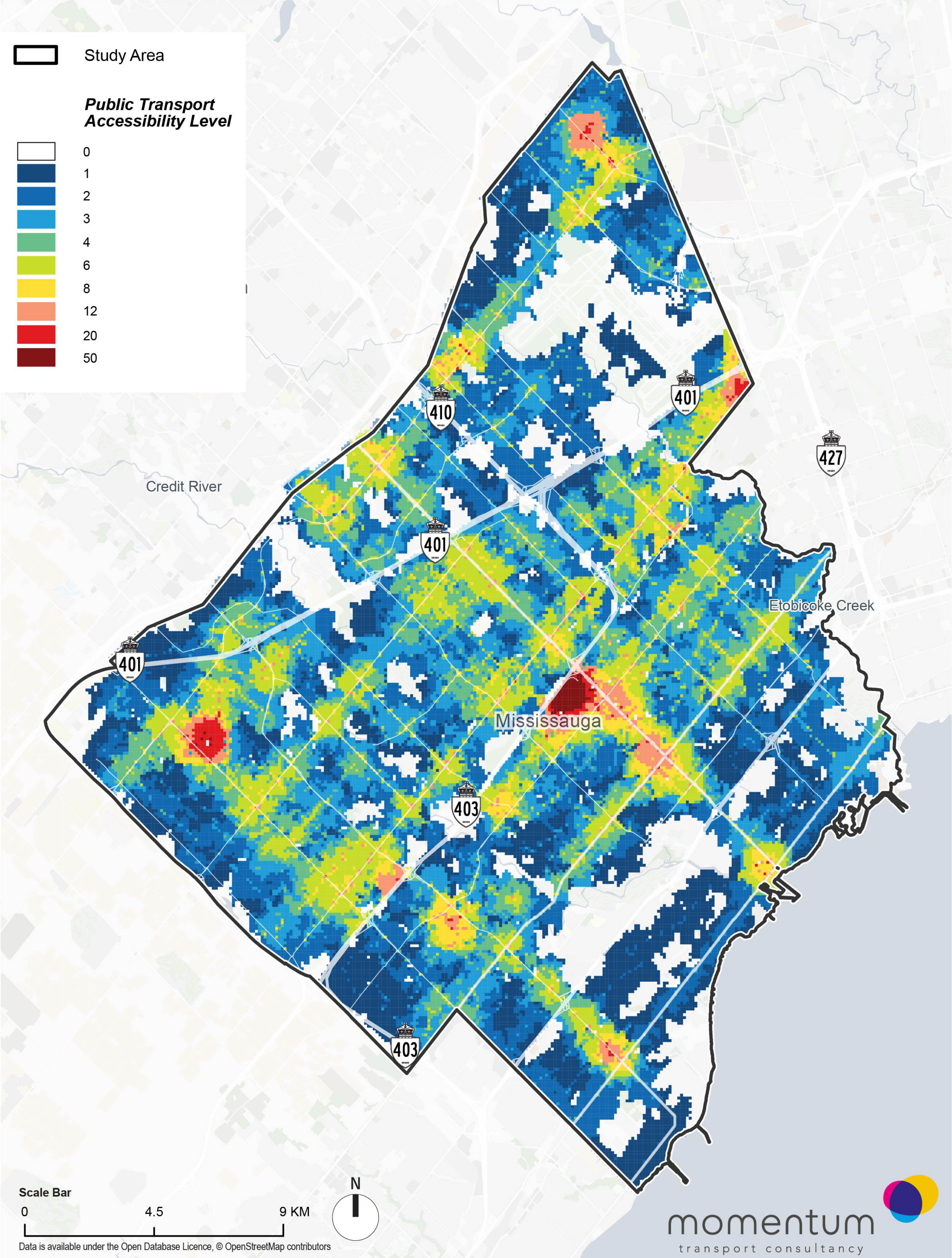
MISSISSAUGA MICROMOBILITY PILOT

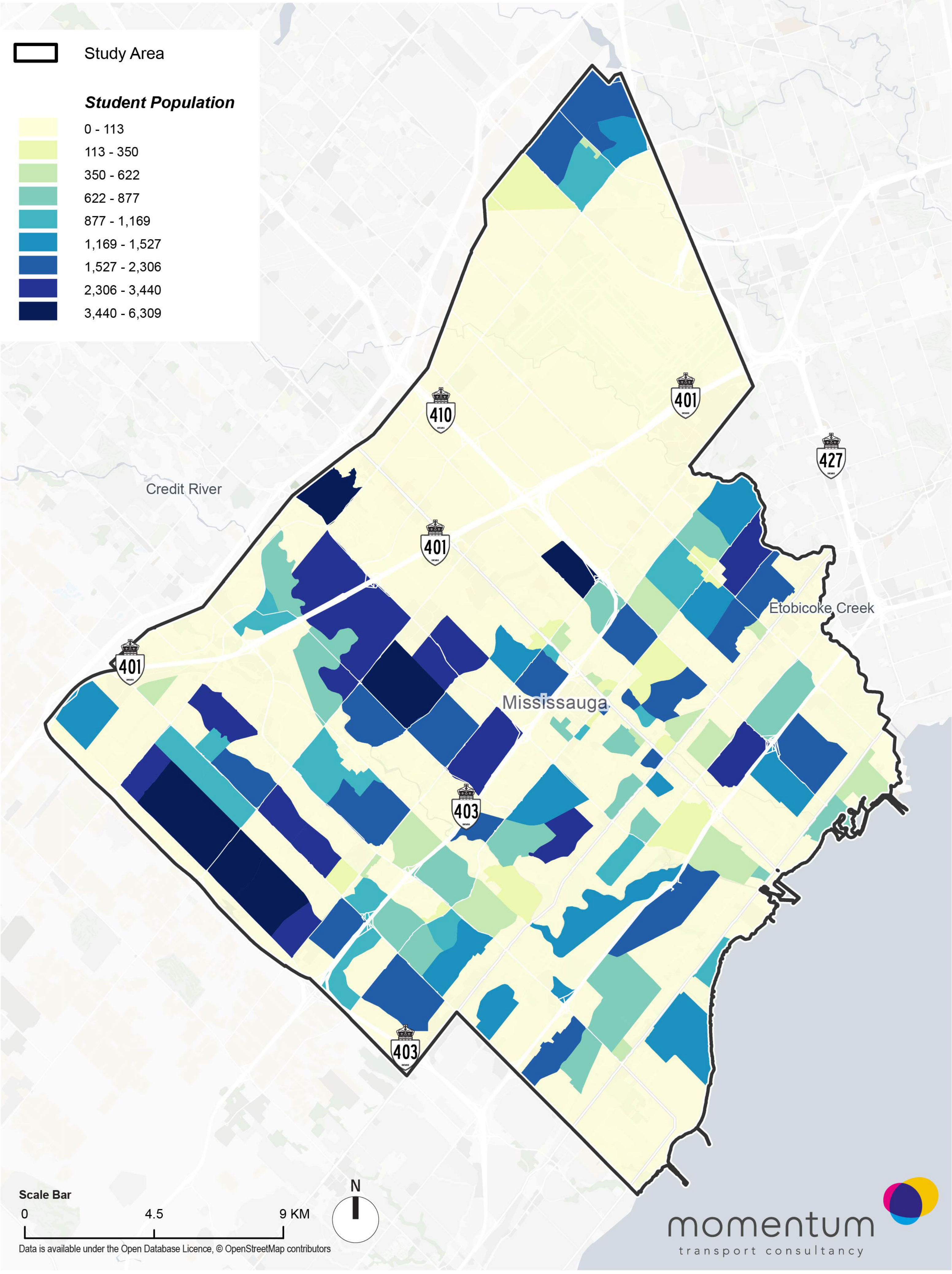
FIGURE 3 : PUBLIC TRANSPORT ACCESSIBILITY LEVEL



Data is available under the Open Database Licence, © OpenStreetMap contributors

MISSISSAUGA MICROMOBILITY PILOT

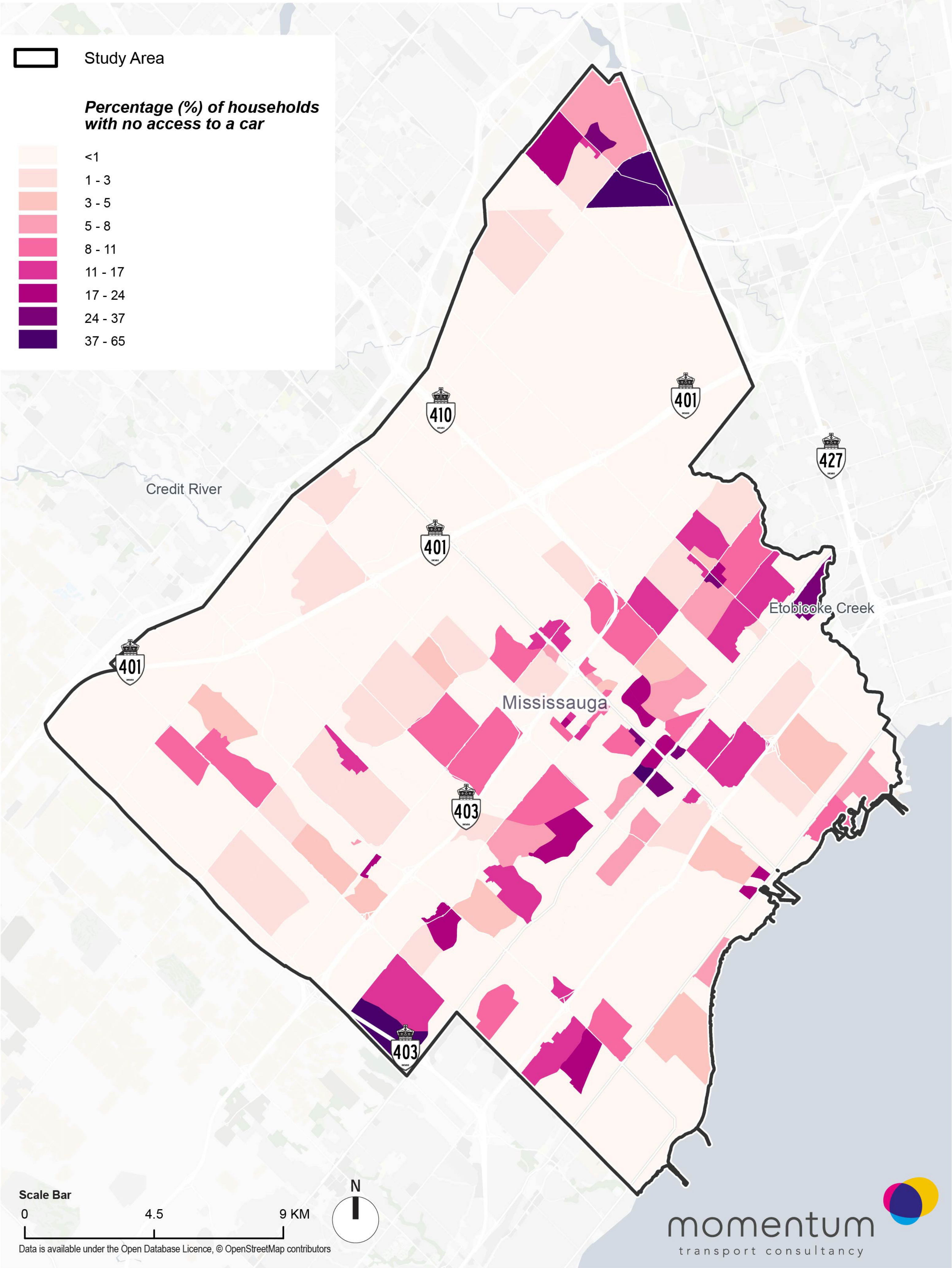
FIGURE 4 : STUDENT POPULATION BY TRAFFIC ZONE



Data is available under the Open Database Licence, © OpenStreetMap contributors

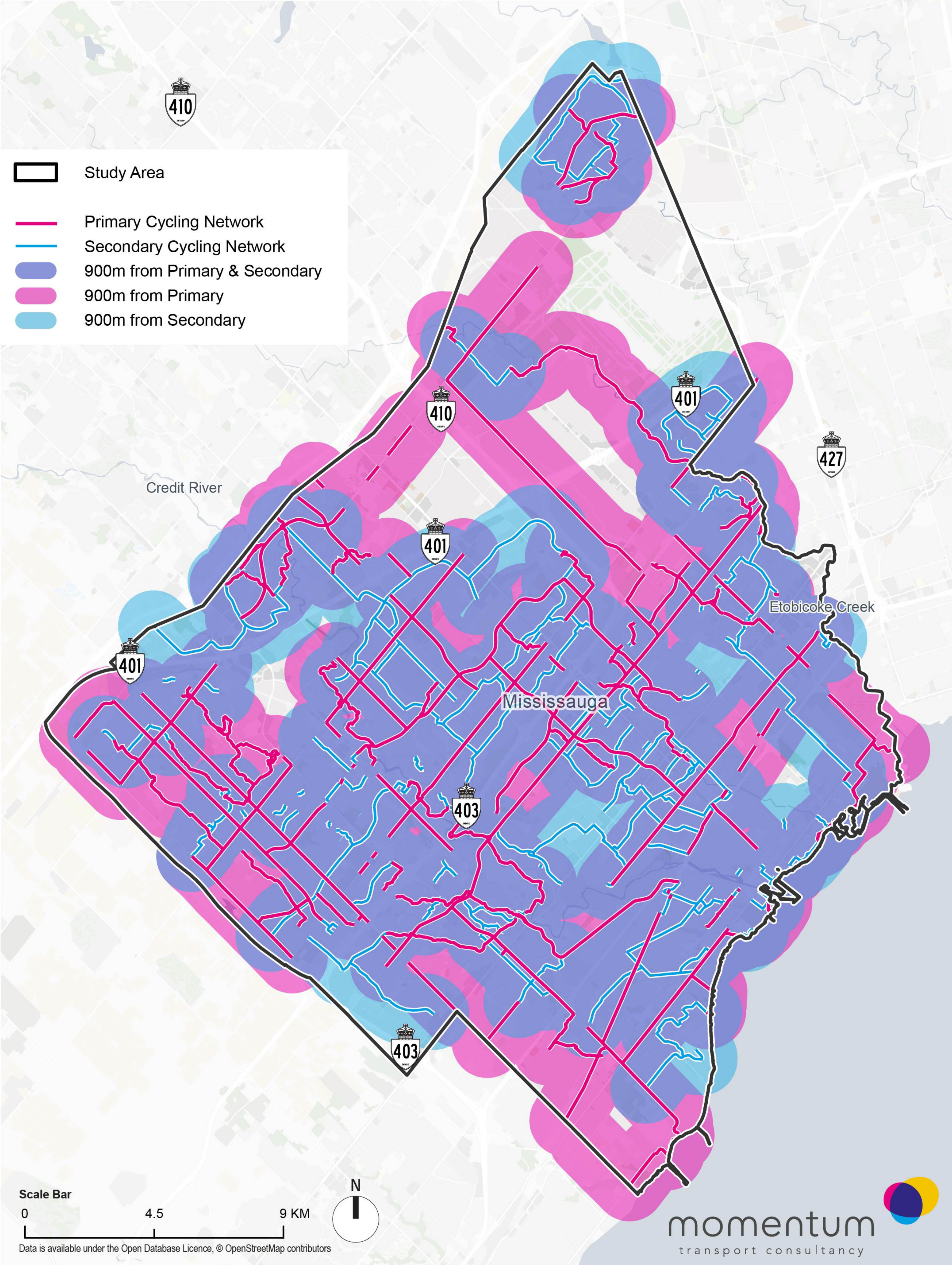
MISSISSAUGA MICROMOBILITY PILOT

FIGURE 5 : PERCENTAGE OF HOUSEHOLDS WITH NO CARS



MISSISSAUGA MICROMOBILITY PILOT

FIGURE 6 : DISTANCE TO THE CYCLING NETWORK



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OTHER INPUTS

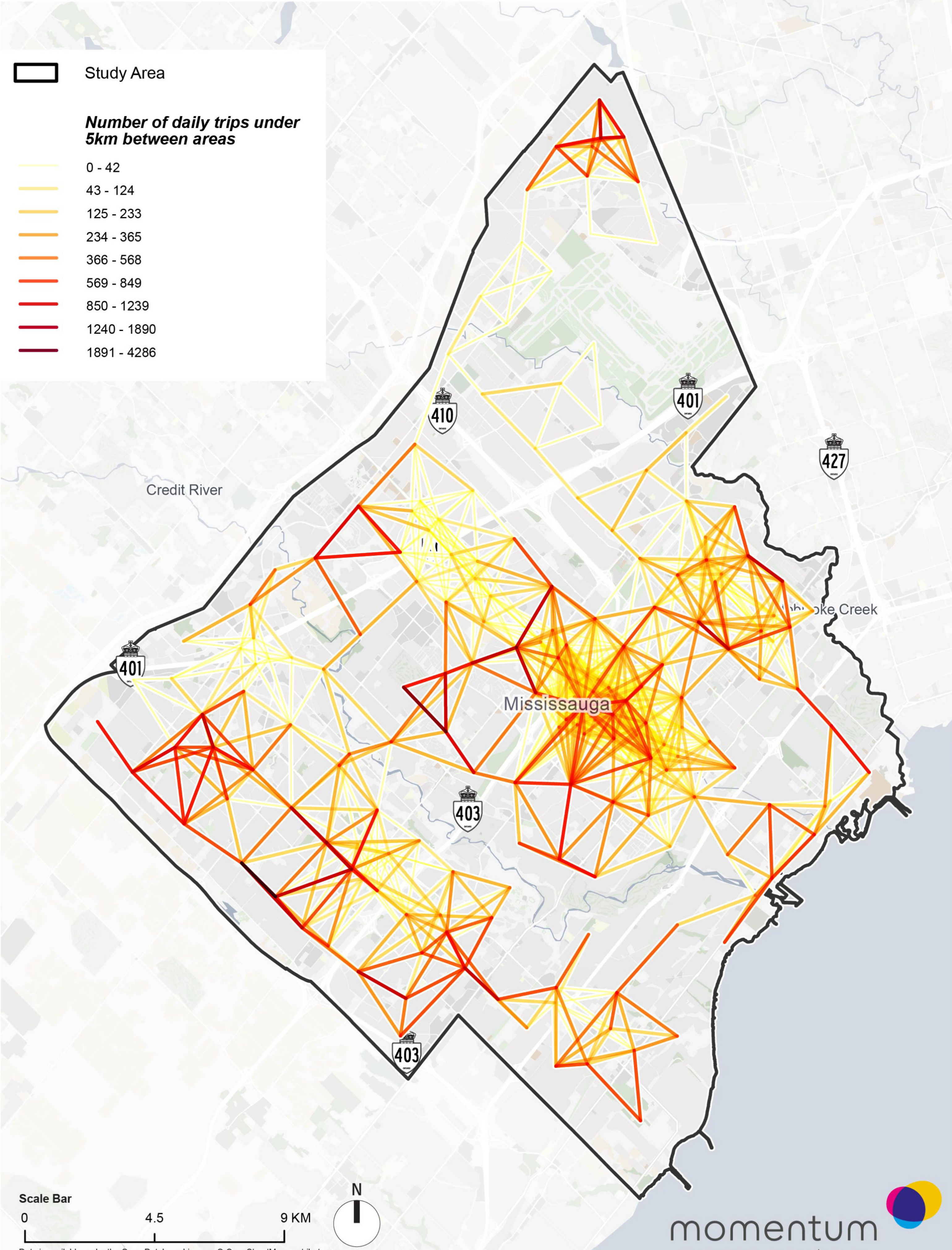
2.3.6 The information on Origin Destination trips and Propensity to cycle was mapped to add complementary information to the analysis in the form of sense check.

2.3.7 The map on Origin and Destination trips informed the boundaries of the service area recommendation by helping ensure that key origins and destinations for short trips are included in the service area.

2.3.8 The same logic was used for the mapping of propensity to cycle. As the variable consists of a composite index taking into account 13 criteria (some of which are highly correlated to the suitability model), it can be used to compare suitability results.

MISSISSAUGA MICROMOBILITY PILOT

FIGURE 7 : NUMBER OF TRIPS UNDER 5km



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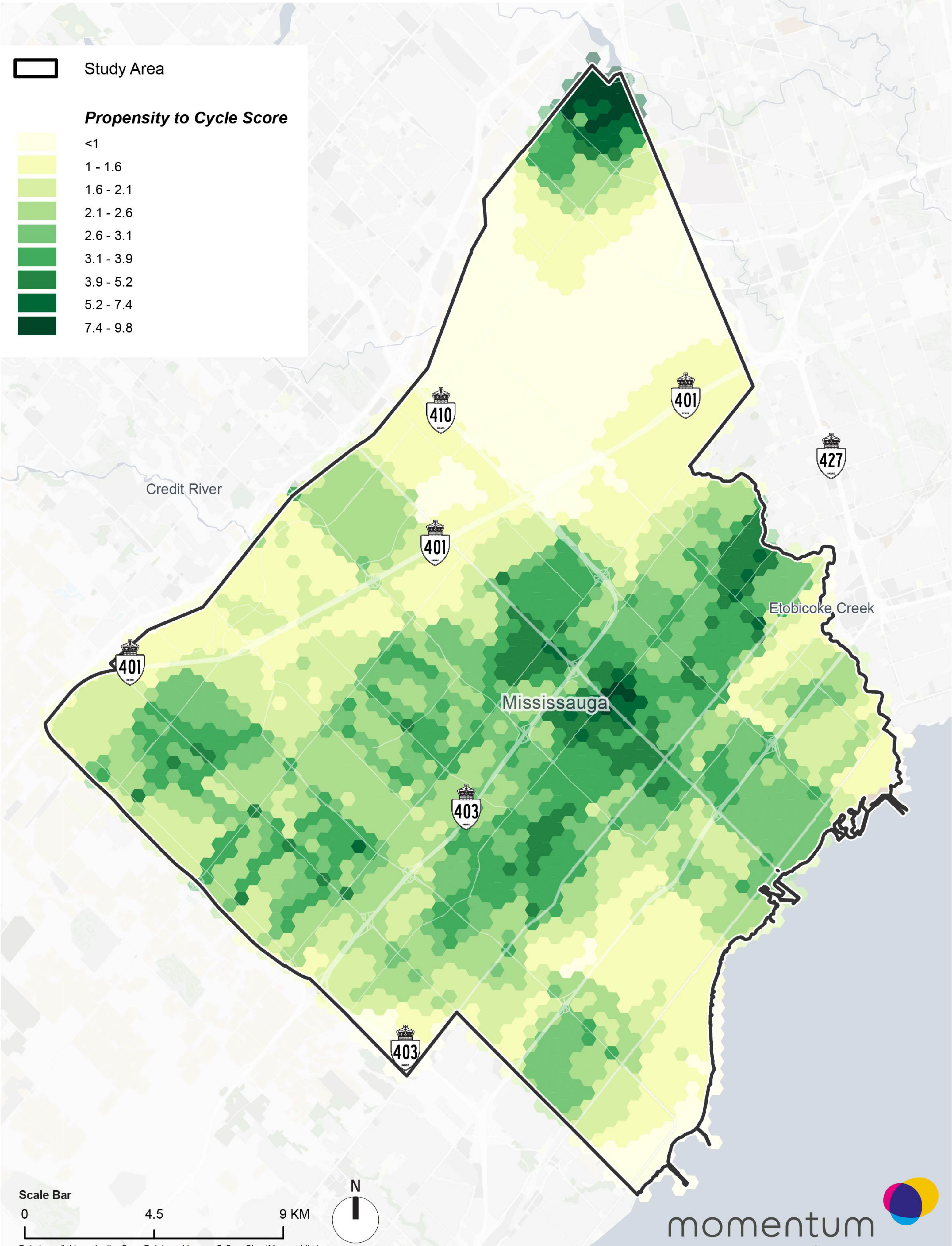
MISSISSAUGA MICROMOBILITY PILOT
FIGURE 8 : PROPENSITY TO CYCLE



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3. SITE SUITABILITY

3.1 Findings

CURRENT CONDITIONS

3.1.1 Figure 9 shows suitability scores across the city, based on existing population and infrastructure. Note that areas with missing inputs have no coloring.

3.1.2 Based on the site suitability model, areas with the highest suitability for micromobility are:

- **The City's central area** – it has the highest suitability for micromobility services, thanks to high population and employment densities.
- **The Hurontario Street transit corridor**, as the corridor connects various amenities and employment centers, making it a strategic axis for a micromobility network.
- **Applewood and Cooksville**, thanks to their mix of residential and commercial zones, along with the access to several transit lines. Their central location also increases their suitability for dockless micromobility.
- **Port Credit**, thanks to its population and employment density, the area's mixed-use environment, cultural attractions, and recreational spaces. Although visitor numbers were not included in the demand model, visitors create demand for micromobility and local businesses, particularly at weekends.
- **Erin Mills** – as well as its residential population, it has several educational institutions, including the University of Toronto Mississauga campus.
- **Meadowvale**, which combines high population density and good public transportation accessibility. On top of this, the density of local amenities means a micromobility system could facilitate short-distance trips and connect residents with essential services.
- **Malton** – the area scored high in the site suitability model, with its accessibility to transit and population density, as well as a cluster of shops and restaurants. As the neighborhood is separated from the rest of the city by Pearson Airport and highways, people in Malton would benefit from micromobility modes to access public transit more quickly.

3.1.3 Other key drivers of demand for micromobility include:

- The International Centre by Pearson Airport
- University of Toronto Mississauga
- Sheridan College Hazel McCallion Campus
- Mohawk College Mississauga Campus

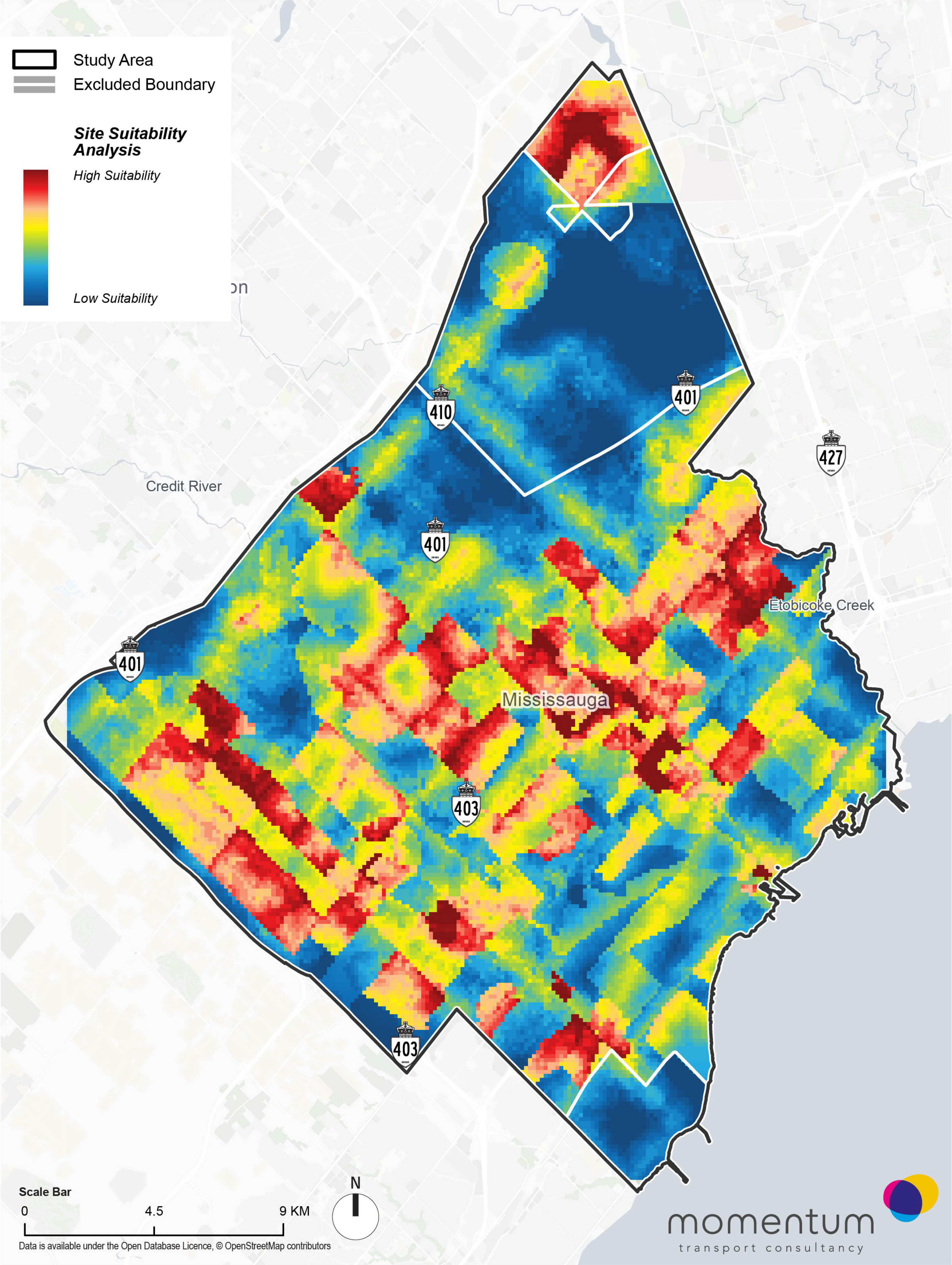
3.1.4 These demand drivers were reflected in the site suitability model as places of employment, but they also generate visitors. It is recommended that micromobility operators consider visitor numbers to these locations, to help ensure the scheme caters to visitor demand.

3.1.5 Areas of low suitability were generally low-density industrial and commercial areas around Pearson Airport and on the Lakeside.

3.1.6 The industrial lakeside state in the southwest corner of the city, the industrial and commercial area south of Malton and west of Pearson International Airport have a very low suitability score.

MISSISSAUGA MICROMOBILITY PILOT

FIGURE 9 : MAP OF SITE SUITABILITY FOR MICROMOBILITY, CURRENT SCENARIO



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FUTURE CONDITIONS

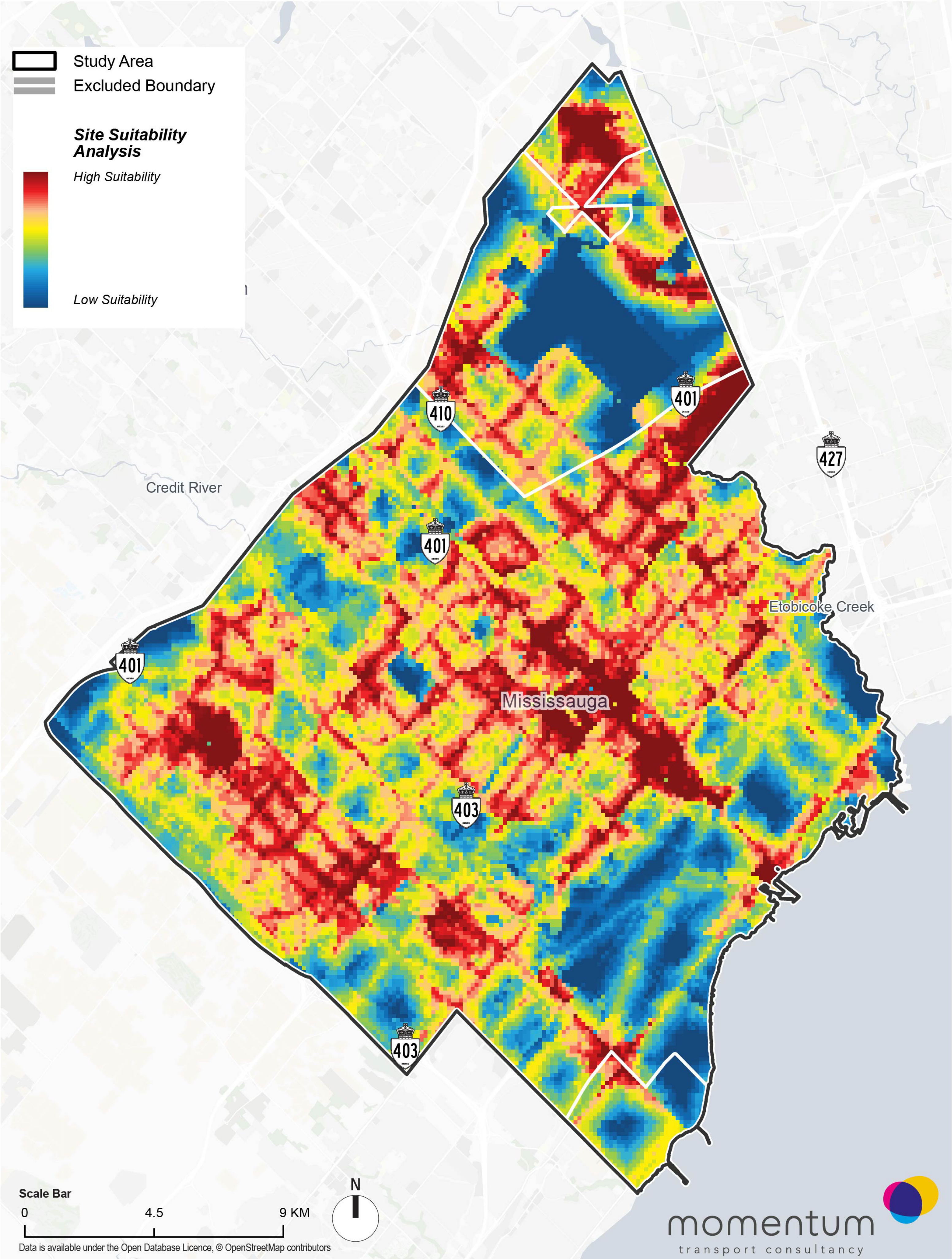
3.1.7 Figure 10 shows the suitability scores across the city for 2031.

3.1.8 The expansion in transit and the cycle networks to 2031 will lead to a marked increase in the number of areas with higher suitability scores.

3.1.9 Increases in population density across the City's central areas, the Hurontario Street corridor, Erin Mills and Cooksville will increase their suitability for micromobility.

MISSISSAUGA MICROMOBILITY PILOT

FIGURE 10 : MAP OF SITE SUITABILITY FOR MICROMOBILITY, FUTURE SCENARIO



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3.2 Service area recommendation

PRINCIPLES

3.2.1 Micromobility service areas are shaped by local demand and costs: larger service areas increase ridership but also costs.

3.2.2 The City of Mississauga is considering a shared dockless micromobility scheme; the dockless element allows vehicles to flow to demand hotspots.

3.2.3 According to EValuate's previous experience with micromobility services, service areas with boundaries that are easy to understand are more popular with users. Contiguous service areas also allow for more trips to be made by micromobility, thanks to network effects.

3.2.4 Only trips within the City of Mississauga were in scope for this report – but a continuous service area with neighboring cities, especially Brampton and Toronto, would enhance user convenience, and therefore scheme take up and operator profitability.

RECOMMENDATION - CURRENT SCENARIO

3.2.5 Based on the principles above, the service area recommendation encompasses all medium and high suitability areas within the city, as well as the areas in between them – with two exceptions:

- Commercial and industrial areas between Highway 401, Highway 410 and Malton, which would be ride-through but no parking zones. Parking would be allowed in Malton Old Village and the International Centre. Ride-through zones make it easier and cheaper for operators to deploy vehicles, while offering users the option to ride to and from Malton to elsewhere in the City (though it is expected that most micromobility trips in Malton would be local to this part of the City).
- The lakeside industrial estate southwest of the city, which would be a no-parking, no-riding zone – given its location at the edge of the city, it is unlikely that users would ride through to get to another location on the other side.

3.2.6 The service area recommendation encompasses 246km2 (Mississauga's total area is 292.4 km2).

RECOMMENDATION - FUTURE SCENARIO

3.2.7 The expansion of the transit and cycle networks is expected to boost site suitability across the City.

3.2.8 If the micromobility scheme is successful, micromobility adoption by 2031 could be high, including in areas with lower suitability scores – which could help review and potentially shrink no-park zones.

3.2.9 As in the current suitability analysis, a joined-up scheme with neighboring cities would increase site suitability, especially near the City's limits.

4. REVENUE AND COST CONSIDERATIONS

4.1 Introduction

4.1.1 This section looks at how the City of Mississauga can create an attractive environment for a micromobility operator to provide a successful shared micromobility scheme. This is to help inform the service area recommendation, the size of the fleet that is likely to be needed to ensure the scheme take up and growth, and other characteristics of the micromobility offer, such as the number of operators.

SCHEME BENCHMARKING

4.1.2 Based on the service area set out above, an estimated 1,500- 2,000 daily trips are likely to be made through a shared micromobility scheme in Mississauga in its first year. This estimate is based on a review of scheme take-up in other cities, and the mode shift that these schemes have enabled, which could be replicated in Mississauga.

4.1.3 Over the first year of the scheme, this level of demand would mean that up to 1,760 micromobility vehicles would be needed across the service area in months with the highest ridership levels.

4.1.4 Based on other schemes in Canada, it is anticipated that a scheme in Mississauga would be highly seasonal. Operators would release micromobility vehicles to match expected demand – with the greatest number of vehicles in circulation over the summer months.

4.1.5 Based on other schemes and to support the scheme profitability, a 3:1 e-scooter-to e-bike ratio has been modelled – so the initial fleet would include up to 900 e-scooters and 300 e-bikes. The next section expands on profitability drivers for shared micromobility schemes.

Table 4.1: Trips and mode share comparison

Variable	Unit	Mississauga	Brampton	Ottawa	Edmonton
Population	n/a	717,961	656,480	1,017,449	1,010,899
Trips / person / day	n/a	1.6	1.6	1.6	1.6
Trips (all modes/day)	n/a	1,172,997	1,800,100	2,520,500	3,139,100
e-scooter trips	daily average	1,760	1,905	600	3,389
e-scooter modal share	n/a	0.15%	0.19%	0.02%	0.11%

Table 4.2: Micromobility scheme comparison

Variable	Unit	Mississauga	Brampton	Ottawa	Edmonton
City Area	km2	255	266	521	766
Density	pax / km2	2811	2469	1954	1320
e-bikes	n/a	300	n/a	n/a	400
e-scooters	n/a	900	750	900	1500
All vehicles	n/a	1200	750	900	1900
Fleet density	vehicles / km2	4.7	2.8	1.7	2.5
Trips	annual	n/a	n/a	n/a	610,000
Trips / vehicle / day	n/a	2.0	2.5	2.3	2.3
Number of operators	n/a	1	3	3	2
Operators	n/a	n/a	Neuron, Big Bird, Scooty Mobility	Big Bird, Lime, Neuron	Big Bird, Lime
Scheme start	n/a	n/a	Apr 2023	June 2020	June 2018

PROFITABILITY DRIVERS

4.1.6 The table below sets out key profitability considerations for micromobility operators, based on existing operations in other cities.

Table 4.3: Profitability drivers

Profitability Driver	Profitability Correlation	Rationale
Service Area		
Population	Positive	Cities with fewer than 100k residents typically require subsidy
Average population density	Positive	Encourages micromobility usage
Contiguous borders of service area	Positive	Minimizing virtual restrictions on where vehicles can travel, including within and between service areas, promotes more journeys
Service area size	Positive (for higher density areas)	Larger service areas increase user convenience and allow for more trips to be taken, which helps cover fixed costs, but variable costs also increase – these can

Profitability Driver	Profitability Correlation	Rationale
		make expansion in lower density areas less profitable Larger service areas also reap the benefits of powered micromobility, as people are willing to make longer trips than with human powered vehicles (unless the car is a more convenient option)
Terrain gradient	Negative	Powered micromobility tends to favor cities with steep terrain, due to higher modal shift from walking
Vehicle Composition		
E-scooters	Positive	Novel way to move around. Greater appeal to a wider range of physical abilities
E-bikes	Negative	Larger size means capex and opex costs are higher than for e-scooters – these have a higher manufacturing cost, higher maintenance cost (more moving parts), higher operating cost (can fit less in a van). Typically the rider pays the same rental price
Vehicle density	Positive then negative	Availability is crucial, particularly for first mile (first leg) of multi-modal journeys. But oversupply of vehicles leads to higher operational costs (energy, maintenance, vandalism)
Parking		
Parking density	Positive	In a mandatory parking model, a greater density of bays enables riders to finish close to their final destination.
Parking capacity	Positive	Sufficient capacity at the desired destination parking bay avoids 1) street clutter associated with overflow parking and 2) reduced future demand due to rider inconvenience of searching for another parking bay
Free floating parking model	Positive	Greater user convenience but can negatively impact the public realm
Mandatory parking model	Negative	Lower user convenience but impact can be limited by sufficient density of parking bays
Parking infrastructure	Minimal	Some physical infrastructure can help riders locate parking bays, particularly if they are empty and / or the rider is unfamiliar with the location

5. RECOMMENDED PARKING LOCATIONS

5.1 Types of micromobility parking

5.1.1 There are several parking types available to the City of Mississauga to manage the introduction of micromobility vehicles:

- **Mandatory parking zones**: users must park in a parking bay, which is an area in the public realm dedicated to parking for micromobility vehicles. The size of bays can vary but each should be able to fit peak demand. User compliance is usually enforced by geofencing – this is a virtual boundary set by technology such as GPS. Users are encouraged by rewards and/or fines to only park in these zones.
- **Recommended parking zones**: users are encouraged to park within a certain area and rewarded for doing so.
- **Hybrid free-floating and mandatory parking zones**: users must park in geofenced areas where sidewalks are in high use (such as city centers and main streets), but in neighborhoods where there is more generous pedestrian space or less pressure on sidewalks, vehicles can be parked outside parking zones (free-floating).
- **Free floating**: users do not have to park within certain areas.

5.1.2 This section identifies recommended parking locations for micromobility vehicles, should the City require mandatory parking in bays.

5.2 Methodology

5.2.1 Higher demand areas will need a higher density of parking bays to improve convenience and reliability for users, and each of these bays will need to accommodate more micromobility vehicles.

Parking locations

5.2.2 Recommended parking locations were determined by developing a parking identification model.

5.2.3 The recommended service area was divided in higher suitability, medium suitability, and lower suitability areas, based on the criteria set out in Table 5.1.

5.2.4 Higher suitability areas have twice the density of parking locations as lower density areas. Higher suitability areas were divided in a 500m grid – each square containing one parking location. Medium suitability areas were divided in a 1000m grid – each square containing one parking location.

5.2.5 It is assumed that areas with the lowest suitability scores wouldn’t require dedicated parking locations, as they can be served by locations in higher suitability areas. No-park and no-ride zones are excluded from this analysis.

Table 5.1: How parking densities have been determined

	Score (as determined in the demand model presented in 3.1.1)	Parking density	Number of parking locations	Fleet size
Higher	Top 50% of areas by suitability score	1 parking location per 500m	272	886
Medium	Following 30% of areas	1 parking location per 1000m	135	252
Lower	Bottom 20% of areas	No dedicated parking location – served by nearest locations in higher suitability locations	-	-

5.2.6 The recommended parking location within each square of the grid is weighted towards areas of higher suitability within that square. This is to maximize user convenience. As a result, parking locations cluster near the higher suitability areas, and distances between parking locations vary.

5.2.7 The exact location of the parking bay is also influenced by the road type: it is assumed that bays won't be provided on highways, pedestrian-only streets or service roads, but instead on the nearest location that micromobility vehicles can access.

5.2.8 Two additional parking bays were manually added to serve Old Malton and the International Centre – in anticipation of additional demand (respectively from residents and visitors) that would not have been captured in our model, due to proximity of these areas to the airport, which scores as low suitability, and the lack of available public data on visitors. These two locations help connect residents and visitors to Malton's GO station.

Number of vehicles

5.2.9 Some parking bays will naturally see a higher demand than others, which means vehicles will gravitate towards higher demand areas. While this is generally desirable as it means vehicles are located where they are most likely to be used, a cap on the number of micromobility vehicles in each bay, or in different areas of the city, can help manage overcrowding or underprovision of vehicles.

5.2.10 The estimated number of vehicles in each parking location would depend on the suitability score for the surrounding area. Parking bays in higher suitability areas would see 3-5 micromobility vehicles, and medium suitability areas would see 1-2 spaces. These numbers are based on a fleet of 1,200 vehicles. Additional bays in Malton were not given a number of vehicles – this will need operator input based on the number of visitors to the International Center, and expected demand in Old Malton.

5.2.11 Figure 11 shows an estimation of how 1,200 vehicles would be initially distributed to match the anticipated level of demand across different areas of the City.

5.2.12 An operator may wish to provide additional bays, for example to accommodate expected visitor demand.

5.2.13 While neighboring municipalities were not in scope for this piece of work, additional bays or parking capacity would also need to be provided near the City's limits to cater for demand from residents, jobs or for recreational opportunities immediately beyond the City's limits.

Parking capacity

5.2.14 Bays will need to fit a larger number of vehicles than those set out by our parking identification work to accommodate spikes in demand.

5.2.15 Overall parking capacity should be at least four times the number of vehicles in circulation to ensure riders can end trips where they want to.

5.3 Recommended parking locations

Summary

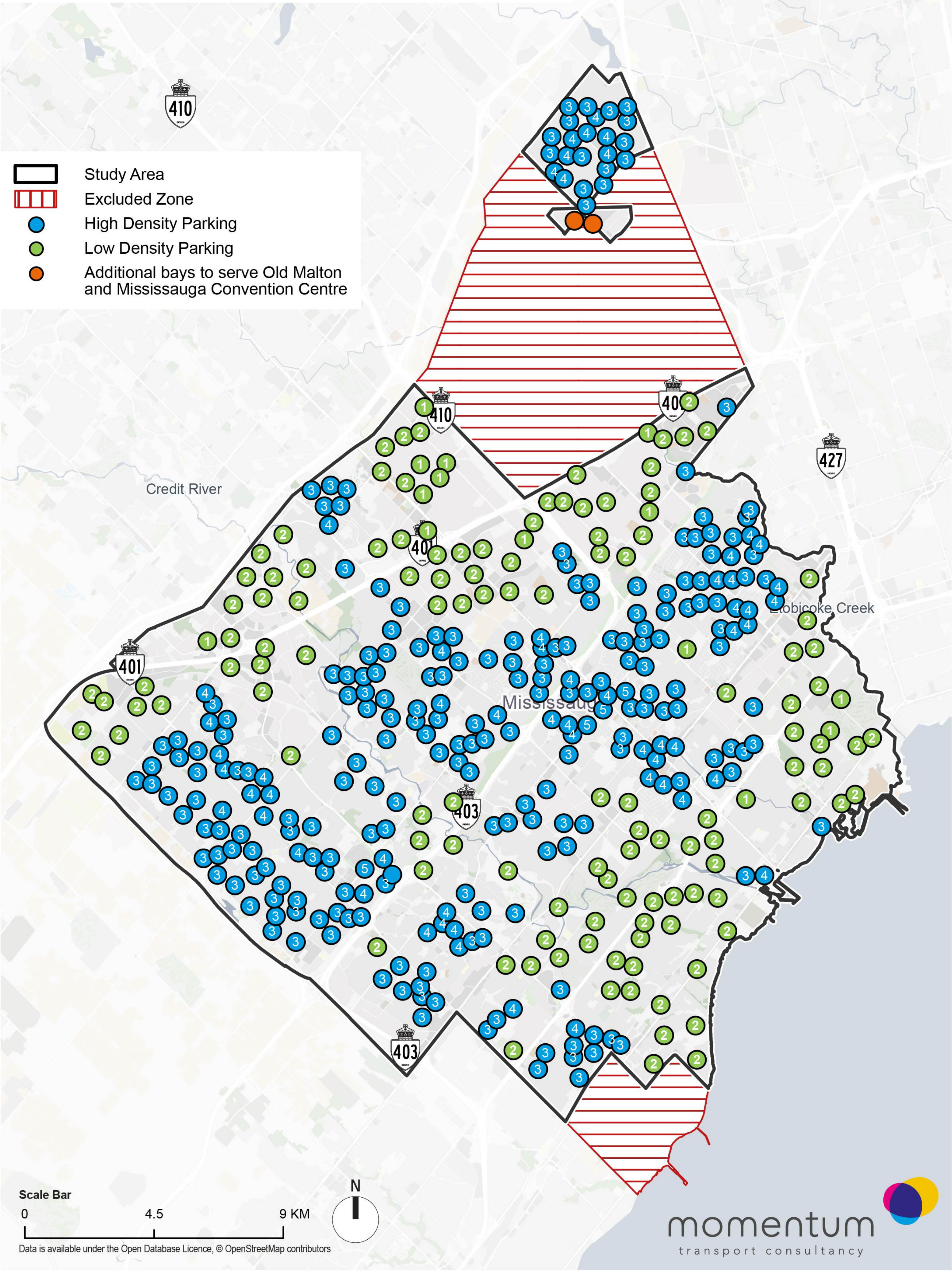
5.3.1 This parking model covers the recommended service area.

5.3.2 409 parking locations are proposed – 407 parking locations were identified through the parking identification model, and together they would include 1,138 micromobility vehicles. This is slightly below the 1,200 average recommended fleet size, to provide flexibility for additional bays or vehicles – for example an additional two bays were identified as required for Old Malton and the International Centre.

5.3.3 The map below shows the recommended location of parking bays and the number of vehicles these bays would include. It is anticipated that this will change based on demand, and vehicle numbers are provided for indicative purposes only.

MISSISSAUGA MICROMOBILITY PILOT

FIGURE 11 : RECOMMENDED PARKING ZONE



6. SUMMARY AND RECOMMENDATIONS

6.1 Key findings

6.1.1 The City of Mississauga can create an attractive environment for users and for a micromobility operator to provide a successful shared micromobility scheme by choosing a single operator and if possible, joining up with neighboring micromobility schemes.

6.1.2 Based on the service area set out below, an estimated 1,500 to 2,000 daily trips are likely to be made through a shared micromobility scheme in Mississauga in its first year. This estimate is based on a review of scheme take-up in other cities, and the mode shift that these schemes have enabled, which could be replicated in Mississauga.

6.1.3 Much of the activity would be concentrated in high demand areas around the city center, Port Credit or Erin Mills.

6.1.4 It is anticipated that the expansion in transit and the cycle infrastructure by 2031 will further increase the number of areas with high suitability.

6.1.5 Figure 12 illustrates the suitability scores across the city, currently and in 2031.

6.2 Recommendations

6.2.1 Following on from the suitability analysis and profitability considerations above, we would recommend that the City of Mississauga:

- Specifies a minimum e-bike deployment – for example that there must be at least one e-bike for three e-scooters – as operators will be encouraged to provide a higher number of e-scooters due to cost considerations[15].
- Agrees with the chosen operator(s) a minimum and a maximum number of vehicles to be available in the city at any one time. These numbers could vary month by month based on the expected seasonal demand and be revised as scheme take up figures become available.
- Commissions a single operator to provide the service, due to the high fixed costs of providing a storage and maintenance warehouse, and operations team, and the micromobility vehicles. This operator value can then be returned to the city through a revenue share, user discounts and passes, or through the provision of e-bikes, which tend to be unprofitable to operate.
- A continuous service area with neighboring cities, especially Brampton and Toronto, would enhance user convenience, scheme take up and operator profitability. Where

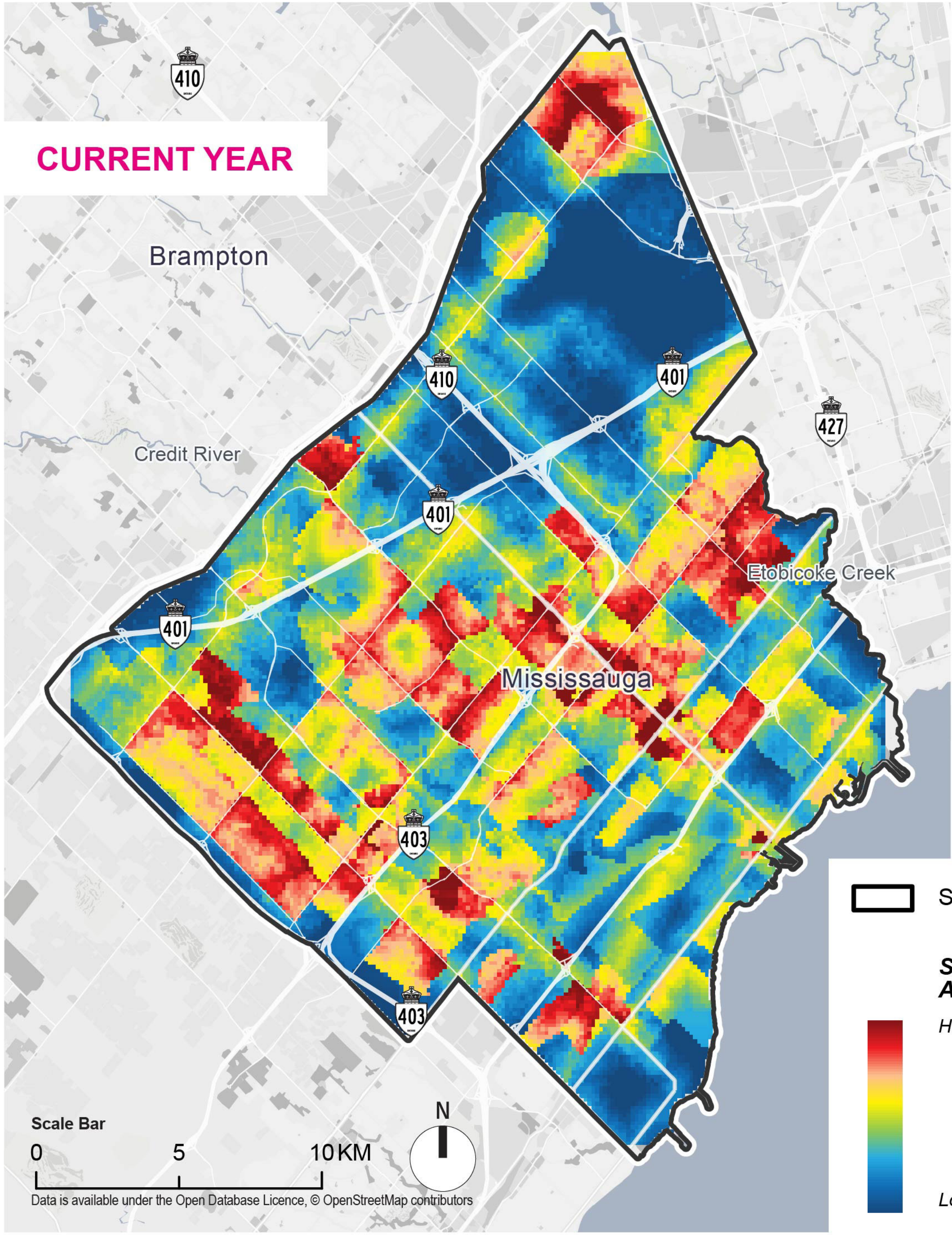
[15] E-bikes are faster and have a longer range than e-scooters, which can make them more attractive for longer or more varied trips. E-Bikes vs Scooters: Pros, Cons, and Which Is Best For You? (micromobilitycoalition.org)

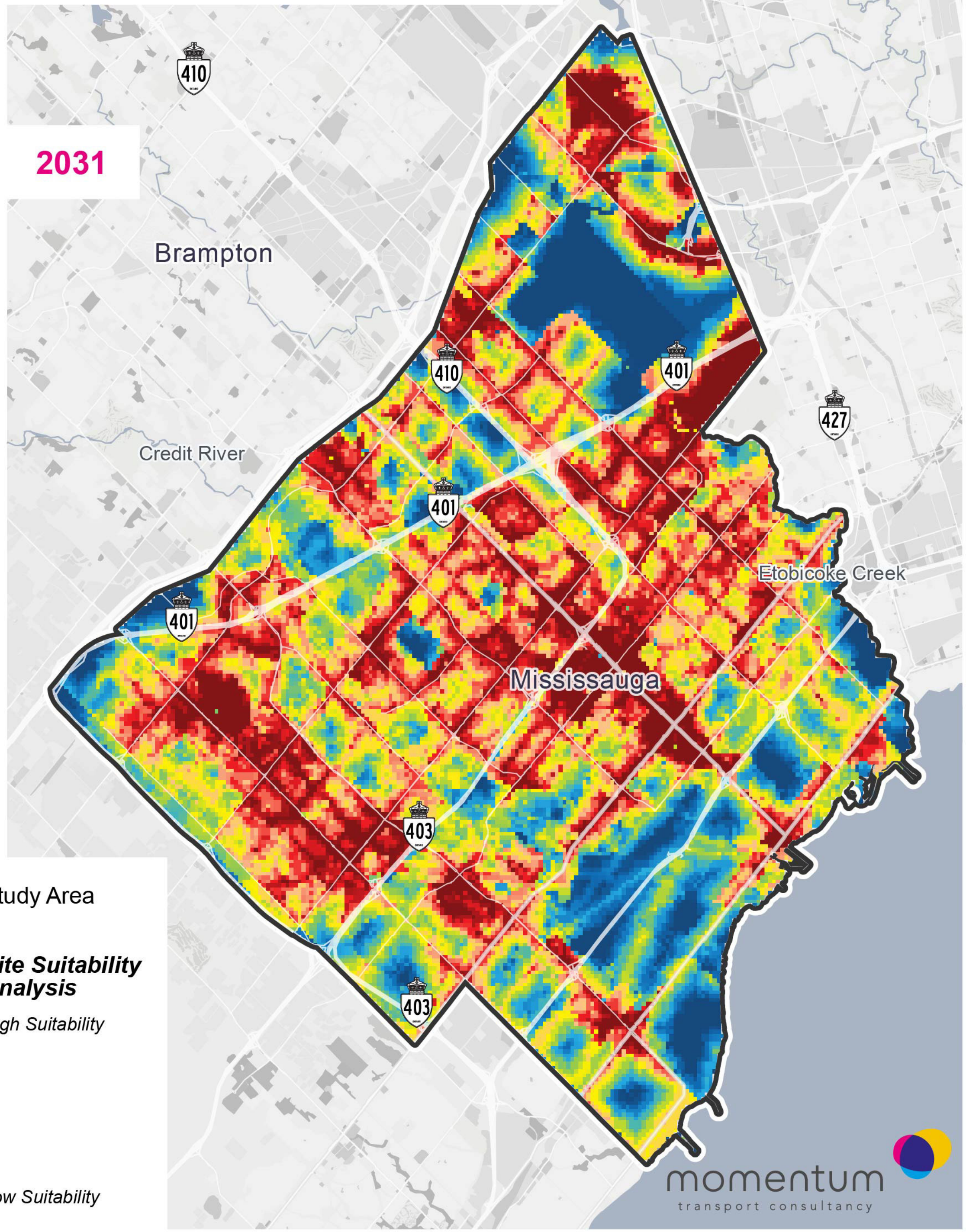
there are shared micromobility schemes in proximity (e.g. Brampton), take-up is likely to be strong due to the network effects.

- The parking solution should reflect the street environment: mandatory parking in bays will mitigate the risk of sidewalk clutter in areas where sidewalk space is at a premium. Arrangements for micromobility can involve a mix of designated bays and free-floating, which can increase user convenience.

MISSISSAUGA MICROMOBILITY PILOT

FIGURE 12 : MAP OF SITE SUITABILITY FOR MICROMOBILITY, CURRENT AND FUTURE MODELS





momentum
transport consultancy

7. ABOUT THE AUTHORS

7.1 Momentum Transport Consultancy

7.1.1 Momentum is an integrated, people-first transport consultancy specializing in the vision, technical understanding and design for transport and people movement in complex environments. Everything we do is carefully and diligently designed to create transport strategies and solutions that inform, integrate with and are integral to, every aspect of the built environment today and for the future.

7.1.2 As a people-focused consultancy originally based in the UK, Momentum has vast experience in a diverse array of international projects and always prioritizes the use of innovative tools, to gain a deeper understanding of the user experience within the urban context. With a focus on the comfort and safety of active travelers in cities, the tools used by Momentum allow for a seamless integration of active transportation solutions into every environment.

7.1.3 Momentum has previously conducted research to support the deployment of micromobility vehicles several North American and European cities – the largest include Dublin, Bordeaux and Rimini.

7.1.4 Momentum provides a holistic vision to transport planning that integrates engineering, technical understanding and design into the process of planning, with the pedestrian safety and comfort at the heart of everything we do. Helped by our fully integrated approach, our teams use a combination of knowledge of local needs and policy requirements and best practice within the industry internationally to deliver active transportation schemes across a variety of locations and environments.

7.2 EValuate

7.2.1 EValuate Strategy Consulting has partnered with Momentum to provide a micromobility offering to cities in the UK, Canada and the Middle East. With a deep understanding of the commercial and operational models of shared micromobility, EValuate has advised central Government and local authorities on a range of topics, from strategy development, to market engagement and procurement.

7.2.2 Beyond micromobility, EValuate has delivered a range of strategy and innovation projects in the transport and infrastructure sectors in the UK and globally. This ranges from electric vehicle charging infrastructure and fleet decarbonization, to identifying innovative applications of emerging transport technologies and new transport modes to help organizations reduce their carbon footprint and improve performance.

APPENDIX A: LITERATURE REVIEW

7.2.3 This section reviews evidence on the type of users and environments that drive demand for micromobility – with a focus on evidence from existing schemes.

Shared Micromobility State of the Industry Report, North American Bike Share Association, 2019

7.2.4 Report on the mobility benefits and profile of micromobility users.

7.2.5 Micromobility services can add first and last-mile connection to transit, complementing the public transport system.

7.2.6 Users of shared micromobility schemes were disproportionately young, male, with higher incomes and higher levels of education.

7.2.7 Larger cities tended to commission a larger number of operators.

Long term assessment of a successful e-bike-sharing system. Key drivers and impact on travel behavior, Julio Raky, Andrés Monzon, 2022

7.2.8 Evaluation of the Madrid Bike Share scheme, combining surveys data with operator statistics.

7.2.9 User profile has evolved over time (2015-2019). It found that “there are more workers and fewer students, and users having higher education used the bike share service more frequently”.

7.2.10 The evidence from Madrid shows a persisting gender gap: 36% of users were women, 64% were men.

7.2.11 Weather factors affected the success of the system – especially heat or cold weather.

7.2.12 Dedicated bike lanes were the most important factor for take up at the early stage. However, it later lost some of its importance, as different types of cycling infrastructure were brought forward, and cyclists became familiar with road traffic interactions.

Spatial associations of dockless shared e-scooter usage, Michael J. Smart, Robert B. Noland, 2020

7.2.13 Analysis of usage of e-scooter data in Austin, Texas to estimate its usage patterns.

7.2.14 The study found that “Usage of e-scooters is associated with areas with high employment rates, and bicycle infrastructure, compatible with the findings of many bike share studies. This implies that more bicycle infrastructure may increase e-scooter usage.”

7.2.15 A high student population significantly increased e-scooter usage.

7.2.16 In the Austin context, e-scooters were widely used for leisure purposes. They were more rarely used for a start to end commute.

7.2.17 Trip origins and destinations were associated with bus stop locations, suggesting that people link e-scooter and bus trips.

E-scooters and sustainability: Investigating the relationship between the density of E-scooter trips and characteristics of sustainable urban development, Aryan Hosseinzadeh, Majeed Algomaiah, Robert Kluger, Zhixia Li, 2021

7.2.18 The study explores how biking and pedestrian infrastructure affect e-scooter usage.

7.2.19 Young individuals (18-29 years old) were more likely to use services.

7.2.20 Commercial land use positively and industrial land use negatively affected E-scooter trip density in both all trips and peak-hours trips.

An Approach to Model the Willingness to Use of E-Scooter Sharing Services in Different Urban Road Environments, Sorkou and al., 2022

7.2.21 Study to identify the factors that influence the willingness of using an e-scooter, with a regression model.

7.2.22 Environmental factors – notably the availability of bike lanes, pavement condition and speed limits - were the most influential in determining e-scooter use.

7.2.23 Pricing policies can be an incentive for attracting users in low density areas.

Exploratory Analysis of Real-Time E-Scooter Trip Data in Washington, D.C., Zhenpeng Zou, Hannah Younes, Segvi Erdogan, Jiahui Wu, 2020

7.2.24 Study to identify travel patterns and behavior related to e-scooter usage.

7.2.25 The correlation coefficients suggest that all bikeway designs were positively correlated with e-scooter trips. Bike lanes and signed bike routes were most conducive to e-scooter usage.

7.2.26 E-scooters were very popular in tourist areas for leisure trips.

APPENDIX B: CORRELATION MATRIX

Figure 13: Correlation matrix, current demand model

```
#              STATISTICS of INDIVIDUAL LAYERS

#   Layer            MIN          MAX          MEAN          STD
#  ------------------------------------------------------------
   CycleSecondary    0.0000       9.0000       3.0409        3.5166
   CyclePrimary      0.0000       9.0000       2.6051        3.2918
   PTAL              0.0000       8.0000       1.2891        0.9541
   Student Pop       0.0000       9.0000       1.0464        2.3972
   PopDensity        0.0000       9.0000       0.7565        1.3875
   PropNoCars        0.0000       9.0000       0.4998        1.3997
   EmploymentDens    0.0000       9.0000       1.4585        1.7948
#  ============================================================

#                   CORRELATION MATRIX

#   Layer          CycleSecondary  CyclePrimary   PTAL      Student Pop   PopDensity   PropNoCars  EmploymentDens
#  -----------------------------------------------------------------------------------------------------------
   CycleSecondary    1.00000       0.65131      0.26091      0.51993      0.68901      0.41659      0.49477
   CyclePrimary      0.65131       1.00000      0.18803      0.48637      0.67528      0.36166      0.38239
   PTAL              0.26091       0.18803      1.00000      0.16137      0.39677      0.25660      0.34656
   Student Pop       0.51993       0.48637      0.16137      1.00000      0.64133      0.63875      0.17812
   PopDensity        0.68901       0.67528      0.39677      0.64133      1.00000      0.52133      0.28581
   PropNoCars        0.41659       0.36166      0.25660      0.63875      0.52133      1.00000      0.21959
   EmploymentDens    0.49477       0.38239      0.34656      0.17812      0.28581      0.21959      1.00000
#  ===============================================================================================================
```

Figure 14: Correlation matrix, future demand model

```
#              STATISTICS of INDIVIDUAL LAYERS

#   Layer            MIN          MAX          MEAN          STD
#  ------------------------------------------------------------
   CycleSecondary    0.0000       9.0000       3.5501        3.7294
   CyclePrimary      0.0000       9.0000       3.9242        3.8147
   PTAL              0.0000       8.0000       1.6817        1.0163
   PopDensity        0.0000       9.0000       0.7376        1.2917
   EmploymentDens    0.0000       9.0000       1.3610        2.1485
#  ============================================================


#                  CORRELATION MATRIX

#   Layer          CycleSecondary CyclePrimary    PTAL       PopDensity    EmploymentDens
#  ------------------------------------------------------------------------------------
   CycleSecondary    1.00000       0.76039       0.19287      0.71273       0.43443
   CyclePrimary      0.76039       1.00000       0.24273      0.66019       0.58976
   PTAL              0.19287       0.24273       1.00000      0.39956       0.19629
   PopDensity        0.71273       0.66019       0.39956      1.00000       0.19443
   EmploymentDens    0.43443       0.58976       0.19629      0.19443       1.00000
#  ====================================================================================
```