

Introduction:

Major public transit investments, such as new rapid transit lines, provide a wide range of benefits for urban residents. However, there are increasing concerns whether existing and future transport networks are distributed equitably across different population groups.

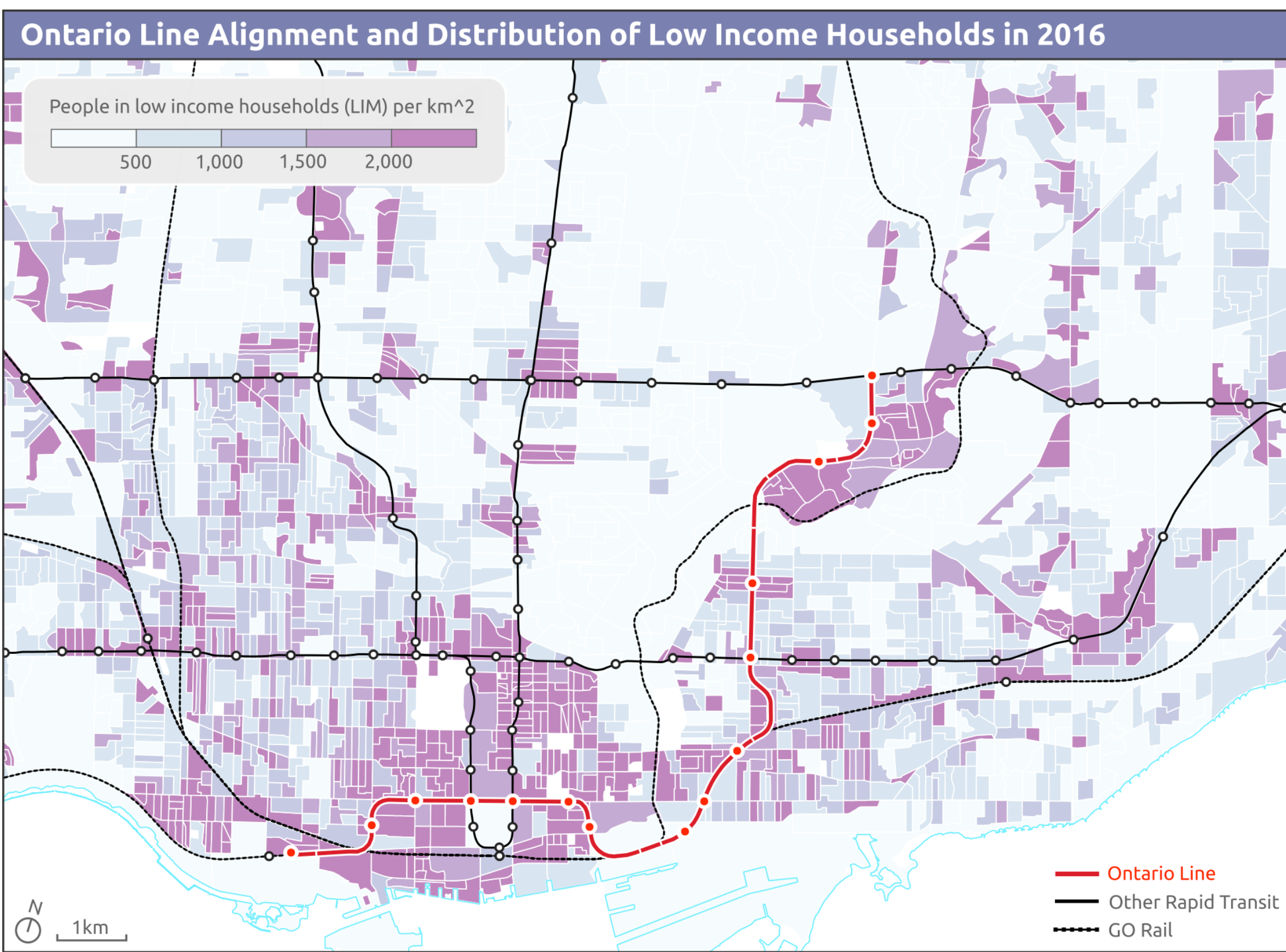
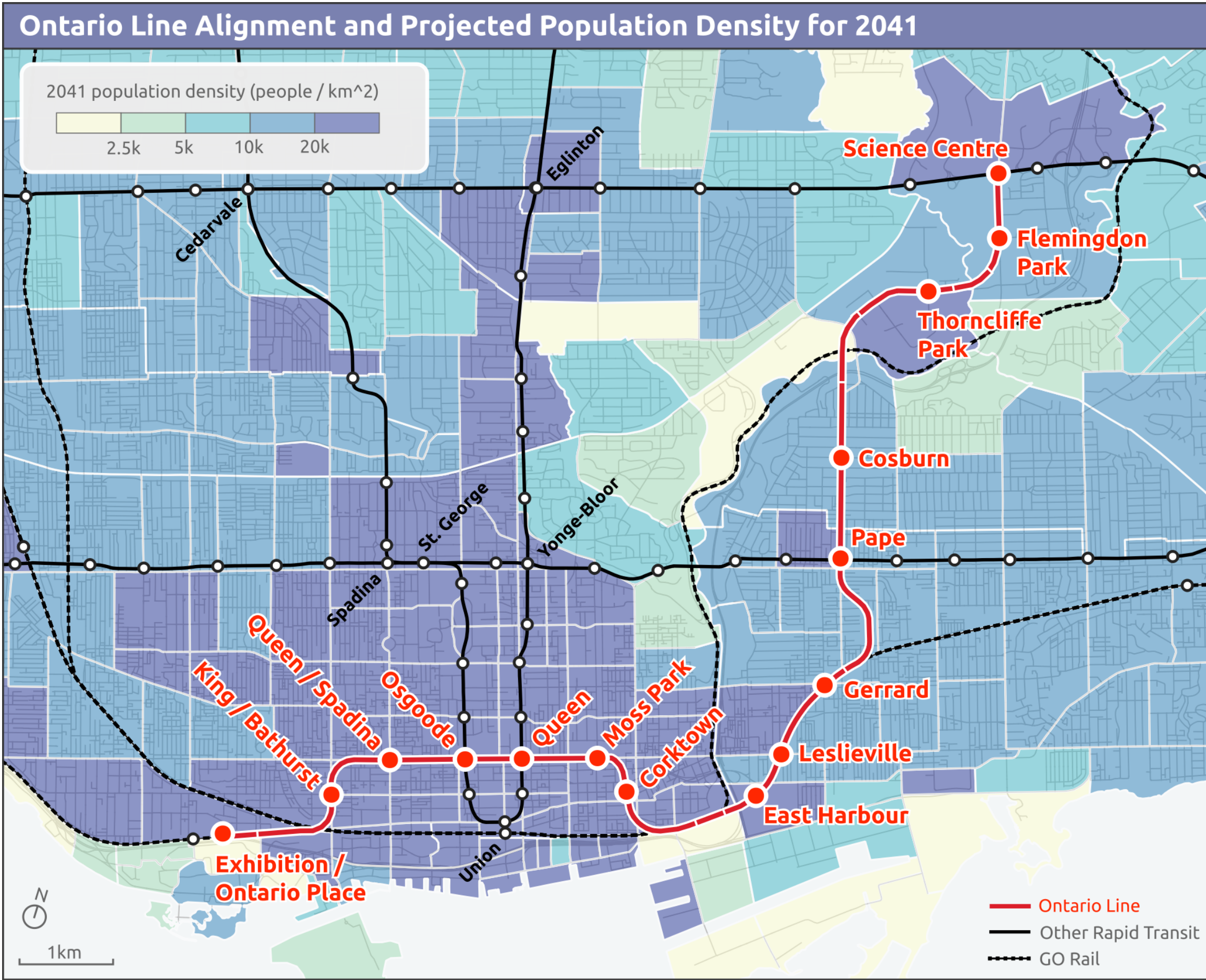
The objective of our paper is to outline a procedure for evaluating the equity impacts of a new rapid transit line across a comprehensive set of metrics: **1)** access to transit, **2)** access to destinations by transit, **3)** travel time savings, and **4)** transit demand. The first two represent changes in opportunities, and the second two, changes in travel outcomes.

We then demonstrate the use of this procedure to assess the benefits of the Ontario Line, a proposed rapid transit line in Toronto, Canada, across several categories of socio-economic status.

We also incorporate a sensitivity analysis to account for the possibility of increased income segregation or transit-induced gentrification.

Data Sources:

- A) SES data from the 2016 census
- B) OpenStreetMap network data
- C) Proposed alignment of the Ontario Line
- D) Population and employment projections for 2041
- E) Modelled travel times and flows in 2041 for two scenarios; with and without the Ontario Line

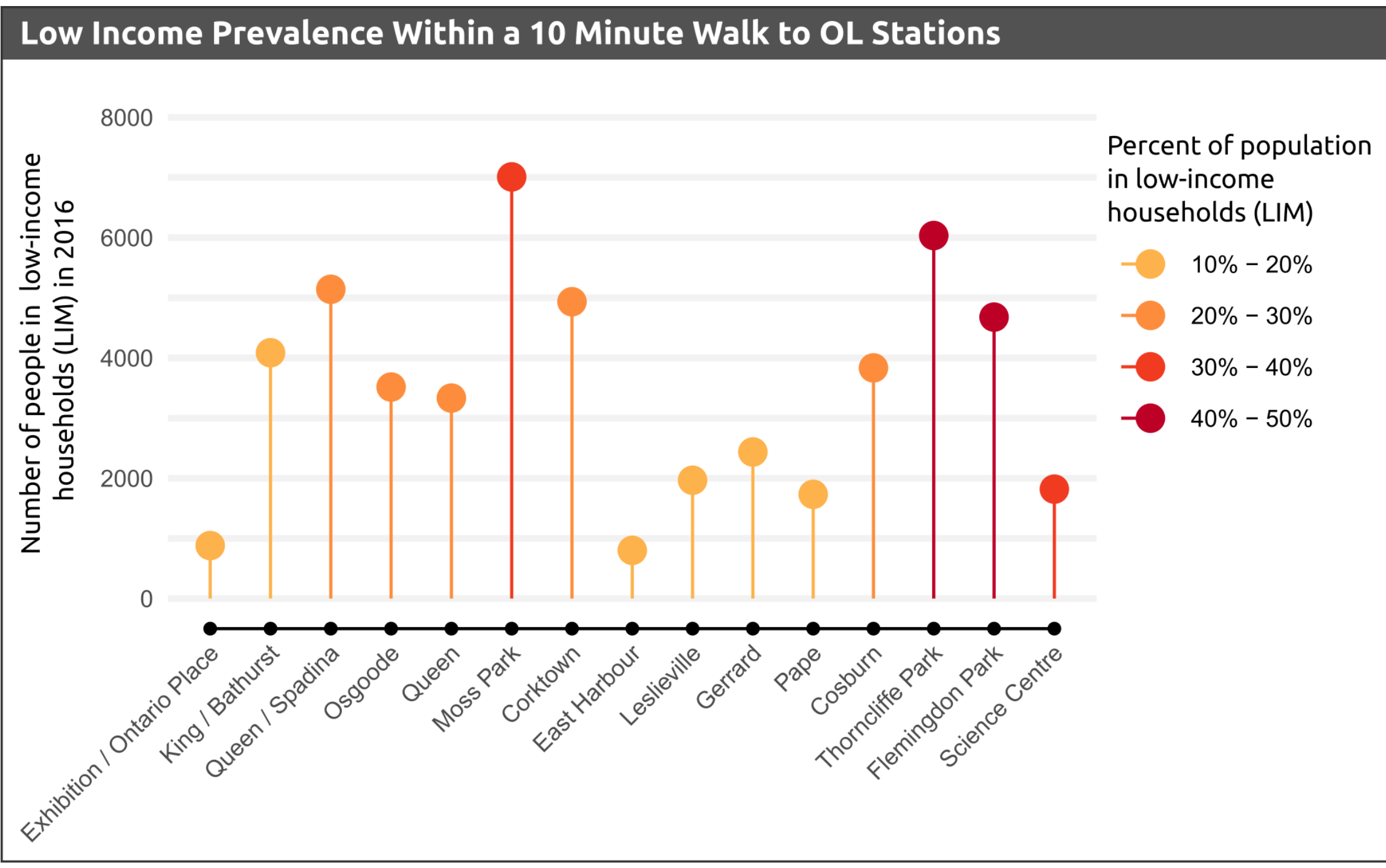
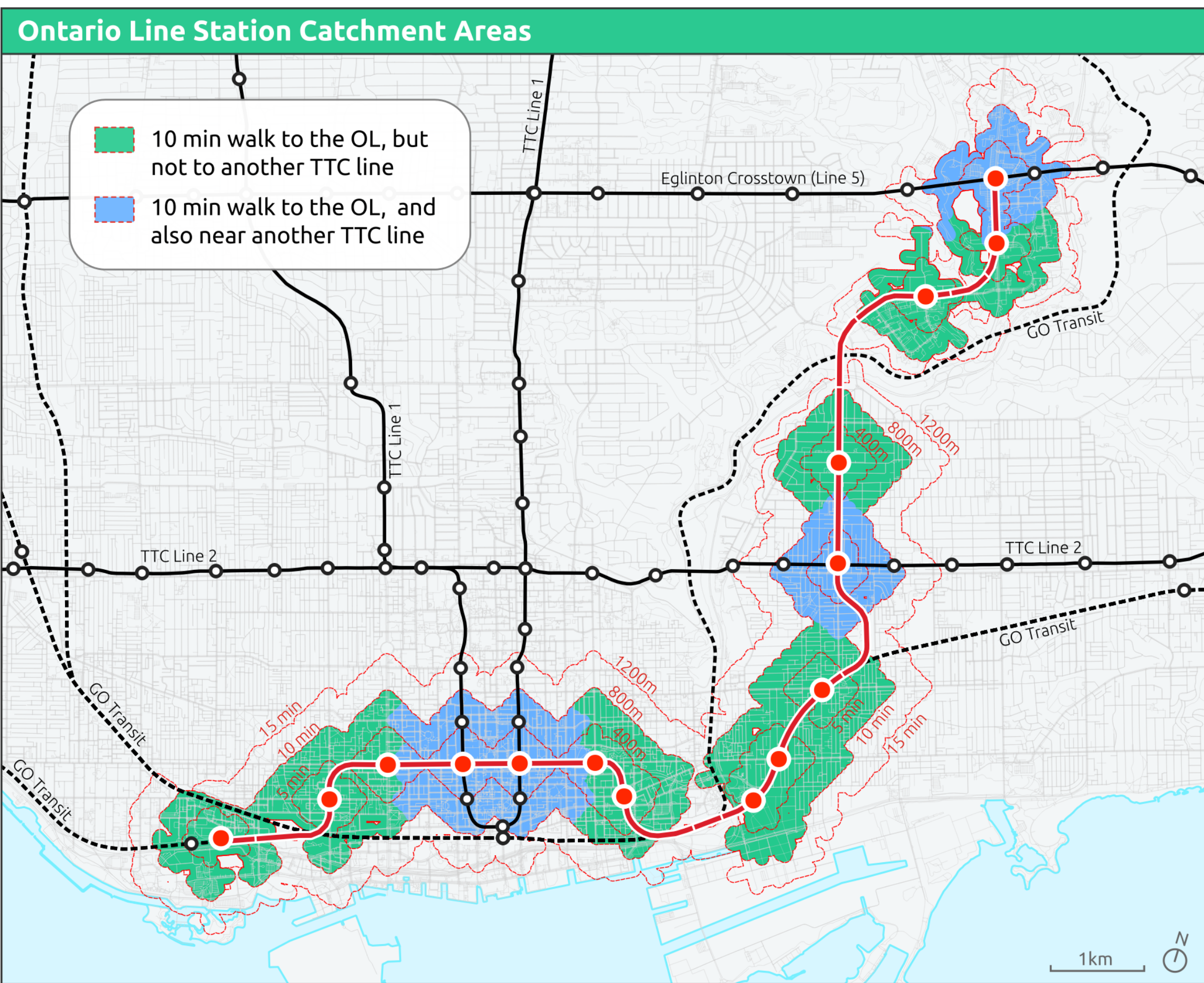


Analysis & Results:

1) Access to Transit

We estimate populations living within walking distance to new rapid transit stations via network analysis and areal interpolation.

Results are summarized for low-income households and other SES groups



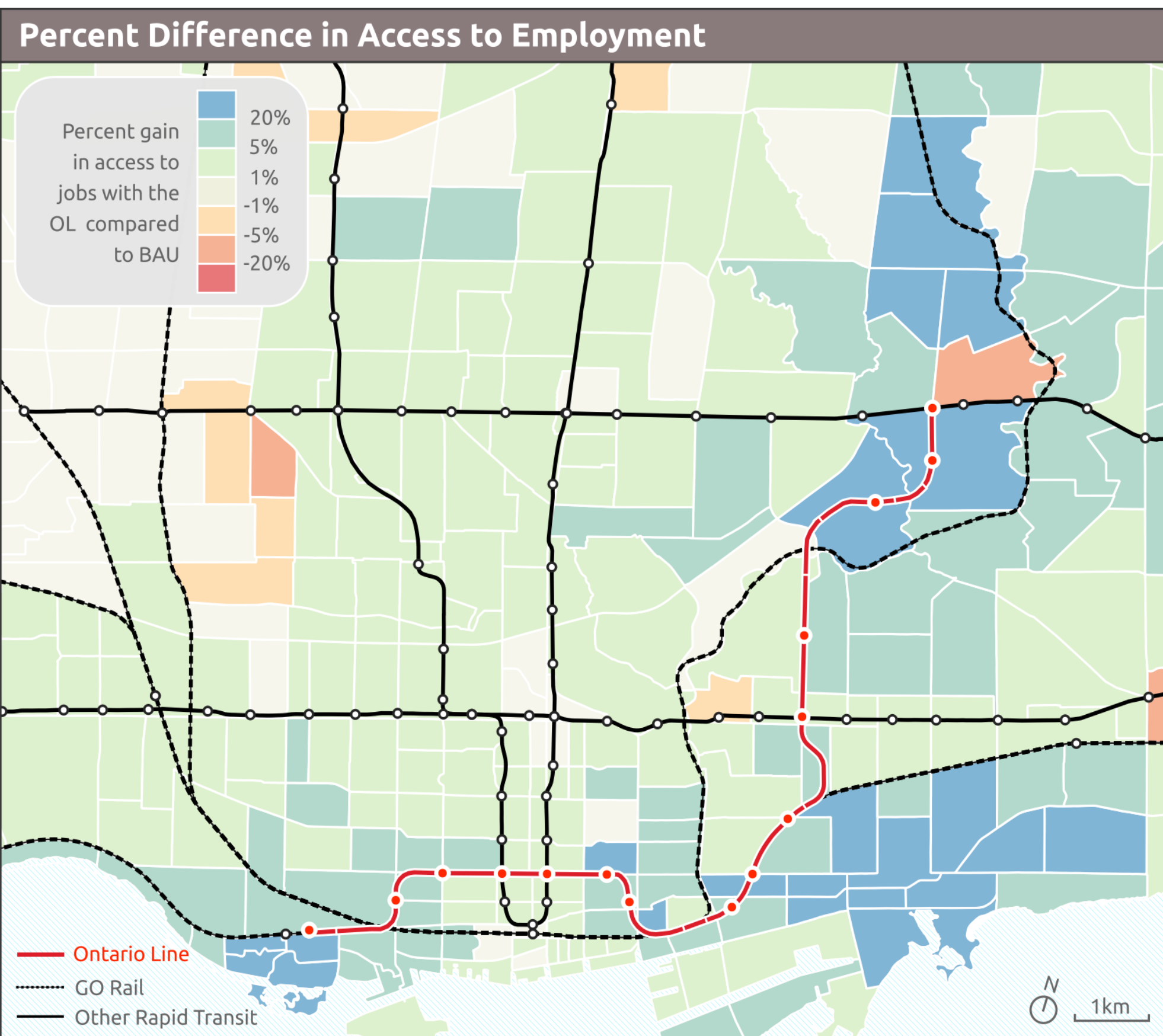
		10 Minute Walk to OL (800m)			
		All Stations	New Stations	Toronto	GTHA
Unemployed	Total	7,000	4,900	122,300	289,000
	Percent	6.7%	6.8%	8.2%	7.7%
Low Income Cut-Off (LICO)	Total	36,200	25,800	469,300	844,100
	Percent	22.2%	22.8%	17.4%	12.3%
Low Income Measure (LIM)	Total	40,500	29,300	543,400	1,039,300
	Percent	24.8%	25.8%	20.2%	15.1%
Visible Minority	Total	76,300	53,300	1,385,900	3,194,000
	Percent	46.7%	47.0%	51.5%	46.5%
Recent Immigrant (2011-2016)	Total	11,000	8,100	188,000	377,400
	Percent	6.7%	7.1%	7.0%	5.5%

Note: the percentages above are based on the category (e.g. unemployed / labour force instead of unemployed / total population)

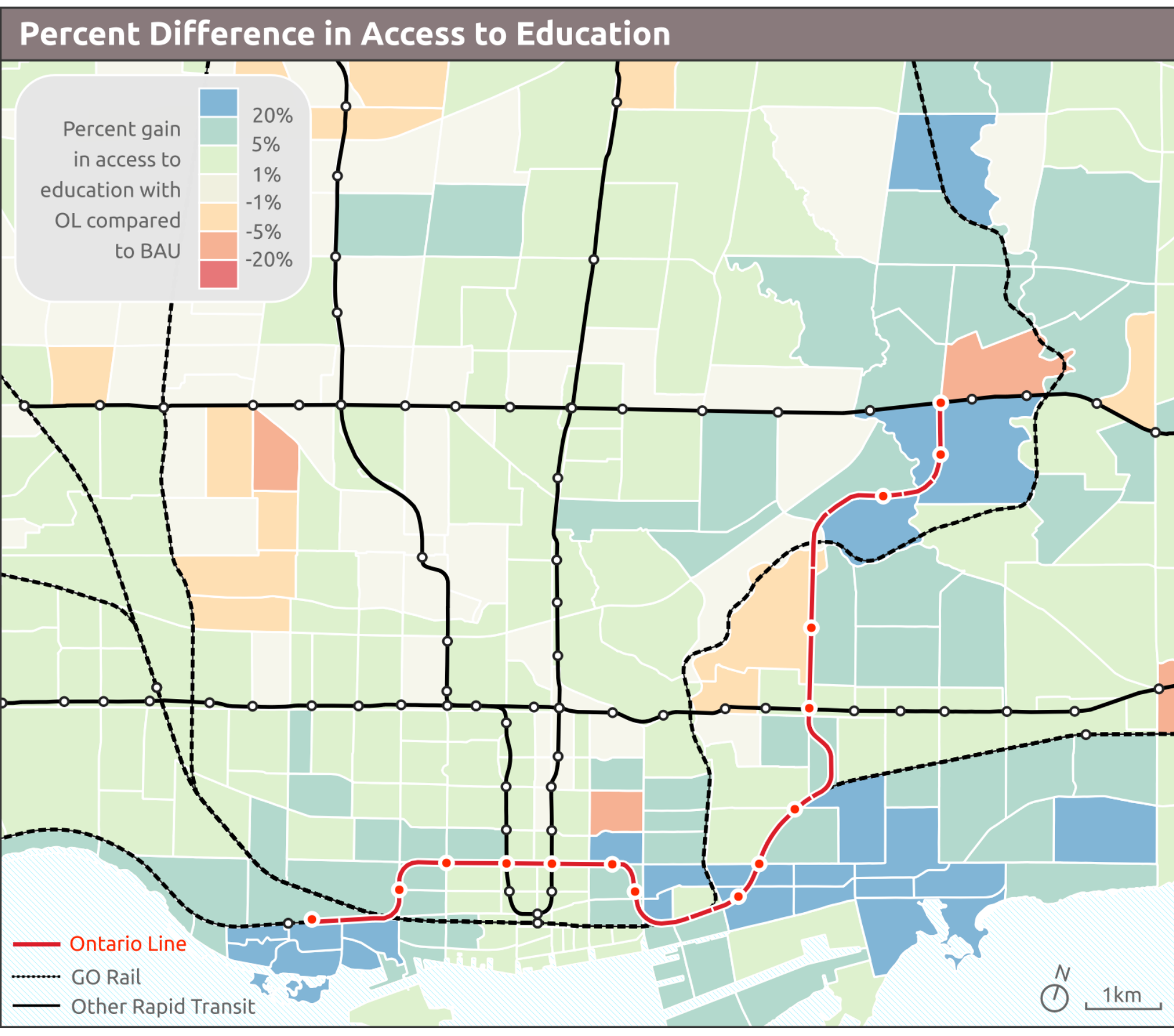
2) Access to Destinations by Transit

We compute gravity-based accessibility measures to estimate changes in accessibility to employment, low-income employment, and education. Results are summarized by SES.

$$A_i = \sum_j o_j f(t_{ij}) \quad f(t_{ij}) = 1 - CDF(t_{ij})$$



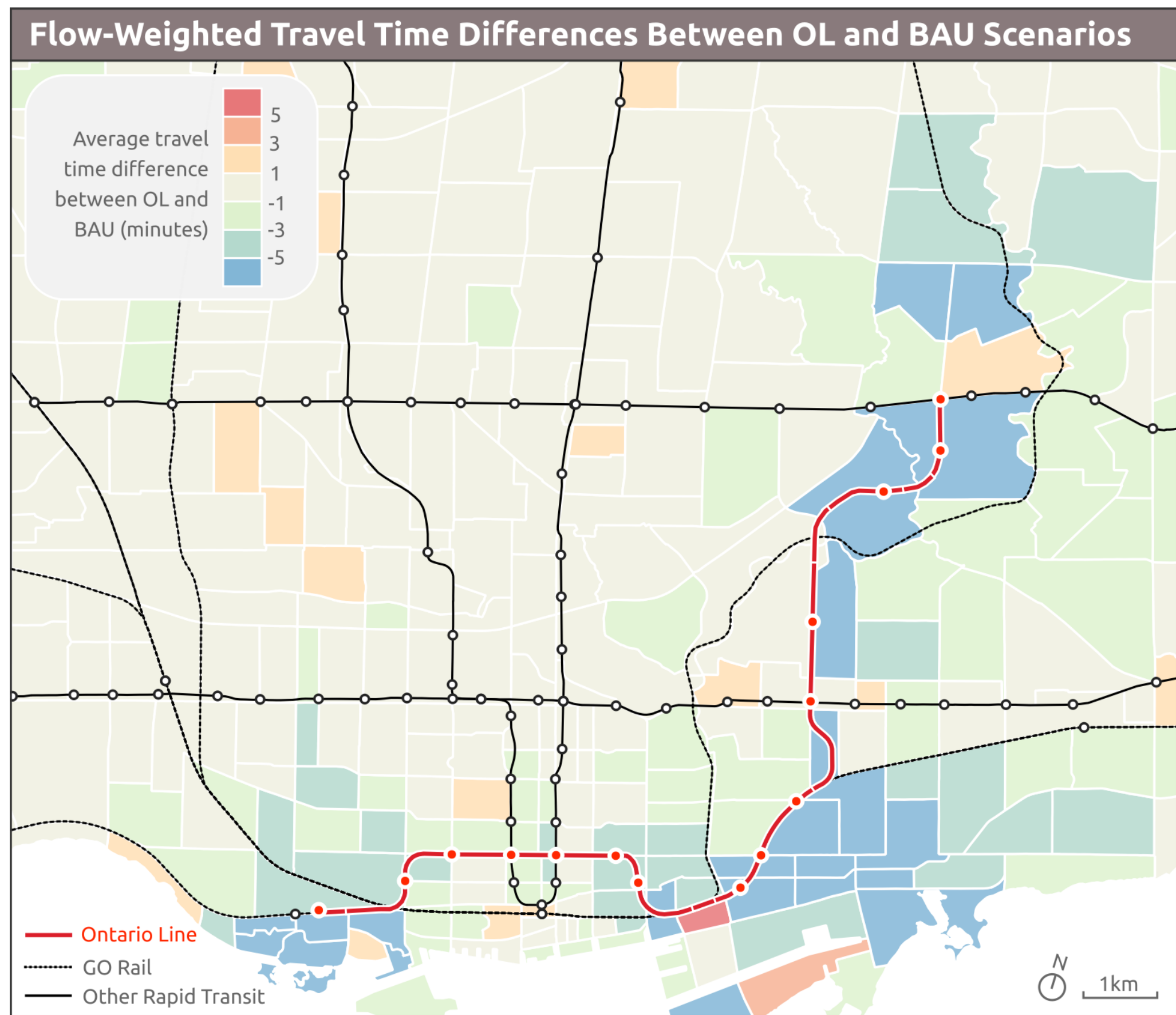
	Percent Increase in Access to Jobs (2041)		
	GTHA	City of Toronto	5km of OL
Overall Population	0.9 %	3.3 %	7.1 %
Unemployed	1.0 %	3.3 %	7.5 %
Low Income Cut-Off (LICO)	1.9 %	3.8 %	8.2 %
Low Income Measure (LIM)	1.8 %	3.8 %	8.7 %
Visible Minority	1.1 %	3.1 %	9.0 %
Recent Immigrant (2011-2016)	1.6 %	3.4 %	8.9 %



	Percent Increase in Access to All Education (2041)		
	GTHA	City of Toronto	5km of OL
Overall Population	1.1 %	3.3 %	6.7 %
Unemployed	1.2 %	3.2 %	6.8 %
Low Income Cut-Off (LICO)	2.0 %	3.7 %	7.6 %
Low Income Measure (LIM)	1.8 %	3.7 %	7.9 %
Visible Minority	1.3 %	3.1 %	8.2 %
Recent Immigrant (2011-2016)	1.6 %	3.3 %	8.0 %

3) Travel Time Savings

Mapping and tabulating the average minutes saved per trip by transit riders, displayed by neighbourhood and SES group.

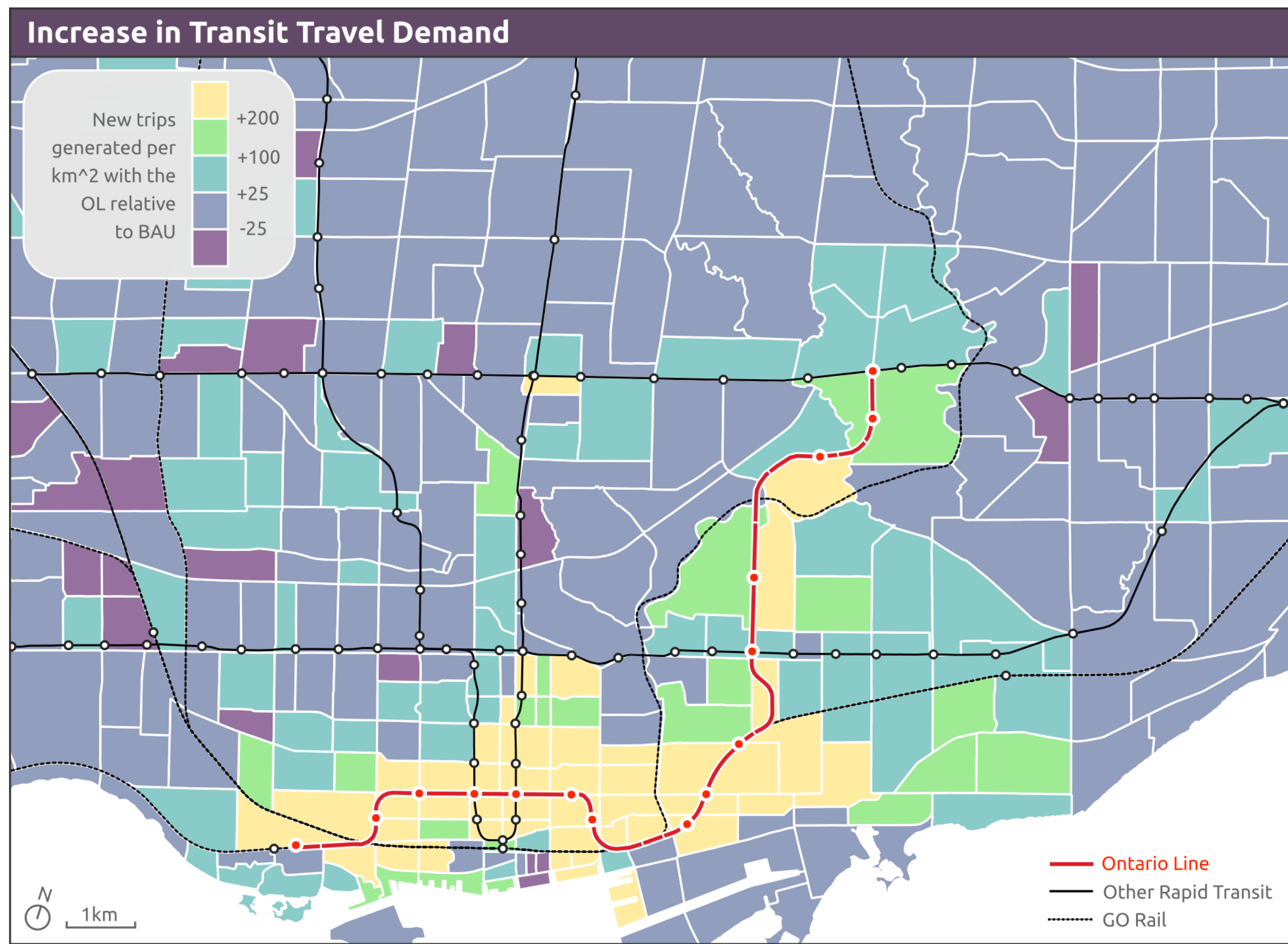


	GTHA		City of Toronto		5km of OL	
	Minutes	Percent	Minutes	Percent	Minutes	Percent
Overall Population	0.69	0.71	1.09	1.75	1.76	3.19
Unemployed	0.65	0.72	1.05	1.69	1.72	3.14
Low Income Cut-Off (LICO)	1.03	1.37	1.20	1.97	1.84	3.42
Low Income Measure (LIM)	0.98	1.21	1.21	1.98	1.94	3.59
Visible Minority	0.86	0.97	1.08	1.69	2.04	3.71
Recent Immigrant (2011-2016)	0.87	1.08	1.00	1.60	1.91	3.47

4) Demand Differentials

Mapping and tabulating increase in transit trips by zone and SES group.

An increase in transit use by residents in a zone can be interpreted as improved utility and quality of life for residents in a neighbourhood.



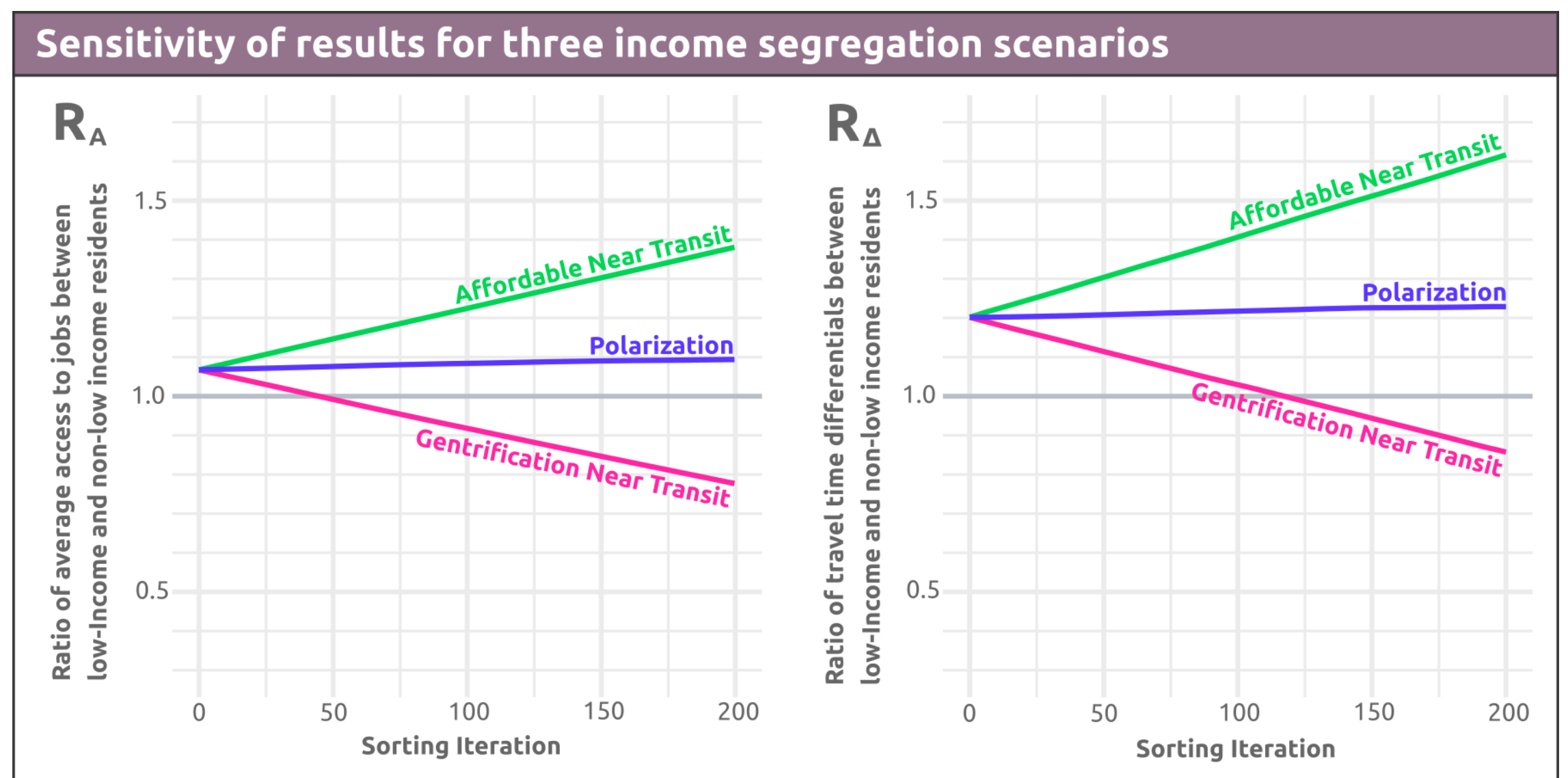
	New Transit Demand (2041)		Toronto (2016)		GTHA (2016)	
	Trips	Percent* of Trips	Percent* of Population	Percent* of Population	Percent* of Population	
Overall Population	15,259					
Unemployed	639	4.9%	8.2%	7.7%		
Low Income Cut-Off (LICO)	2,663	17.9%	17.4%	12.3%		
Low Income Measure (LIM)	3,037	20.4%	20.2%	15.1%		
Visible Minority	6,099	40.9%	51.5%	46.5%		
Recent Immigrant (2011-2016)	806	5.4%	7.0%	5.5%		

*based on sub-group that each belongs to (e.g. private households, labour force, etc.), not the overall population.

5) Sensitivity to Population Dynamics

Accounting for uncertainty in future population dynamics via a sensitivity analysis for three scenarios: **A)** increased income polarization, **B)** gentrification near transit, and **C)** affordable housing near transit.

For each scenario, we run a residential sorting process where low-income populations are redistributed to new neighbourhoods. For each iteration, we compute ratios of accessibility and travel time savings, comparing low-income households to the overall population.



Conclusions:

We find that overall, the benefits of the Ontario Line are evenly distributed across population groups, with modest concentrations specifically among lower-SES groups, particularly those below the poverty line.

However, this will not be the case if gentrification occurs in areas of relatively higher transit accessibility causing a substantial spatial redistribution of low-income households to concentrate in less accessible neighbourhoods.

Overall, the procedure outlined in this paper can also be applied in other regions and for a variety of transport land-use scenarios if data are available.

Future work should examine benefits for other times of day and days of the week, a variety of employment land-use projections, and include a more detailed analysis of potential population dynamics.