Benchmarking, Planning, and Promoting Transit-Oriented Intensification in Rapid Transit Station Areas

March 2016

This project was produced by MITL with support from the Government of Ontario

McMASTER INSTITUTE FOR TRANSPORTATION & LOGISTICS

Ontario

Benchmarking, Planning, and Promoting Transit-Oriented Intensification in Rapid Transit Station Areas

This project was produced with support from the Places to Grow Implementation Fund. The views expressed in this publication are those of the McMaster Institute for Transportation and Logistics and do not necessarily reflect those of the Government of Ontario.

Christopher D. Higgins

McMaster Institute of Transportation and Logistics
McMaster University
Hamilton, Ontario

March 2016

mitl.mcmaster.ca
@MITLnews

Table of Contents

1

Introduction

As population and employment in the Greater Golden Horseshoe (GGH) region increase, there is a need to continue investing in rapid transit infrastructure to connect people and jobs, reduce harmful greenhouse gas emissions from transportation, and ensure that congestion does not negatively affect Ontario's economic growth. However, changes to Ontario's transportation network do not happen in isolation. Transportation and land use are symbiotic processes, and for rapid transit to have a meaningful impact on shaping travel patterns in the region, new and existing rapid transit infrastructure projects must be integrated with land use planning to promote transit-oriented development (TOD).

TOD is generally understood as higher density, mixed-use, and pedestrian-friendly development around transit stations, and this concept has been shown to offer many benefits. Higher levels of population and employment densities around stations create a larger market for transit ridership, which can increase farebox revenue and balance flows on a transit network. Mixing of land uses also increases the potential for interaction between trip origins and destinations, and pedestrian-friendly 'Complete Street' urban design facilitates increased walking trips to and from the transit station and other local amenities (Higgins & Ferguson, 2012).

In terms of travel behaviour outcomes, implementations of TOD have been shown to result in increased transit ridership and reduced automobile dependence as well as higher levels of internal trip capture rates around transit stations compared to traditional automobile-oriented suburban developments (Ewing et al., 2011). Furthermore, Complete Streets have been shown to increase walking and cycling (Pucher et al.,

2011) and have even been associated with greater levels of economic development (Ferguson et al., 2015). More active transportation choices can promote healthier lifestyles and reduce transportation-related greenhouse gas emissions. Such benefits can also be self-reinforcing, as a network of TODs can create more opportunities for interaction along a transit system and potentially reduce the need for a private automobile. Finally, TOD has been shown to be particularly appealing for certain segments of the population, namely those in the baby-boomer cohort and their children (Cervero et al., 2004; Dittmar et al., 2004), a group Foot (1998) refers to as the ‘echo boomers’.

Taken together, TOD can offer a number of quality of life benefits for individuals, and for planners and policymakers, TOD is a great way to maximize the return on investment from existing and new rapid transit infrastructure. To help achieve these goals, the *Places to Grow Act, 2006* and Growth Plan for the Greater Golden Horseshoe combine with the *Greenbelt Act, 2005* and Big Move regional transportation plan to form the backbone of the Province of Ontario’s comprehensive growth management strategy for the GGH. The Growth Plan in particular provides direction to municipalities to increase population and employment densities around existing and planned rapid transit stations and along identified intensification corridors, and to do so in a way that is consistent with TOD.

This policy and planning framework is essential for helping the region to grow in a way that is more environmentally sustainable, socially equitable, and economically prosperous. However, it is clear from the literature on TOD that there is no ‘one-size-fits-all’ approach to TOD planning across transit station areas. Care must be taken to understand existing conditions, the scale and character of potential TOD implementations, and the right policy tools for supporting such development. For example, some future LRT station areas in Mississauga, Toronto, or Hamilton are already high density and pedestrian friendly, while others feature low-density and automobile-oriented land uses. Furthermore, replicating the level of density seen around some TTC stations in Toronto may be appropriate for some other locations throughout the region, but such intensity can also be wholly incompatible with what would be considered acceptable in other contexts. Finally, strategies to promote TOD should not only consider built environment characteristics, but other factors such as the socioeconomic and demographic profile of existing neighbourhoods and the displacement of vulnerable households, and the headwinds to new development and redevelopment posed by challenging real estate market conditions.

Nevertheless, adopting a context-sensitive approach to TOD poses its own challenges. With more than 400 rapid transit stations either in existence or in various stages of planning in the GGH, there is considerable diversity in station area contexts throughout the region. This diversity creates complexity for planners and policymakers at both the local and provincial levels in terms of understanding existing TOD conditions and potential policy interventions. Furthermore, such complexity also impedes the general public’s understanding how TOD is being implemented in their local community.

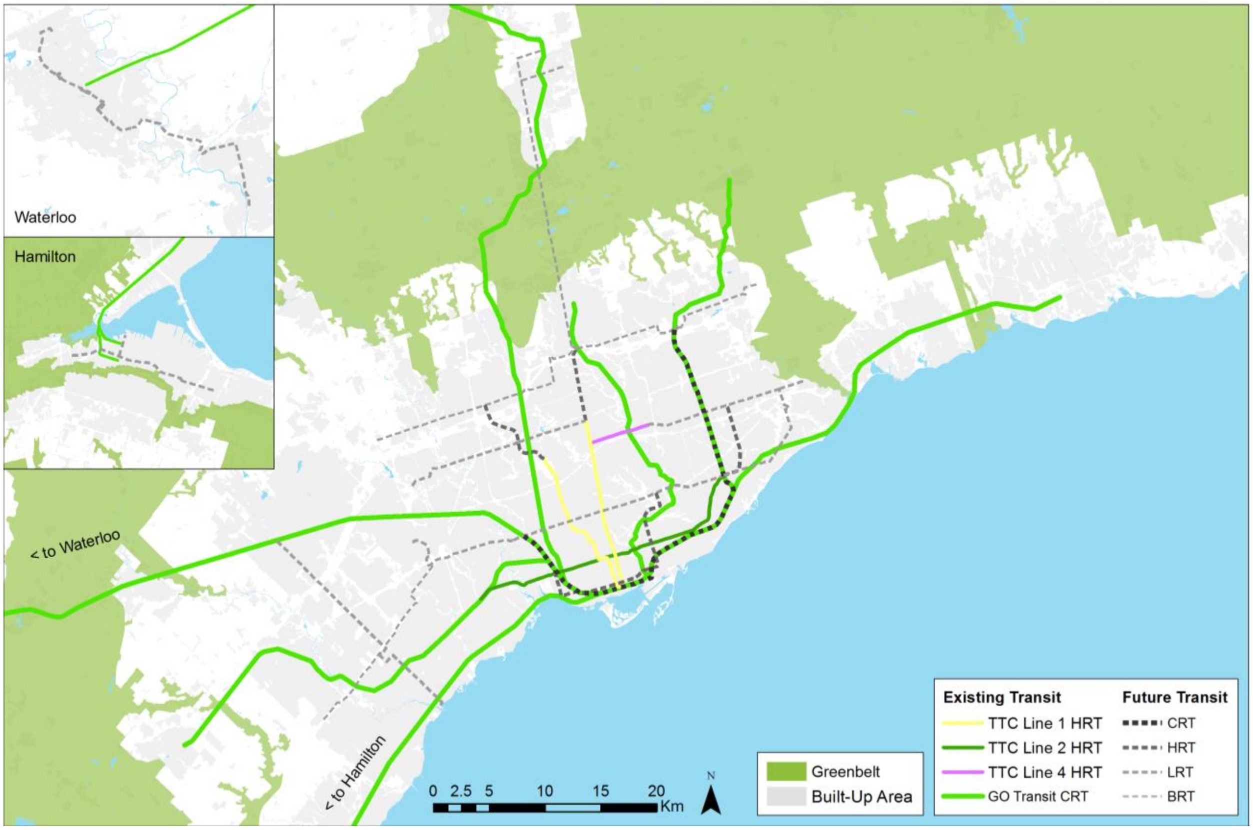
What is needed is a tool that can reduce this complexity to help existing local and provincial approaches to transit and TOD planning in the GGH and aid in building awareness of how the Growth Plan will affect individual neighbourhoods. To that end, the present project develops and applies an innovative planning tool that distils station area characteristics into a typology of similar station types. Next, this tool is applied to benchmark TOD in present and future rapid transit station areas in the GGH, identifying TOD performance and contrasting this performance with existing and proposed policy and planning to identify areas that can benefit from more targeted interventions. Finally, the project uses the information from the typology to perform a detailed case study of the Hamilton A-Line and B-Line LRT, examining station area characteristics, any challenges to TOD, and potential policy responses to maximize the return on investment for this significant infrastructure project.

Classifying TOD in the GGH Region

As shown in Figure 2-1, the GGH region is home to 61.5km of existing Heavy Rail Transit (HRT) across three Toronto Transit Commission (TTC) subway lines and 452km of Commuter Rail Transit (CRT) over 7 GO lines. This project also focuses on a number of future rapid transit lines and extensions in various stages of construction and planning across the region, including 41km of new CRT through the SmartTrack project, 42km of new HRT over 4 lines, 146km of Light Rail Transit (LRT) over 13 lines and extensions, and 95km of Bus Rapid Transit (BRT) across 3 lines. Across the selected projects there are 418 individual transit stations. It should be noted that only a subset of these future projects have started construction or have secured funding, with the rest in various stages of planning. It should be noted that alignments and station locations for future infrastructure are purely conceptual and their inclusion in the present study should not be construed as a commitment for construction. This list of projects is simply a hypothetical sample and changes in terms of alignments, station locations, and other features are likely to occur.

Within this sample of 418 stations, there is a great diversity in implementations of TOD in existing and future rapid transit station areas in the GGH. This creates complexity for understanding an area's present TOD and its performance against policy benchmarks, as well as its future TOD potential. One way in which this complexity can be reduced is through the production of rapid transit station area TOD typologies, wherein characteristics of station areas are quantified and classified using clustering models. From this, a typology of broadly similar station types can be used to better understand existing conditions and contrast them with policy benchmarks for TOD performance. This chapter first presents a brief overview of the TOD typology approach and constructs its own for the GGH region.

Figure 2-1. Existing and Future Rapid Transit Infrastructure in the GGH Region



2.1. The TOD Typology Approach

The academic literature reveals emerging interest in creating typologies of rapid transit stations to aid in policy and planning (Higgins & Kanaroglou, 2016b), and the literature can be broken down by two main goals. First, several authors have proposed different types of potential TOD implementations to make the land use changes associated with the concept more sensitive to local context. This research is normative in the sense that it seeks to develop typologies for how TOD should be implemented. For example, Calthorpe (1993) argued that there can be no 'one-size-fits-all' approach to implementing TOD and promoted either 'urban' or 'neighbourhood' scale designs. Dittmar and Poticha (2004) produced a more detailed TOD typology consisting of 6 hypothetical contexts: urban downtown, urban neighbourhood, suburban centre, suburban neighbourhood, neighbourhood transit zone, and commuter town centre. Some cities have pursued this approach in their own TOD planning. The City of Denver (2014) delineated 5 different station area TOD types around its LRT and CRT lines: downtown, urban centre, general urban, urban, and suburban. These station types are then used to create context-sensitive planning policies to help turn their visions into reality.

A second area of research works from a positive perspective and is interested in classifying rapid transit station areas according to their existing characteristics. Bertolini (1999) for example produced a 'node-place' index to classify stations in the Netherlands according to their nodal accessibility and land use intensity and diversity. This model has been expanded and applied to Switzerland in the work of Reusser et al. (2008) and Zemp et al. (2011), and to Tokyo by Chorus and Bertolini (2011).

Beyond node-place models, other researchers have sought other ways to classify existing station area TOD characteristics. Atkinson-Palombo (2010) identified 5 neighbourhood types along Phoenix's first LRT line based on their land use mix: amenity rich, residential-dominated mixed-use, amenity-rich with vacant land, amenity-dominated mixed-use, and residential. Atkinson-Palombo and Kuby (2011) examined transit-oriented overlay zoning around the same line and measured twelve separate transportation, social, demographic, and land use characteristics. A clustering model revealed 5 station types: transportation nodes, high population rental neighbourhoods, areas of urban poverty, employment and amenity centres, and middle-income mixed use. Finally, Kamruzzaman et al. (2014) measured density, land use diversity, public transit accessibility, and the pedestrian environment to classify TOD in census collection districts in Brisbane, Australia. The model resulted in four station types: existing neighbourhood residential TOD, activity centre TOD, potential TOD, and non-TOD.

This project continues the tradition of the positive approaches and will classify the TOD performance of all 418 existing and future station areas in the GGH. However, we improve on these studies by utilizing latent class model-based clustering methods and a comprehensive quantification of TOD inputs and outcomes.

2.2. Methodology

The method used to create a TOD typology from the GGH consists of utilizing latent class model-based clustering techniques to classify a number of measures of TOD. We detail both the model and TOD variables below. This method is derived from the work of Higgins and Kanaroglou (2016b) but is refined with employment data from Statistics Canada's 2011 National Household Survey.

2.2.1. Latent Class Clustering

Clustering involves classifying observations into similar groups, and typically this is done through the use of Ward's method or the k-means method. However, compared to these approaches, latent class clustering models have the added benefits of being able to accommodate a mix of variable types (nominal, ordinal, continuous) and unstandardized variables, and offer the user statistics such as the Bayesian Information Criterion (BIC) to determine the optimal number of cluster solutions. Readers interested in a more detailed overview of latent class models in general and compared to other TOD typologies specifically are directed to the work of Masyn (2013) and Higgins and Kanaroglou (2016b) respectively.

2.2.2. Model Variables

To classify TOD in the GGH region, it is important to make a conceptual distinction between measures of TOD *inputs* and TOD *outcomes*. Here we are primarily interested in quantifying TOD *inputs* - the factors that come together to produce a built form that is transit supportive. How can TOD input factors be measured? While Cervero et al. (2004) note that no strict definition of TOD exists, the concept is generally understood to refer to a high-density, mixed-use, and walkable built form around a transit facility. To measure TOD inputs we turn to the 'D' variables first proposed by Cervero and Kockelman (1997) and expanded by Ewing and Cervero (2010): distance to transit, density, diversity, design, and destination accessibility.

TOD *outputs* on the other hand refer to the ways in which TOD inputs ultimately affect things like travel behaviour. Renne (2009b) notes that there are a number of other ways to measure the performance of TOD outcomes, including transit ridership and alternative mode use, transit farebox returns, household automobile ownership levels and vehicle-kilometres travelled (VKT), changes in property values, or other economic development indicators.

There is a final 'D' variable, that of demographics, and it is more conceptually problematic. As noted in the introduction, the TOD concept is said to be particularly appealing to certain demographic sub-markets, which can be both an outcome in terms of people locating in existing TODs, as well as an input, as the existence of TOD preferences creates market demand for TOD projects. However, because we are primarily interested in benchmarking the input performance of TOD in terms of built environment and accessibility characteristics, we consider demographics a TOD outcome.

Next we present the definition of each input variable and its relation to TOD as well as how it is operationalized in our model. A summary of each of the measures that enters the model is presented below in Table 2-1.

Distance to Transit. The distance from a station, or how we are defining what constitutes a station catchment area, is a key input into our typology model. Our approach uses the work of Guerra et al. (2013) as a base and defines a catchment area in two ways. The first is a station's *theoretical* catchment area, measured according to a distance of 800 metres from a station, and is used to capture the general context in which a station is located. The second is a station's *functional* catchment area, measured as the area covered by a 10-minute walk on the road and pedestrian path network from a station. This catchment area captures how we assume a station is typically used. For a visual depiction of each, refer to Figure 2-2 below.

Density. This measure reflects the intensity of opportunities for interaction within a station area. For the present study, *density* is measured as the total population and employment per hectare within a station's theoretical catchment area. Data on population and employment is from the 2011 Canadian Census of Population and National Household Survey and refers to population counts and place of work destinations at the Dissemination Area (DA) level of geography. From this, we also calculate a measure of *development mix* to control for each station's orientation to either population or employment land uses, which is the ratio of employment and population to employment in a station's circular 800 metre theoretical catchment area.

Diversity. Compared to single-use structures, which host only residential or commercial activities for example, mixed land uses help promote greater potential for interaction in a smaller geographic area by hosting two or more uses within a single structure or site, such as a condominium tower with street-level commercial activity. Measuring land use mix is a proxy for how locationally-efficient and amenity-rich an area may be. In previous work, land use mix is typically operationalized through a measure of entropy or Simpson indices. However, we capture diversity directly through the proportion of single-use residential, commercial, industrial, and institutional parcels in a station's theoretical area and parcels with a mix of residential and either commercial or institutional land uses.

Design. The start and end of transit journeys are typically made on foot, and because of this, TOD champions pedestrian-oriented street design and high levels of street connectivity. Much of this is directly related to the implementation of Complete Streets concepts, a detailed review of which can be found in Ferguson et al. (2015). To measure street design, we compare a station's functional buffer, which is the area of distance that can be travelled on the road and pedestrian path network within a transit station area, with a station's circular theoretical buffer, which is the area contained within 800 metres from the station. This ratio of a station's functional area to its theoretical area serves as a useful proxy for pedestrian friendliness and the quality of pedestrian access to the transit station as it implicitly captures street connectivity and intersection and cul-de-sac density. However, it cannot measure more qualitative aspects of the pedestrian environment.

Destination Accessibility. This refers to the transportation accessibility benefits offered by rapid transit. To measure this, we calculate functional population and employment totals within a 10-minute walk of the station and travel times between all station origin and destination pairs. For existing infrastructure, this is done by using travel time information from transit agency General Transit Feed Specification timetables. For future infrastructure, end-to-end travel times are drawn from planning documents. All of this information is input into the ArcGIS Network Analyst to create a travel time matrix. A station's accessibility is then captured by a measure of *interaction potential* detailed in Table 2-1.

Table 2-1. Latent Class Model Variables and Definitions

1. *Density:*
   Reflects density and the intensity of land use development in a station area. Calculated as total Population + Employment / Hectare within each station's theoretical buffer area.
2. *Development Mix:*
   A statistic ranging between 0 and 1 that reflects the balance between population and employment in a station area. Calculated as the ratio of Employment to Population + Employment.
3. *Street Connectivity:*
   Measures overall street connectivity and the quality of pedestrian access to the transit station. Calculated as the ratio of a station's 10-minute walk buffer on the local road network to its 800-m circular buffer. In this case all station buffers were permitted to overlap to give a measure of overall street connectivity in the neighbourhood.
4. *Interaction Potential:*
   Regional station accessibility and interaction potential, or measure of gravity considering population, employment, and travel time. For station areas oriented to population (Development Mix <.5), total interaction potential is calculated as:

$$POPEMPGRAV_{ij} = \ln \sum_{\forall j \neq i} \frac{(Pop_i)(Emp_j)}{TT_{ij}^2}$$

   Where:
   Pop_i = the total population in the labour force in station i
   Emp_j = the total employment in station j
   TT_{ij} = the travel time on transit between stations i and j
   The numerator is reversed for stations oriented to employment (Development Mix >.5)
5. *Land Use Mix:*
   The proportion of residential, commercial, institutional, mixed, and industrial land in each station area. Commercial and institutional lands are combined into a single category.

2.2.3. Model Estimation

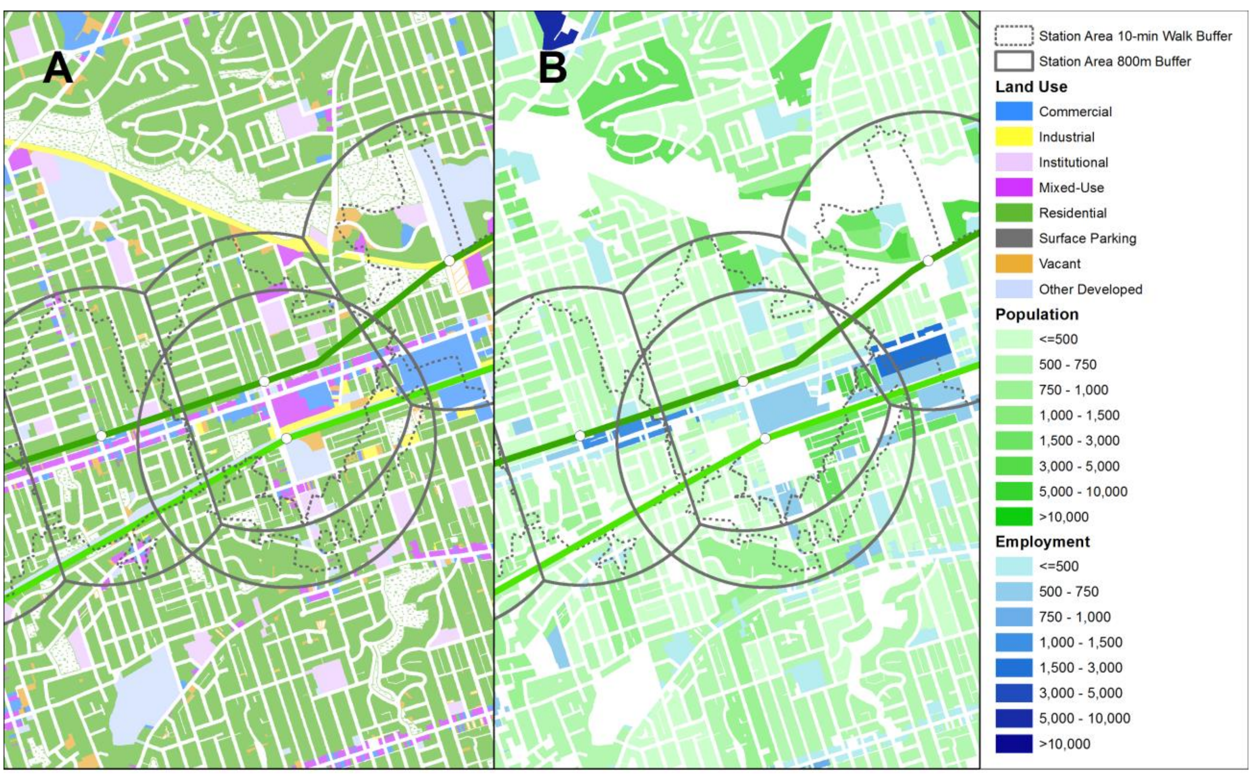
As detailed in Higgins and Kanaroglou (2016b), the typology is estimated as follows. First, stations are located geographically. This consists of placing points that correspond to the location of each existing station. For future stations, locations are determined based on planning documents that feature precise station locations, or the names of cross-streets. For the latter, station points are placed at the intersection of these streets.

From this, each station's theoretical and functional catchment area buffers are calculated. Buffers of adjacent stations are not permitted to overlap, as this would lead to a double-counting of station area characteristics in the model, such as the amount of population and employment at a station for the Destination Accessibility metrics, and it was our goal to capture each station's unique catchment area. The exception to this is for overlapping buffers on the GO and SmartTrack CRT lines and every other rapid transit line. This was done because an analysis of the Transportation Tomorrow Survey for 2011 revealed that the vast majority of individuals do not transfer between the CRT and HRT networks (88% of trips) and between the HRT and CRT networks (97% of trips). As such, commuter rail transit appears to attract a very different type of trip in the region, and with little overlap in network usage we allowed the station buffers of each network type to cover one another.

Next, ArcGIS is used to quantify the variables detailed in Table 2-1. Information on land use, population, and employment in each station catchment area buffer is calculated over two steps. First, to improve the accuracy of population and employment counts from the 2011 Census and National Household Survey, land use data is first used to remove any areas from each DA that were not oriented to population or employment. Second, the proportion of each type of data in particular station buffers is determined. If for example 60% of a population DA with 1,000 inhabitants is in a station buffer, we assign 600 of them to the station area. This is repeated for all DAs in the station area and summed.

Figure 2-2 provides a graphical depiction of this process near the Danforth GO and several stations on the TTC's Line 2 subway in the City of Toronto. Here land use data is shown in Panel A, population and employment data in Panel B, and both panels show a station's theoretical and functional catchment buffers. All of the information above is combined and input into the latent class model to estimate the typology.

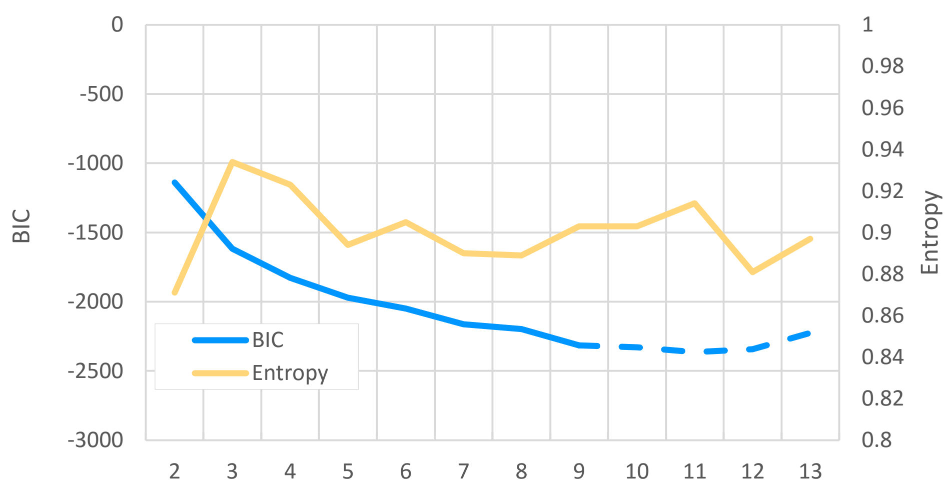
Figure 2-2. Overview of Station Area Land Use (A), Population and Employment Data (B), and Methods of Analysis



2.2.4. Results

Using MPLUS version 7.2, the best fitting model according to the Bayesian Information Criterion was one with 9 station types (Figure 2-3), after which models fail to converge as they are attempting to extract more clusters than supported by the data. To avoid issues with local independence, a covariate relationship between density and interaction potential was specified (see Higgins and Kanaroglou (2016b) for more information). Stations around the Lester B. Pearson International Airport were manually excluded from the model as their land use characteristics were almost entirely 'Other Developed', which created an outlier category that caused models to not converge. Because of this, it was determined these three stations belong in their own 'Airport' cluster.

Figure 2-3. Latent Class Model Fit Statistics

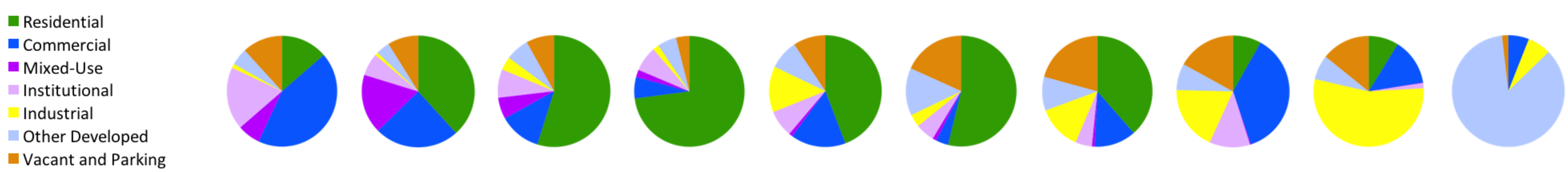


Together with the 9 clusters from the model, the addition of the airport cluster resulted in 10 distinct station types within the study area. Results from the clustering model are displayed in Table 2-2, including information manually obtained for the *Airport* station type, and this information is used to derive the station names at the top of this table and defined in Table 2-3. From Table 2-2 we can see that the model is useful for delineating the key characteristics of different station area categories. *Urban Commercial Core* stations for example feature very high average densities of 753 people and jobs per hectare, though of this, their development mix is predominately oriented to employment (0.92). Likewise, most land is dedicated to commercial and institutional uses. Walking connectivity is the highest among all station types at 0.61, and transit accessibility to people and jobs is very high at 20.38, reflective of their central location.

Moving down the hierarchy of station types, the context of each type becomes more suburban in character. For example, average land use densities of 130 people and jobs per hectare in *Inner Urban Neighbourhoods* are very high compared to an average of 27 within *Exurban Neighbourhoods*. More urban stations generally feature higher levels of land use mixing, walking connectivity, and transit accessibility. In contrast, more *Suburban*-type stations feature more homogeneous land uses, lower development intensity, transit accessibility to people and jobs, and walking connectivity attributable to cul-de-sac street designs and larger parcels.

Table 2-2. Latent Class Model Results – TOD Input Performance

TOD Measure (Average)	1. Urban Commercial Core	2. Urban Mixed-Use Core	3. Inner Urban Neighbourhood	4. Urban Neighbourhood	5. Suburban Neighbourhood	6. Outer Suburban Neighbourhood	7. Exurban Neighbourhood	8. Suburban Centre	9. Outer Suburban Industrial Park	10. Airport[1]	Standard Deviation
Accessibility											
Interaction Potential	20.38***	19.96***	18.24***	16.77***	15.84***	14.78***	12.99***	15.59***	14.83***	11.82	1.54***
Land Use											
Normalized Density	753***	436***	130***	68***	50***	32***	27***	38***	29***	15	1.15***
Development Mix (Prop.)	0.85***	0.55***	0.37***	0.15***	0.44***	0.13***	0.42***	0.89***	0.85***	1.00	0.12***
Walk Connectivity (Prop.)	0.61***	0.59***	0.56***	0.53***	0.47***	0.39***	0.25***	0.44***	0.37***	0.32	0.08***
Land Use Mix											
Residential (Prop.)	0.10***	0.29***	0.47***	0.65***	0.37***	0.41***	0.30***	0.07***	0.07**	0.00	0.12***
Commercial/ Institut. (Prop.)	0.57***	0.30***	0.19***	0.13***	0.22***	0.08***	0.14***	0.45***	0.13***	0.06	0.09***
Mixed-Use (Prop.)	0.06***	0.17***	0.06***	0.02***	0.01***	0.01***	0.01***	0.00**	0.00*	0.00	0.00***
Industrial (Prop.)	0.01***	0.01	0.04***	0.02***	0.12***	0.03***	0.11***	0.18***	0.48**	0.07	0.08***
Land Use Overview											



	1	2	3	4	5	6	7	8	9	10	SD
	n=12	*n*=8	*n*=51	*n*=123	*n*=83	*n*=54	*n*=21	*n*=27	*n*=36	*n*=3	*n*=418
Model Covariates											
Normalized Density with Interaction Potential				0.35***							

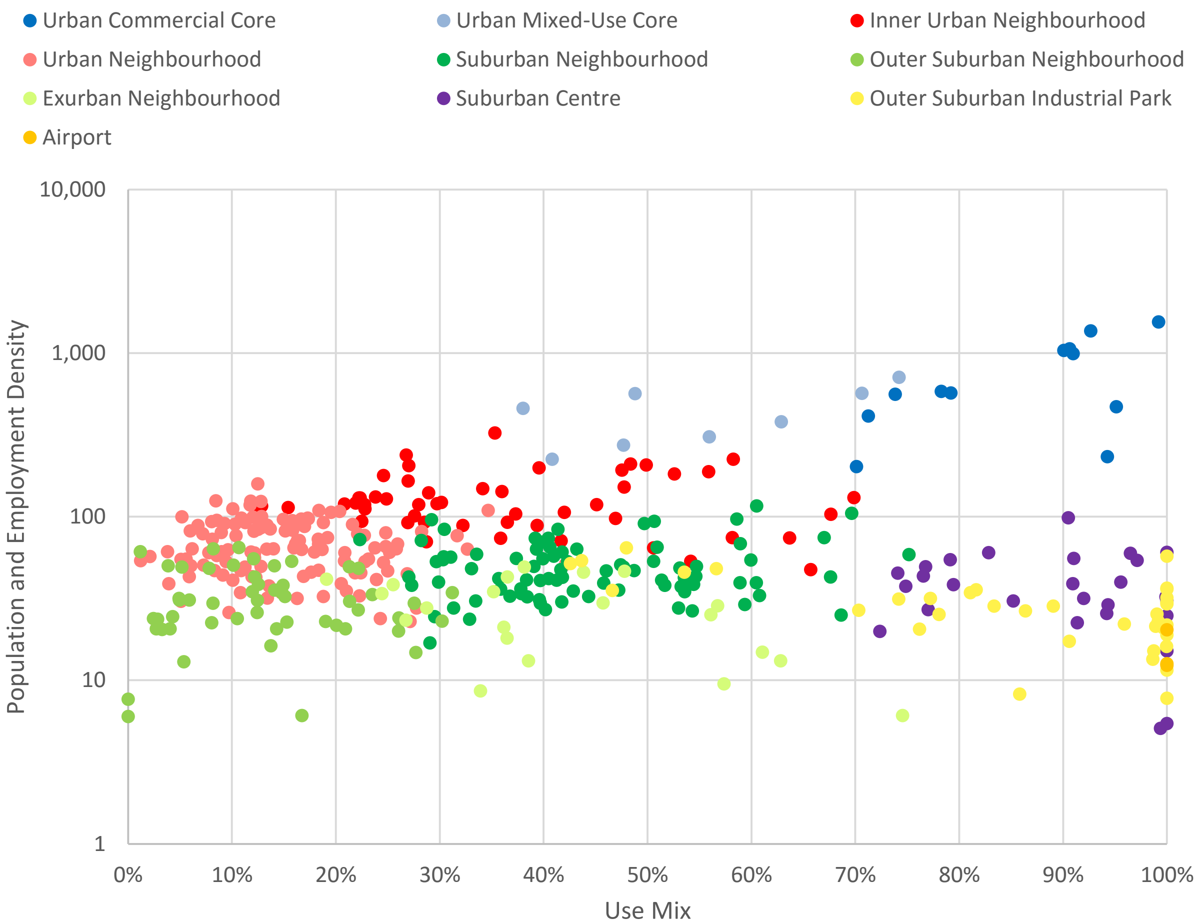
Notes: * indicates statistical significance at the .10% level, ** at the .05% level, and *** at the .01% level or smaller; 1) qualitative assessment

Table 2-3. Station Type Definitions

	Station Type	Definition
1.	Urban Commercial Core	Stations are located in the downtown core of the City of Toronto and served by high-capacity subway and commuter rail rapid transit. Primarily commercial and institutional land uses with some residential development and mixing of uses at very high population and employment densities. One other station of this type can be found in downtown Hamilton.
2.	Urban Mixed-Use Core	Stations with very high population and employment densities and a high mixing of uses. Generally located just outside the urban commercial core in the City of Toronto and at key regional intensification hubs.
3.	Inner Urban Neighbourhood	Stations with high-density residential, commercial, and mixed uses with high levels of accessibility to employment and jobs due to their location close to the urban core. A grid street pattern ensures good pedestrian accessibility.
4.	Urban Neighbourhood	Rapid transit stations located in predominately residential neighbourhoods that feature higher densities and some commercial activity and land use mixing. Station areas are older and well-established, feature a grid street pattern, and have good access to population and employment.
5.	Suburban Neighbourhood	Predominately residential areas with some commercial and institutional development but lower overall population and employment densities. Located farther from employment centres and increasing use of cul-de-sac street layout. Important trip origins along future rapid transit lines.
6.	Outer Suburban Neighbourhood	Low-density residential suburban or exurban areas with some commercial and industrial development. Many stations are located along CRT corridors. Low pedestrian accessibility due to automobile-oriented urban design. Large proportions of vacant land provide opportunities for future intensification.
7.	Exurban Neighbourhood	Low-density and automobile-oriented suburban and exurban areas. Predominately residential land use with some commercial and industrial development. Vacant land may present opportunities for future intensification.
8.	Suburban Centre	Station areas oriented to employment with high levels of commercial, industrial, and institutional land uses, but lower overall development intensity. Stations are important secondary destinations along present and future rapid transit lines and generally correspond to important regional sub-centres.
9.	Outer Suburban Industrial Park	Predominately automobile-oriented suburban and exurban industrial areas that feature low overall development intensity and low levels of pedestrian accessibility. Stations are located along CRT corridors and future rapid transit lines.
10.	Airport	LRT stations that service Lester B. Pearson International Airport and its surrounding environs. Stations feature low employment densities, but exist as important regional trip destinations.

Of the station categories, *Neighbourhood*-type stations are more balanced compared to other station types. An example of this can be seen in Figure 2-4 below. Here we plot each station by their density and development mix, and clear clusters of stations can be identified. The y-axis shows that more urban stations are generally higher in density than their suburban counterparts. Furthermore, the x-axis shows how *Urban Commercial Core*, *Suburban Centre*, and *Outer Suburban Industrial Park* stations are more oriented to employment uses while *Neighbourhood*-type stations are balanced or oriented to residential uses. It should be noted though that the information in Figure 2-4 displays only two of the TOD input measures that enter the typology model. The model considers all of the variables simultaneously when classifying stations.

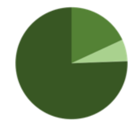
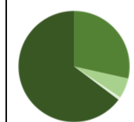
Figure 2-4. Rapid Transit Station Area Development Mix and Intensity



Finally, using the typology, it is interesting to contrast station types with different measures of TOD outputs. Using data from the 2011 Canadian Census of Population and the Transportation Tomorrow Survey, Table 2-4 shows several measures of travel behaviour and socioeconomic and demographic characteristics for each station type. Those that live in *Urban Commercial Core* and *Urban Mixed-Use Core* stations for example exhibit very high proportions of transit and walking use relative to other station types. Furthermore, their household vehicle kilometres travelled (HHVKT) is quite low. Rates of cycling appear only in more *Urban*-type stations, though in general cycling use is low relative to other modes and peaks at 3% in *Inner Urban Neighbourhoods*.

High proportions of those aged 20-34 and those with a Bachelor's degree or above suggests that these stations offer an environment that is particularly attractive to the young and highly-educated individuals. This is in line with the notion that TOD is particularly attractive to the millennial, or 'echo-boomer' cohort. However, these stations also feature proportions of those between the ages of 50-64 that are lower than the sample average, which demonstrates that this type of TOD is not particularly appealing to the empty-nesters of the baby-boom generation relative to other contexts. Median incomes are lower than the sample average of nearly $70,000, but the high proportion of those between the ages of 20-34 suggests that there are likely fewer dual-income households compared to other stations. In contrast, more *Suburban* station types are associated with lower levels of transit and alternative mode use, and higher automobile use measured as a proportion of all commutes and HHVKT.

Table 2-4. TOD Output Performance

TOD Measure (Average)	1. Urban Commercial Core	2. Urban Mixed-Use Core	3. Inner Urban Neighbourhood	4. Urban Neighbourhood	5. Suburban Neighbourhood	6. Outer Suburban Neighbourhood	7. Exurban Neighbourhood	8. Suburban Centre	9. Outer Suburban Industrial Park	10. Airport	Sample Average
Commute Mode Share Transit Walking Cycling Auto										-	
Travel Characteristics											
HHVKT	10.77	10.01	16.92	26.40	27.19	33.57	40.70	11.53	12.56	-	23.56
Socioeconomic Characteristics											
Average Median Household Income	$57,080	$57,274	$58,620	$72,838	$72,797	$79,075	$77,156	$59,076	$72,042	-	$69,665
Bachelor's Degree or Above (Prop.)	0.55	0.54	0.39	0.29	0.27	0.26	0.25	0.29	0.22	-	0.30
Demographic Characteristics											
Age 20-34 (Prop.)	0.42	0.40	0.28	0.21	0.21	0.19	0.21	0.26	0.22	-	0.23
Age 50-65 (Prop.)	0.15	0.15	0.18	0.20	0.20	0.20	0.20	0.19	0.20	-	0.19
	n=12	*n*=8	*n*=51	*n*=123	*n*=83	*n*=54	*n*=21	*n*=27	*n*=36	*n*=3	*n*=418

2.3. Station Types and the TOD Concept

What does this information mean in terms of classifying TOD? Transit-oriented development is the provision of higher-density, mixed-use, and pedestrian-friendly development oriented to transit, and if it is successful it should result in higher levels of transit and alternative mode use, and be attractive to particular segments of the population. Utilizing the information on TOD inputs and outputs presented above, we cannot say there is one 'best' TOD station type. Instead, we arrive at a scale of TOD wherein more *Urban*-type stations are more reflective of TOD as a concept. From this, Chapter 3 applies the typology to benchmark stations along present and future infrastructure in the region according to their TOD performance and identify opportunities for promoting greater transit-oriented intensification.

Still, it is also important to note that the TOD typology presented here measures the concept at a high-level using quantitative indicators associated with the 'D' variables. To focus only on this aspect would miss qualitative aspects of TOD that are also important in determining levels of transit-orientation around transit stations. To illuminate this aspect, Chapter 4 performs a detailed case study of two station areas along the future B-Line LRT in Hamilton.

Benchmarking TOD in Rapid Transit Station Areas

With the typology established, the project now turns to an application of the results of Chapter 2 to provide a more detailed investigation of the station area contexts along individual lines. Projects are evaluated according to the distribution of station types in general, and the locations of specific station types along each transit corridor. From this, the research offers a high-level benchmarking of TOD conditions around present and future infrastructure projects. We also comment on the potential for future transit-oriented intensification with a focus on existing development intensity in terms of population and job densities, and contrast this with information on intensification targets.

In terms of intensification, the Growth Plan for the Greater Golden Horseshoe region offers direction to municipalities to intensify land use development within key areas. This is operationalized through 5 different types of intensification area: high-density Urban Growth Centres that are the focal points of major regional centres and sub-centres, Intensification Nodes located around strategic infrastructure that can support higher density development, Intensification Corridors and Major Transit Station Areas (MTSA) that are planned to achieve an increase in density to support existing and planned transit service, and Other Major Opportunities, which are key areas of interest for intensification in the future.

The Growth Plan only sets explicit density targets for Urban Growth Centres, and these vary by municipality (Table 3-1). Other municipalities in the region are to achieve lower density levels, but they are omitted from this table as they do not host any of the projects in this study. For the purposes of the present project, it is assumed that target density levels for Intensification Nodes and Corridors are set at

100 and 50 people and jobs per hectare respectively. No targets are explicitly set for MTSAs or Other Major Opportunities, but in the case of this study, each station area is, or should be designated as a MTSA.

Table 3-1. Density Targets by Intensification Designation

Intensification Designation	Intensification Target (People + Jobs / Hectare)	Applicable Areas
Urban Growth Centres	400	City of Toronto
	200	Downtown Brampton Downtown Burlington Downtown Hamilton Downtown Milton Markham Centre Mississauga City Centre Newmarket Centre Midtown Oakville Downtown Oshawa Downtown Pickering Richmond Hill/Langstaff Gateway Vaughan Corporate Centre Downtown Kitchener Uptown Waterloo
Intensification Node	*(100)*	
Intensification Corridor	*(50)*	
Major Transit Station Area	-	
Other Major Opportunities	-	

Metrolinx, the provincial agency responsible for planning and implementing rapid transit projects across the GGH, has also identified a number of Mobility Hubs around the region. Mobility Hubs are important hubs of activity located around the intersection of major rapid transit infrastructure projects, and to ensure they are as supportive of transit as possible, Metrolinx (2011) lays out several recommended target levels of development intensity that vary by transit mode (Table 3-2). Recently, the proposed Growth Plan for the Greater Golden Horseshoe, 2016 includes minimum density targets that are to be achieved in MTSAs designated by municipalities by the year 2041 or earlier (Table 3-2). These targets vary from a high of 200 people and jobs per hectare in HRT subway station areas to 150 in express rail CRT stations. While the 2006 Growth Plan for the Greater Golden Horseshoe does not specify density levels for MTSAs, these target levels for individual modes offer another way of benchmarking how existing levels of development compare with those that are supportive of investments in each type of transit technology.

Table 3-2. Suggested and Proposed MTSA Densities

Predominant Transit Mode	Intensification Target (People + Jobs / Hectare) *Metrolinx Mobility Hubs*	*Proposed Growth Plan 2016*
HRT Subway	250+	200
Express Rail CRT	150-300	150
Light Rail Transit	200-400	160
Bus Rapid Transit	100-250	160
Regional Rail CRT	50-200	-
Bus/Streetcar	50-150	-

For the individual lines below, we identify stations that are designated as within an Urban Growth Centre, Intensification Node or Intensification Corridor and contrast existing levels of population and employment density with the targets in Table 3-1. We also highlight which stations are Mobility Hubs, but do not explicitly compare densities with the target density ranges proposed by Metrolinx (2011) or the 2016 proposed changes Growth Plan.

To begin, we first display a summary table with the distribution of station types along existing and future rapid transit lines across the region in Table 3-3. In assigning stations to lines, interchange stations are counted for each line that they connect to. However, stations that are the origin for a line extension are not counted twice. For example, Finch station is counted for the Line 1 subway and for the Finch West LRT Phase 2 project, but not for the proposed Yonge North subway extension. Overall average population and employment densities for each project are also shown in Figure 3-1. The density of GO's Union Station is very high at nearly 1,000 people and jobs per hectare, but is truncated to highlight variation in the remaining lines.

To get a better idea of how the individual station areas of each project reflect TOD as a concept, the following sections examine each line in greater detail. Projects are separated by mode, from HRT lines and extensions to LRT, BRT, and finally CRT. Each project contains a brief summary, an evaluation of existing land use development patterns relative to the TOD concept, and opportunities for transit-oriented intensification in the future.

Figure 3-1. Project Average Density

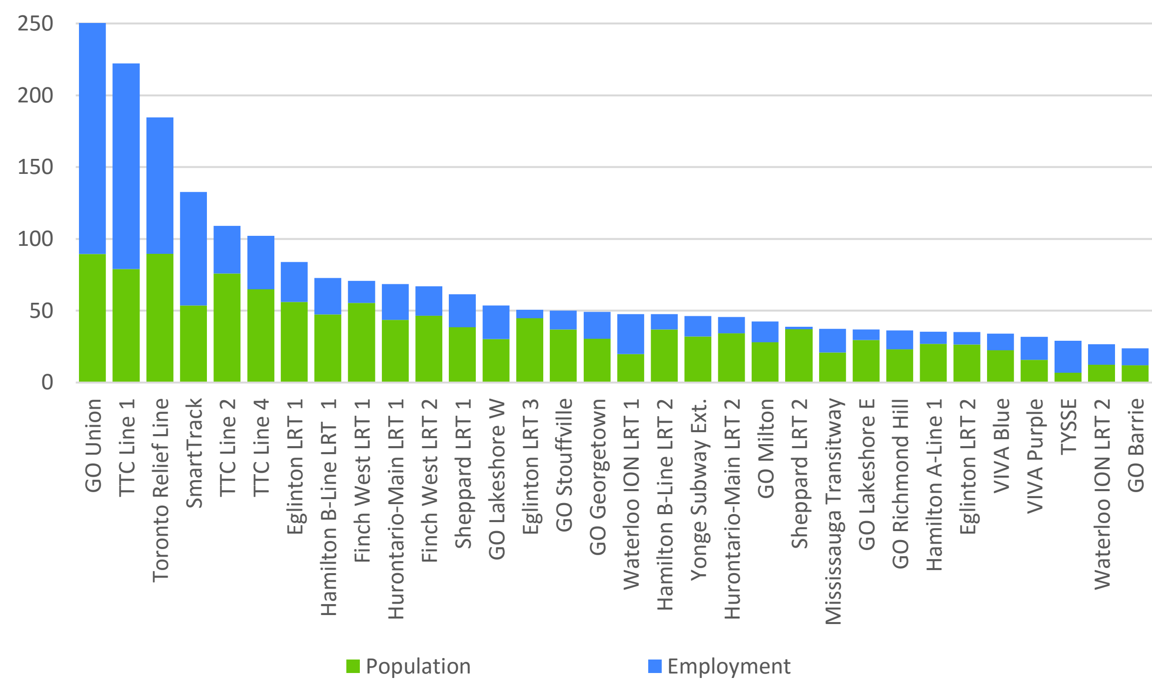


Table 3-3. Station Typology by Existing and Future Rapid Transit Projects

Row Labels	1. Urban Commercial Core	2. Urban Mixed-Use Core	3. Inner Urban Neighbourhood	4. Urban Neighbourhood	5. Suburban Neighbourhood	6. Outer Suburban Neighbourhood	7. Exurban Neighbourhood	8. Suburban Centre	9. Outer Suburban Industrial Park	10. Airport	Total
GO Transit Regional CRT											
Barrie					1	2	3		1		7
Georgetown			2	1	1	3	1		2		10
Lakeshore East				3	1	2	2		1		9
Lakeshore West			1	2	3	2	2		2		12
Milton				1	2	2	1		2		8
Richmond Hill					1	2	1				4
Stouffville				3	2	1	3				9
Union Station	1										1
TTC Subway/HRT											
Line 1 (Yonge-University-Spadina)	9	4	9	6	4						32
Line 2 (Bloor-Danforth)		2	10	16	1	2					31
Line 4 (Sheppard)			2	2	1						5
Future CRT											
SmartTrack	2		4	3	4	1	2		3		19
Future Subway/HRT											
Scarborough Line 2 Extension					1						1
Toronto Relief Line	2	2	11	2				1			18
Vaughan Line 1 Extension (TYSSE)					1			3	2		6
Yonge North Line 1 Extension			1	3	1	1					6
Future LRT											
Eglinton LRT Phase 1		1	1	12	7	1		2	1		25
Eglinton LRT Phase 2				5		7	1	1		3	17
Eglinton LRT Phase 3				13	2	4					19
Finch West LRT Phase 1			1	7	5	3	1		2		19
Finch West LRT Phase 2			1	4	2	1			3		11
Sheppard East LRT Phase 1			1	10	10				4		25
Sheppard East LRT Phase 2						3					3
Hamilton A- and B-Line LRT Phase 1	1		3	8	3	1					16
Hamilton B-Line LRT Phase 2				3							3
Hurontario-Main LRT Phase 1		1	3	8	4	1		1	4		22
Hurontario-Main LRT Phase 2			1	3							4
Waterloo ION LRT Phase 1			5	1	5	1		4	1		17
Waterloo ION LRT Phase 2					2	1	1	1	2		7
Future BRT											
Mississauga Transitway					3	3	2	3	1		12
VIVA Blue				8	14	4	1	2			29
VIVA Purple			1	6	7	8	3	10	6		41
Total	15	10	57	130	88	56	24	28	37	3	448

3.1. Heavy Rail Transit

3.1.1. TTC Line 1, Toronto-York Spadina Subway Extension (TYSSE), and Yonge North Subway Extension

Project Key Information			
Line Length (kilometres)	45	Total Population	296,047
Average Density (ppl+jobs/ha)	158	Total Employment	502,573
Total Stations	44		
Urban Commercial Core	9	*Outer Suburban Neighbourhood*	1
Urban Mixed-Use Core	4	*Exurban Neighbourhood*	-
Inner Urban Neighbourhood	10	*Suburban Centre*	3
Urban Neighbourhood	19	*Outer Suburban Industrial Park*	2
Suburban Neighbourhood	6	*Airport*	-

The TTC's Line 1 subway is the region's oldest HRT line. With the Yonge segment opening in 1954, the line has been extended several times, including the addition of the University and Spadina segments in 1963 and 1978. At present Line 1 is 30km in length with 32 stations that connect many neighbourhoods in Toronto to the downtown core. The Toronto-York Spadina Subway Extension is an extension of the Spadina segment north from Sheppard West to Vaughan Metropolitan Centre and is presently under construction for a planned opening in 2017. This extension is 8km in length with 6 new stations. An extension of the Yonge segment of Line 1 has also been proposed. This would see a 7km extension of the line north from Finch station to Richmond Hill Centre. No funding for this extension has been secured at present. Should both extensions be constructed, the entire line would feature 44 stations that serve a total population base of nearly 300,000 people and more than half a million jobs for an average density of 158 people and jobs per hectare.

From Figures 3-2 to 3-4 we can see that station area contexts along the Line 1 subway vary dramatically. The central portion of the line services a number of very high density *Urban Commercial* and *Mixed-Use Core* stations, followed by many medium- to high-density *Inner Urban* and *Urban Neighbourhoods* in the City of Toronto. From this, the existing Line 1 subway is generally very transit-oriented, with high levels of development intensity, land use mixing, pedestrian accessibility, and access to people and jobs. Important opportunities for further intensification exist within North York to meet the targets of its Urban Growth Centre. The line's outer segments, including the TYSSE project, are much lower in development intensity, largely characterized by *Suburban* type stations that should seek to intensify to justify their high levels of transit service. To that end, some outer stations have intensification designations, but plans should ensure they intensify in the future to support and justify HRT service.

Figure 3-2. Station Area Land Use: TTC Line 1, TYSSE, and Yonge North Extension

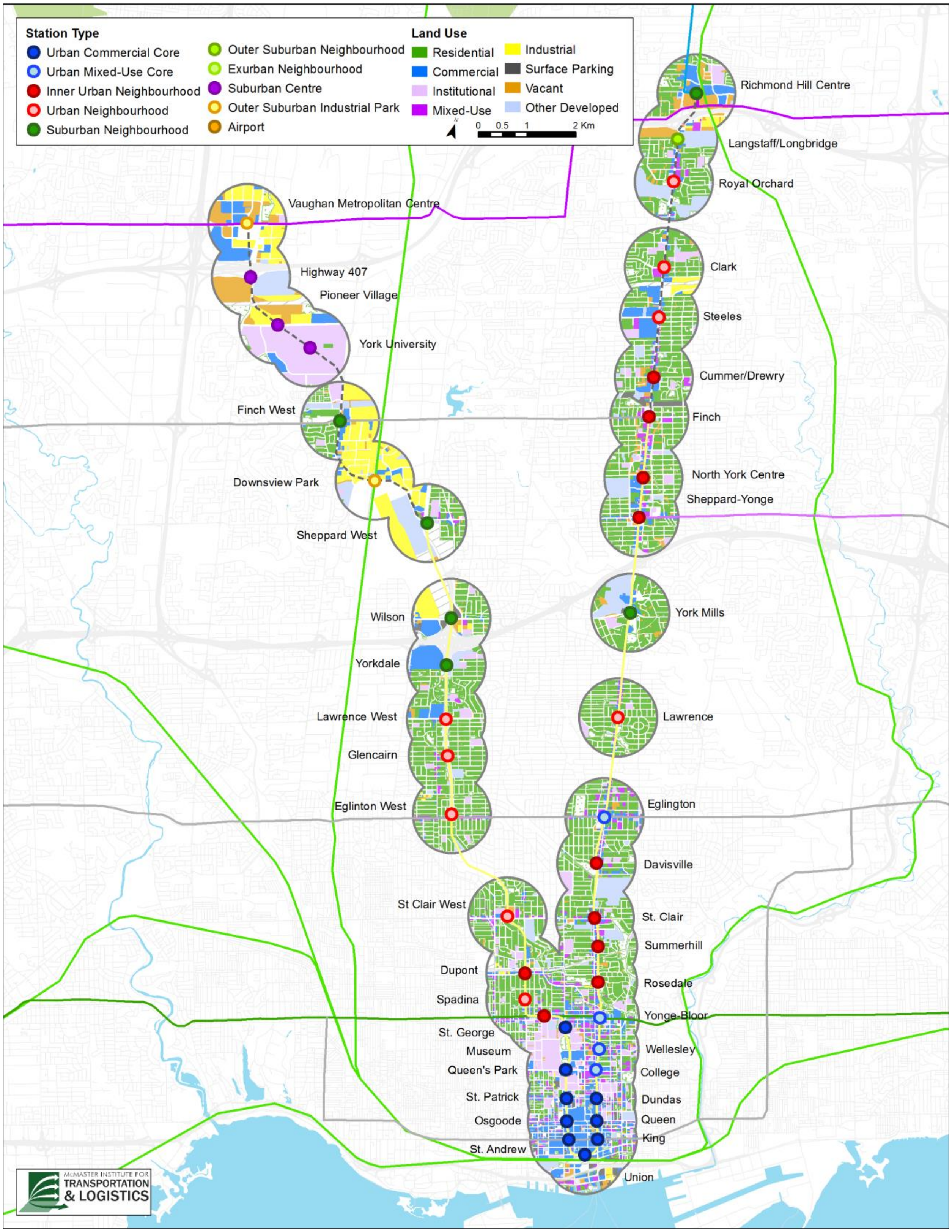


Figure 3-3. Station Area Intensification Designations: TTC Line 1, TYSSE, and Yonge North Extension

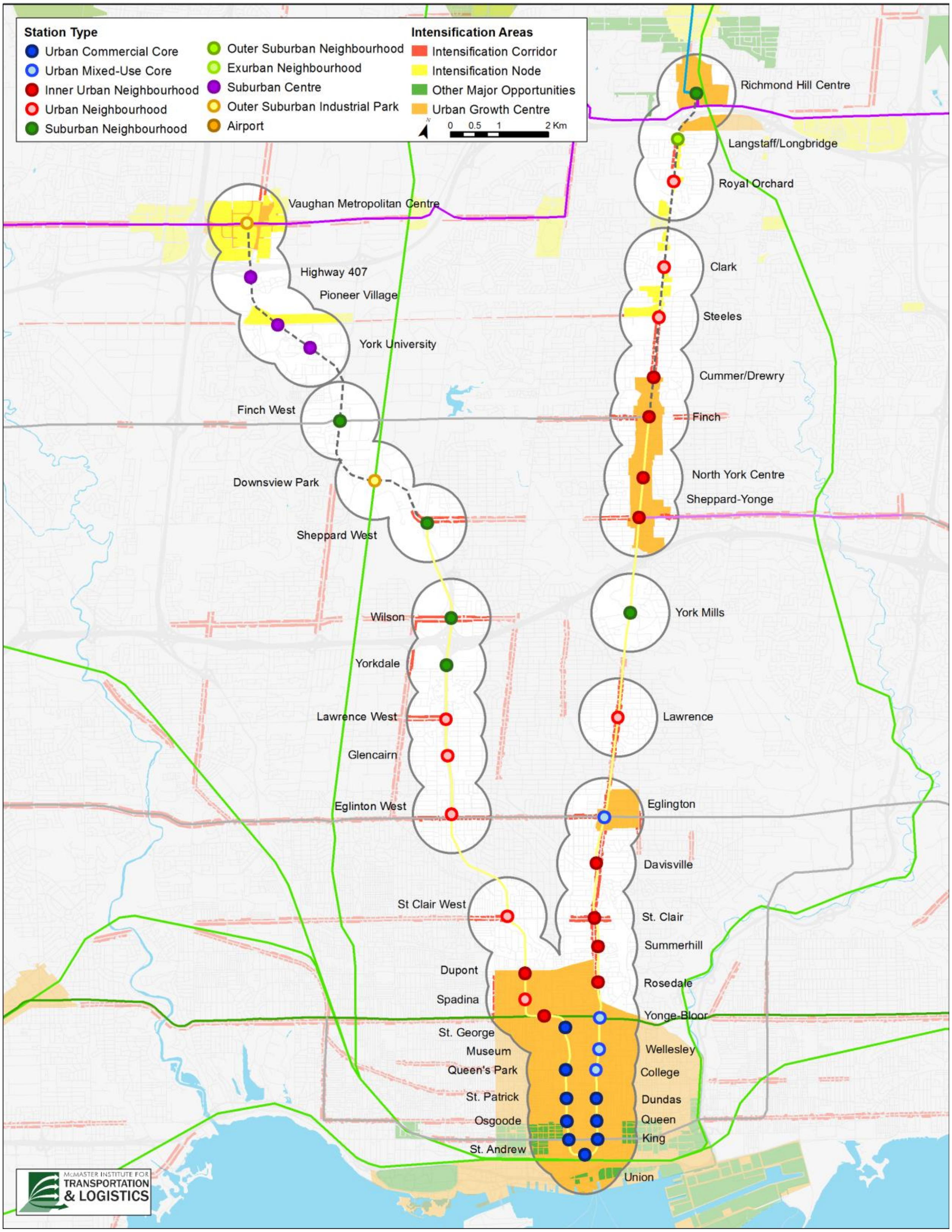
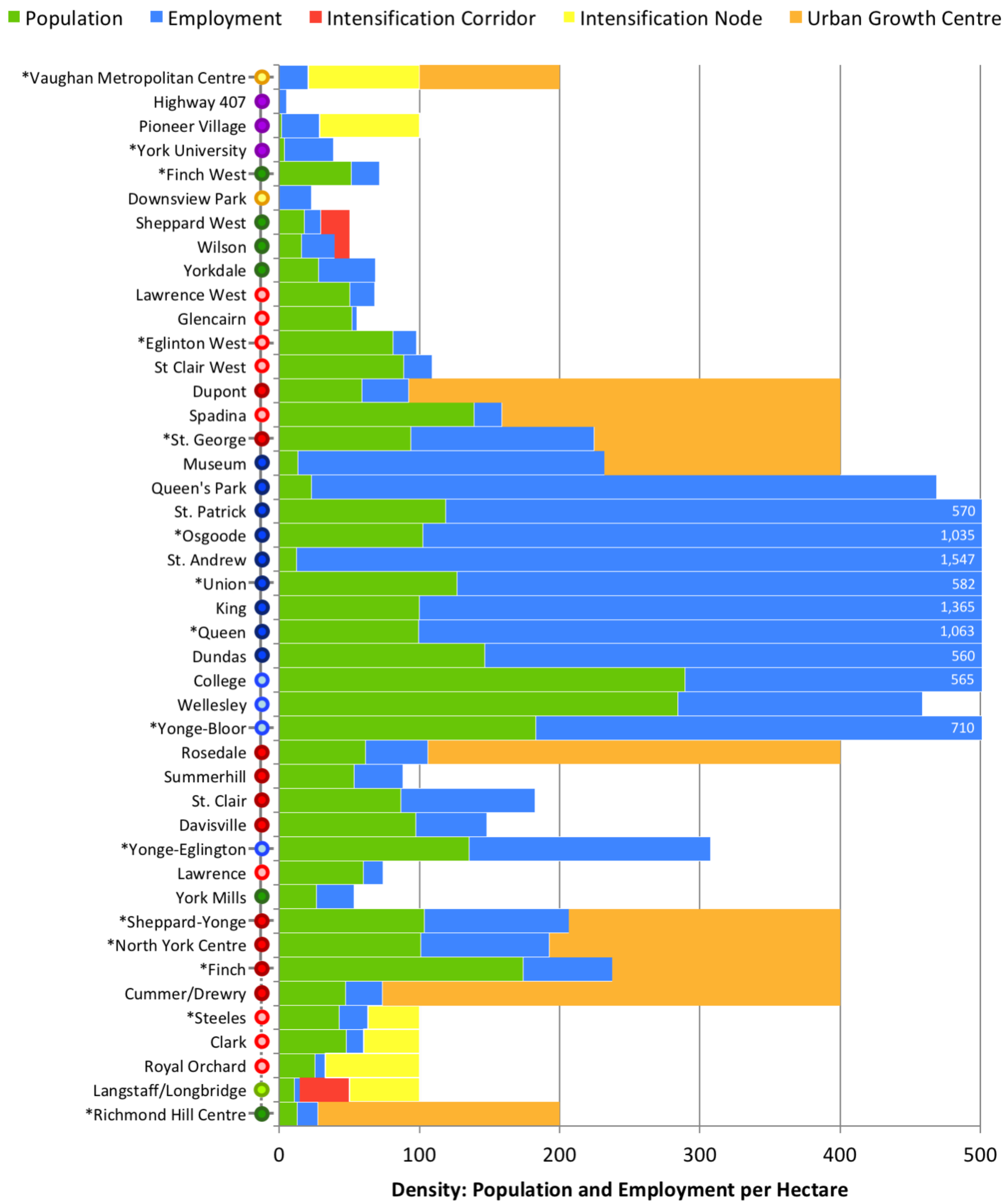


Figure 3-4. Population and Employment Density: TTC Line 1, TYSSE, and Yonge North Extension



* indicates station is designated as a Mobility Hub by Metrolinx

3.1.2. TTC Line 2 and Scarborough Subway Extension

Project Key Information			
Line Length (kilometres)	33	Population	274,936
Average Density (ppl+jobs/ha)	109	Employment	119,931
Total Stations	32		
Urban Commercial Core	-	*Outer Suburban Neighbourhood*	2
Urban Mixed-Use Core	2	*Exurban Neighbourhood*	1
Inner Urban Neighbourhood	10	*Suburban Centre*	-
Urban Neighbourhood	16	*Outer Suburban Industrial Park*	5
Suburban Neighbourhood	2	*Airport*	-

The Line 2 TTC subway, also known as the Bloor-Danforth Line, is the City of Toronto's second HRT line. Opening in 1966, the line has since been extended to encompass 31 stations from Kipling in the west to Kennedy in the east. The line is 26km in length and fairly high-density relative to others, connecting the City of Toronto's dense inner suburbs to the northern part of Toronto's central business district. A 1-stop 7km extension to the Scarborough Town Centre and the future Sheppard East LRT has been proposed. Options for this alignment have changed over time, from LRT service to replace the aging TTC Line 3 to a 3-stop subway from Kennedy Station. However, the 1-stop option above is the City of Toronto's preferred solution at present due to synergies between it and the proposed SmartTrack line on the nearby GO corridor. Should the extension be built, the entire Line 2 subway would serve approximately 275,000 people and 120,000 jobs across its 32 stations for an average density of 109 people and jobs per hectare.

Like Line 1, Figures 3-5 to 3-7 together show that Line 2 of the TTC Subway is very urban in character. Most stations are high-density, pedestrian friendly, and are balanced between population and employment. A few stations tend to be more suburban in their built form, and here improvements to their pedestrian environment and development intensity would be beneficial. The line also features some areas that are not meeting intensification targets, and Metrolinx has identified other key Mobility Hubs around which future TOD should be concentrated. The potential Scarborough Subway Extension is one of these stations, and although it is fairly high density already, its categorization as a *Suburban Neighbourhood* suggests it could benefit from future TOD.

Figure 3-5. Station Area Land Use: TTC Line 2 and Scarborough Subway Extension

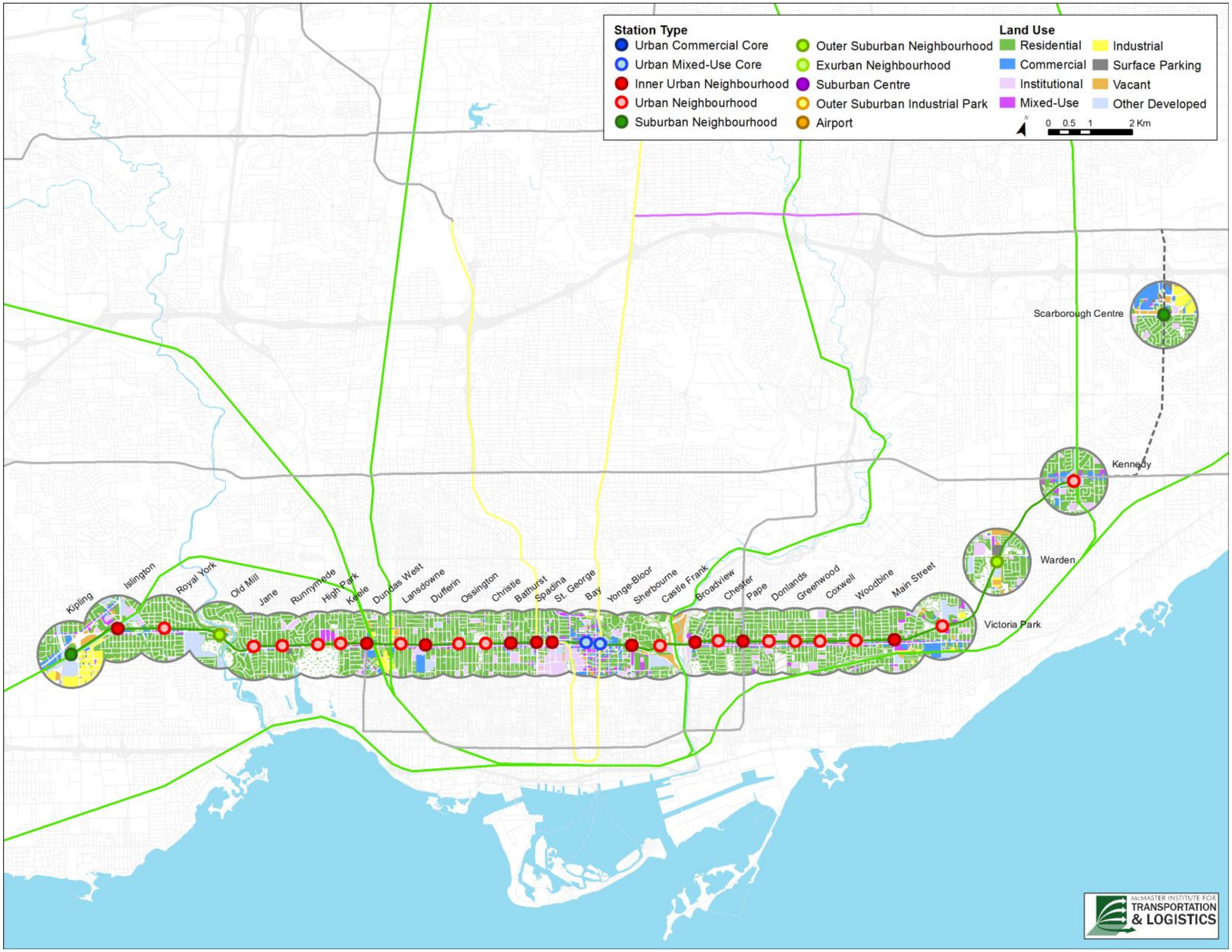


Figure 3-6. Station Area Intensification Designations: TTC Line 2 and Scarborough Subway Extension

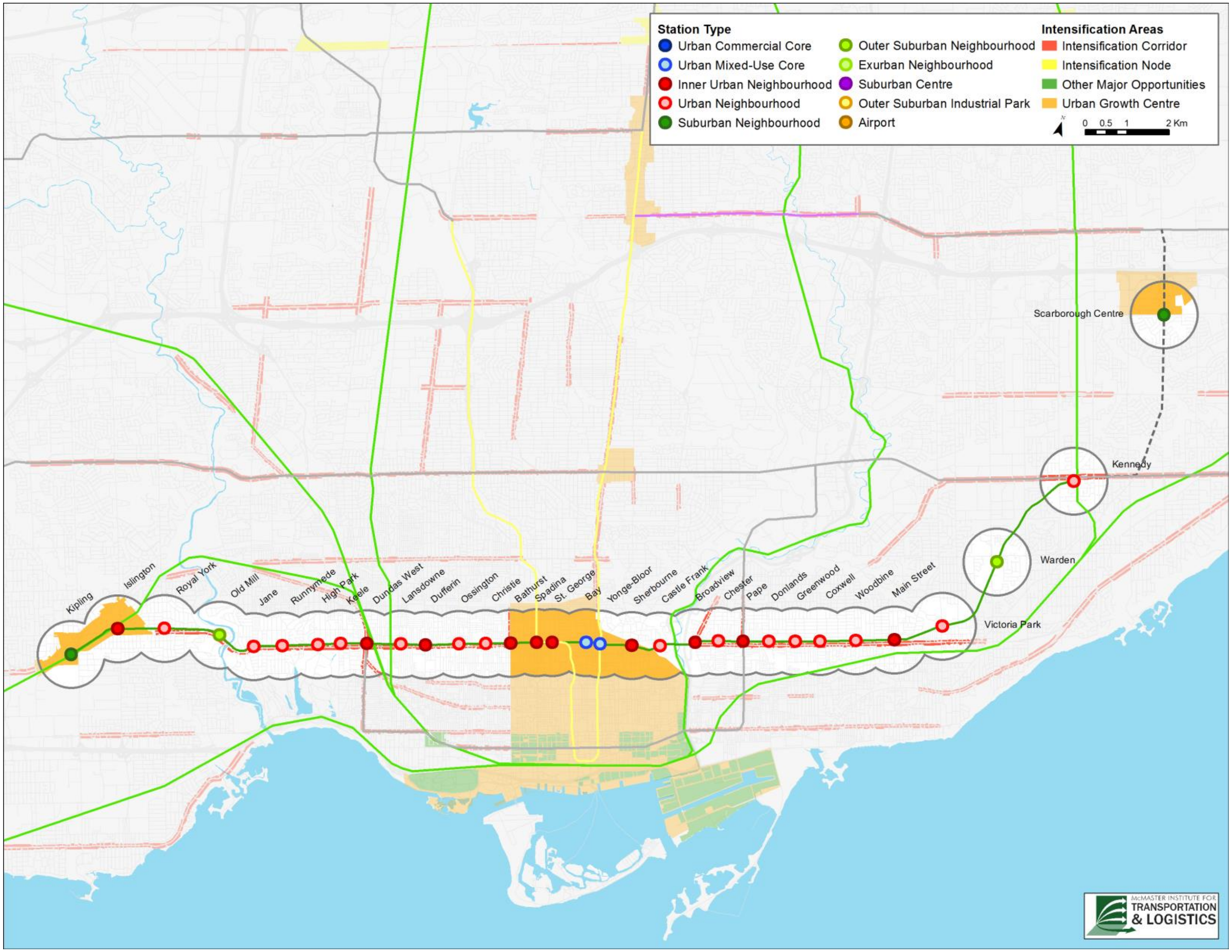
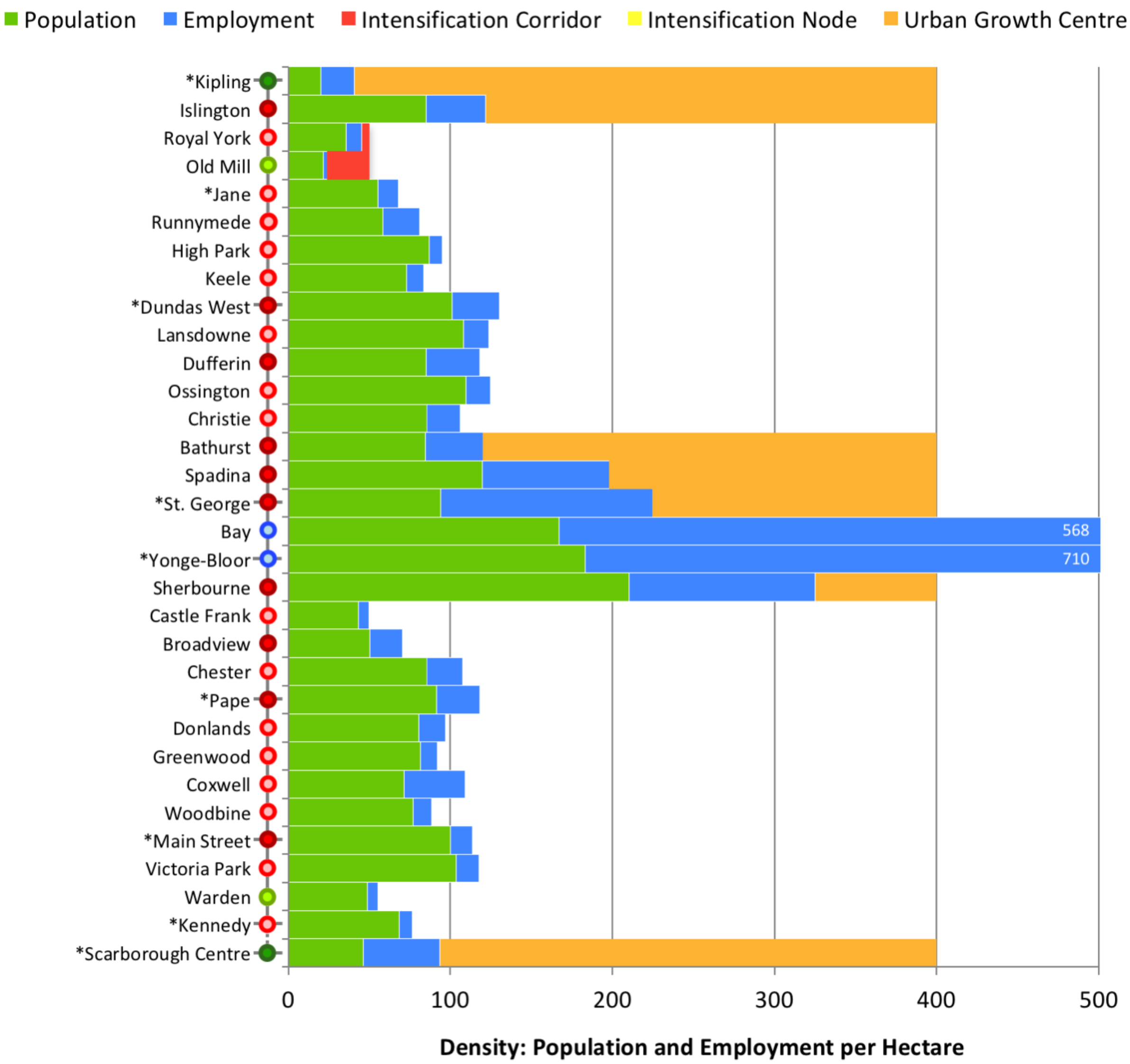


Figure 3-7. Population and Employment Density: TTC Line 2 and Scarborough Subway Extension



* indicates station is designated as a Mobility Hub by Metrolinx

3.1.3. Toronto Relief Line

Project Key Information			
Line Length (kilometres)	19	Population	207,639
Average Density (ppl+jobs/ha)	185	Employment	219,504
Total Stations	18		
Urban Commercial Core	2	*Outer Suburban Neighbourhood*	-
Urban Mixed-Use Core	2	*Exurban Neighbourhood*	-
Inner Urban Neighbourhood	11	*Suburban Centre*	1
Urban Neighbourhood	2	*Outer Suburban Industrial Park*	-
Suburban Neighbourhood	-	*Airport*	-

The Toronto Relief Line is a proposed HRT project in the City of Toronto. The line travels from the Dundas West station on the Line 2 subway to the central business district where it bisects the Line 1 subway. From there it travels to Pape station on Line 2 and terminates at Don Mills station on the future Eglinton Crosstown LRT Phase 1. As the name implies, the line is designed to reduce crowding on the Yonge portion of the Line 1 subway and Union Station. A preliminary benefits case analysis was completed by Metrolinx in 2012, which identified several different potential alignments for the line. For the present project we have assumed a full build-out of the 19km line with 18 stations. No funding decision has been made with regards to constructing the Relief Line, but it is listed as one of Metrolinx's top-15 priorities in the region. If built, its 18 stations would serve approximately 208,000 people and 220,000 jobs for an average density of 185 people and jobs per hectare.

The Relief Line as proposed runs through some of the region's highest-density areas (Figures 3-8 to 3-10). All stations feature densities of around 100 people and jobs per hectare, and those in the central business district are even higher. From this, the quality of space along the line is among the most transit-oriented of all the lines in the present study. Stations in the downtown core are either Urban Commercial Core stations or very high density and mixed-use Urban Mixed-Use Core stations. Stations located outside of the downtown core are mixed-use, pedestrian friendly, and amenity rich neighbourhoods. Don Mills station, while high density, it is generally oriented to employment with high proportions of commercial and industrial land uses. Thorncliffe Park station is similar in land use, but more balanced in development mix. In both cases, any under-utilized industrial lands may present ideal locations for future TOD projects. In terms of intensification, opportunities exist for the Parliament and Bayview stations, which are designated as part of the City of Toronto's Urban Growth Centre. Other important intensification nodes are at the Dundas West, Pape, and Don Mills stations, which are key Mobility Hubs.

Figure 3-8. Station Area Land Use: Toronto Relief Line

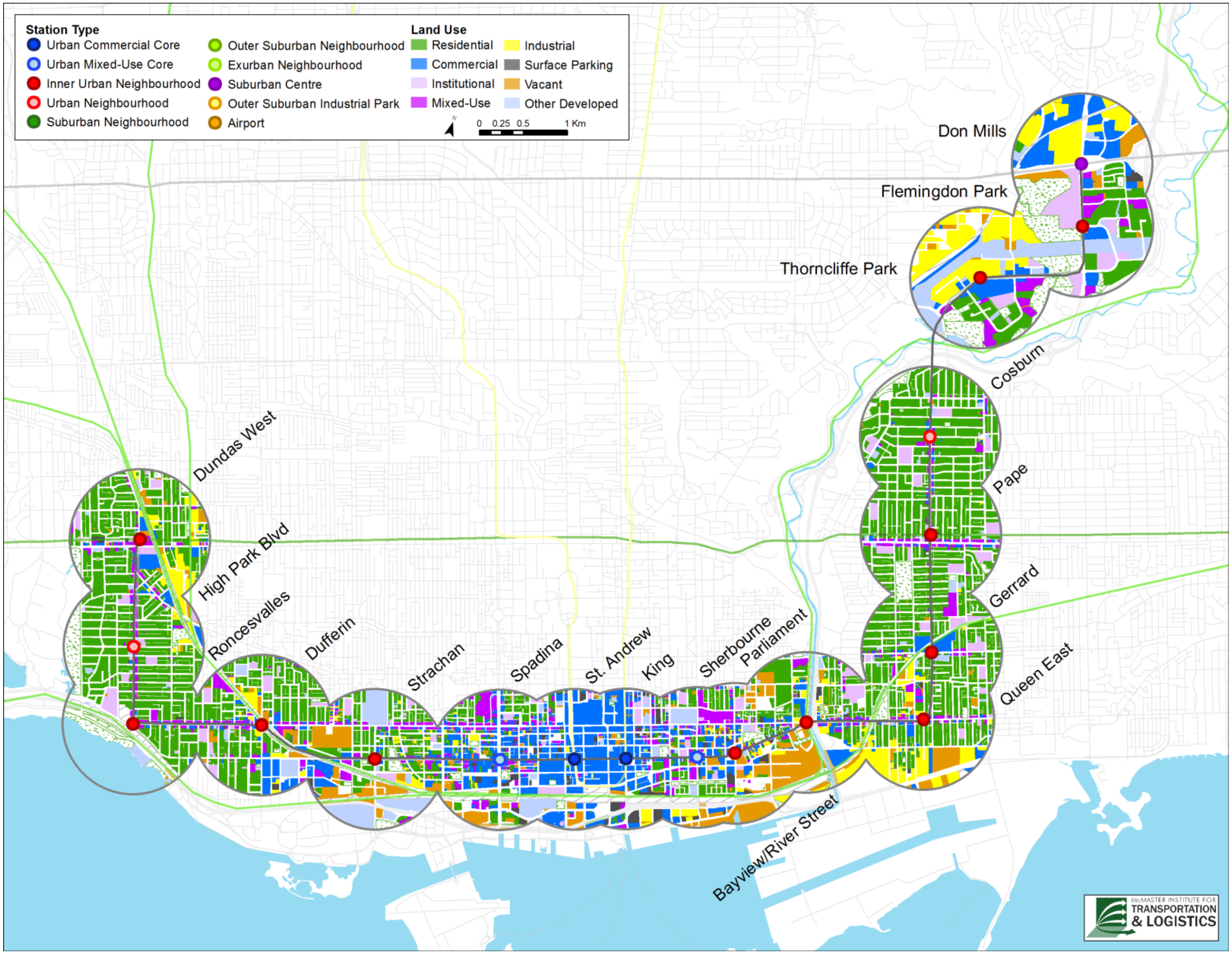


Figure 3-9. Station Area Intensification Designations: Toronto Relief Line

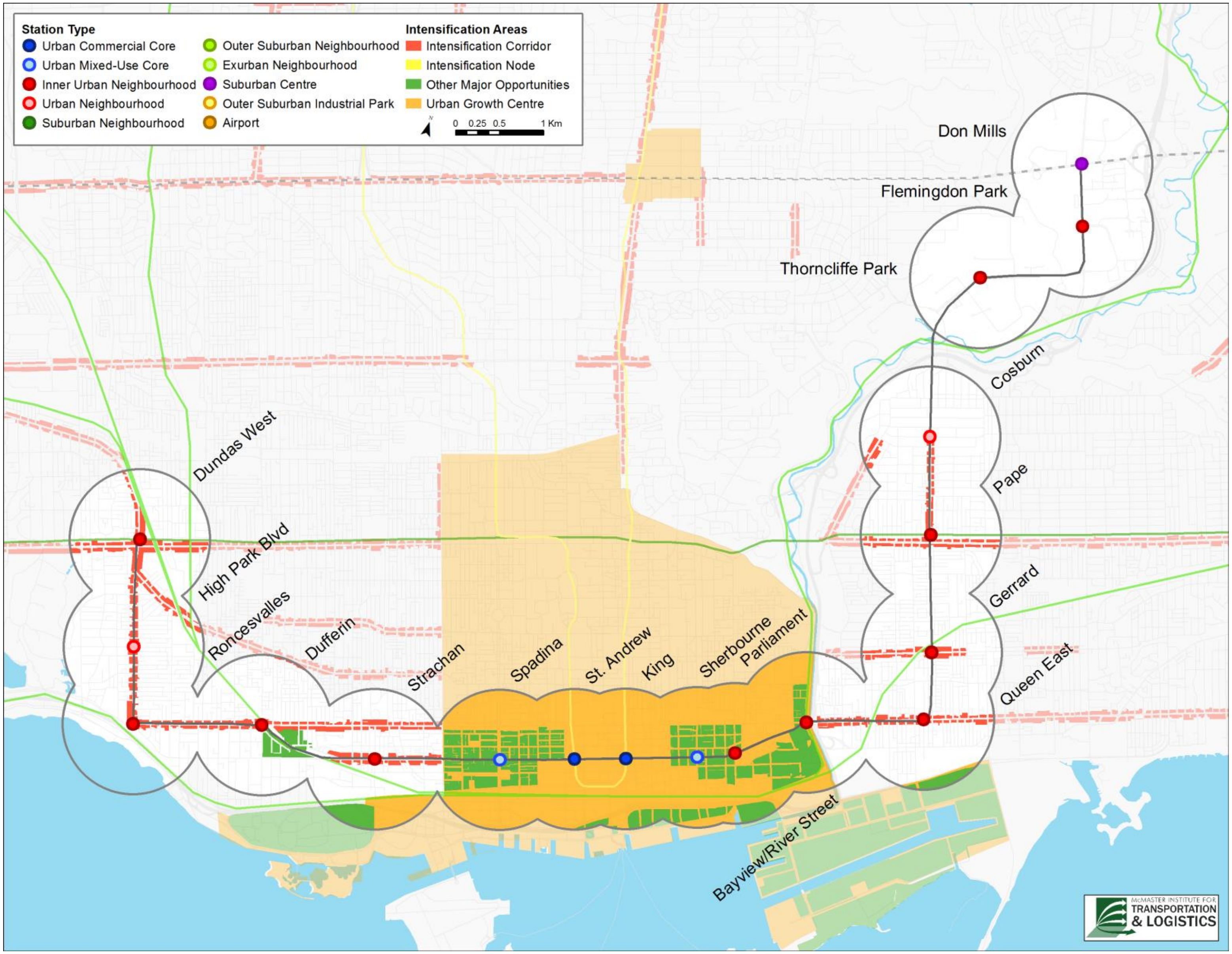
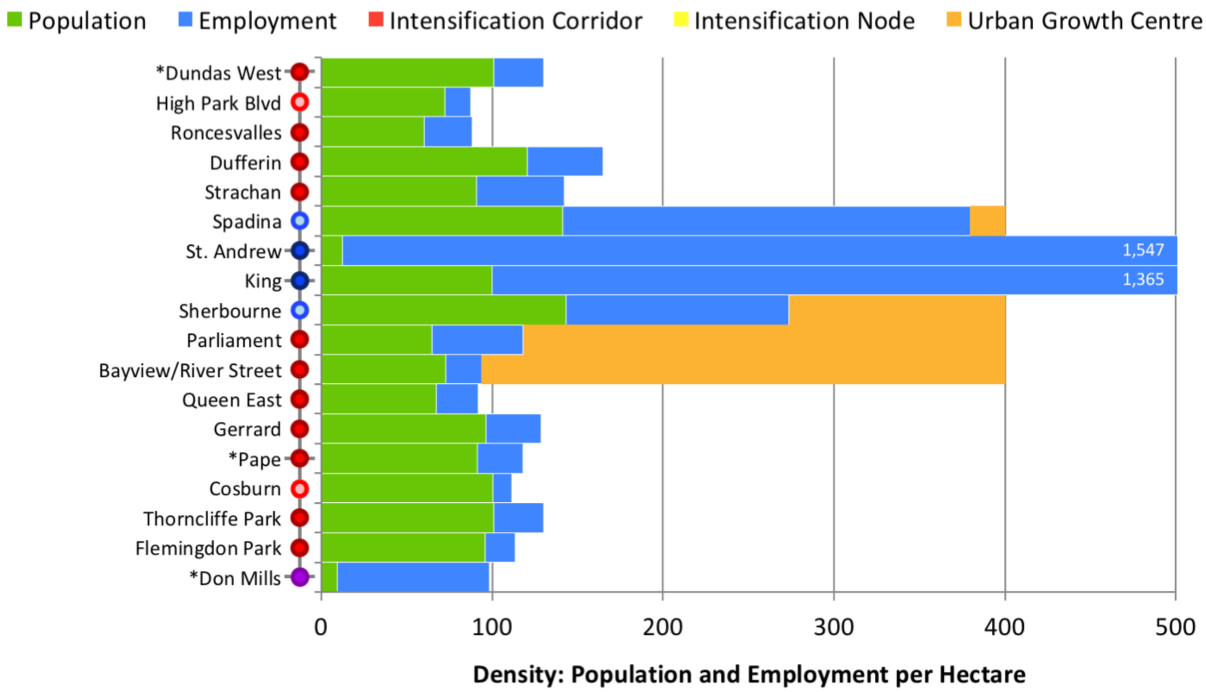


Figure 3-10. Population and Employment Density: Toronto Relief Line



* indicates station is designated as a Mobility Hub by Metrolinx

3.2. Light Rail Transit

3.2.1. Eglinton Crosstown LRT Phases 1, 2, and 3

Project Key Information			
Line Length (kilometres)	42	Population	286,341
Average Density (ppl+jobs/ha)	61	Employment	105,363
Total Stations	62		
Urban Commercial Core	-	*Outer Suburban Neighbourhood*	13
Urban Mixed-Use Core	1	*Exurban Neighbourhood*	1
Inner Urban Neighbourhood	1	*Suburban Centre*	3
Urban Neighbourhood	30	*Outer Suburban Industrial Park*	1
Suburban Neighbourhood	9	*Airport*	3

The Eglinton Crosstown LRT is a 42km LRT line in the City of Toronto. The first phase of the line is presently under construction and on schedule to become operational in 2021. Phase 1 is approximately 18km in length, running from the future Mt. Dennis GO / SmartTrack station in the west, Eglinton West and Yonge-Eglinton stations on the Line 1 Subway, and Kennedy station on the Line 2 subway in the east. 10km of Phase 1 will run underground, from Keele to Laird stations. Phase 2 is proposed to be approximately 14km and travel west to the Lester B. Pearson International Airport. Phase 3 is proposed to be 11km and travel east to Morningside station on the Sheppard East LRT. While station names and locations may change over time, for the present study we have identified 62 stations across all three phases. If built, these stations would serve approximately 286,000 people and 105,000 jobs for an average density of 61 people and jobs per hectare.

The entire Eglinton Crosstown LRT features a range of station types along its corridor (Figures 3-11 to 3-17). Among all phases, the line is predominately urban, with 53% of its stations in the urban category. These stations are higher density, feature a mixing of land uses and neighbourhood amenities, and a pedestrian-friendly built environment. The remainder of the line is more suburban, with 37% of stations exhibiting lower densities, segregated land uses, and a greater orientation to the personal automobile. Outside of these stations, the Crosstown LRT also connects several Suburban Centres, Outer Suburban Industrial Parks, and three stations near the Pearson Airport. Across project phases, Phase 1 of the Eglinton Crosstown LRT traverses a corridor that is medium- to high-density in terms of population and employment. Phase 3 is less dense, with Phase 2 lower still. The distribution of station types is also not equal across each segment. Of the urban stations, 40% are located along Phase 1 and another 40% along Phase 3. In contrast, Phase 2 is more suburban in character, with 41% of its stations classified as low-density, Outer Suburban Neighbourhoods and another 6% as Exurban Neighbourhoods.

In terms of transit-oriented intensification, it is clear that Phase 2 could benefit most from supportive policy and planning. Here only 4 stations feature densities greater than 50 people and jobs per hectare. Some stations are designated as within an intensification corridor, and Commerce station is within an intensification node. However, many stations along both Phases 2 and 3 do not have any intensification designation. Furthermore, while a large number of stations are urban and transit-oriented, groups of more suburban stations along all three phases could benefit from policies and plans that promote higher-density, mixed-use development and improve the pedestrian environment. Stations such as Ferrand and Wynford already feature high densities but are categorized as Suburban Neighbourhoods. In this case, this is due to a lack of pedestrian accessibility attributable to large commercial and industrial parcels and a more suburban street design.

Figure 3-11. Station Area Land Use: Eglinton Crosstown LRT Phase 1 and 2

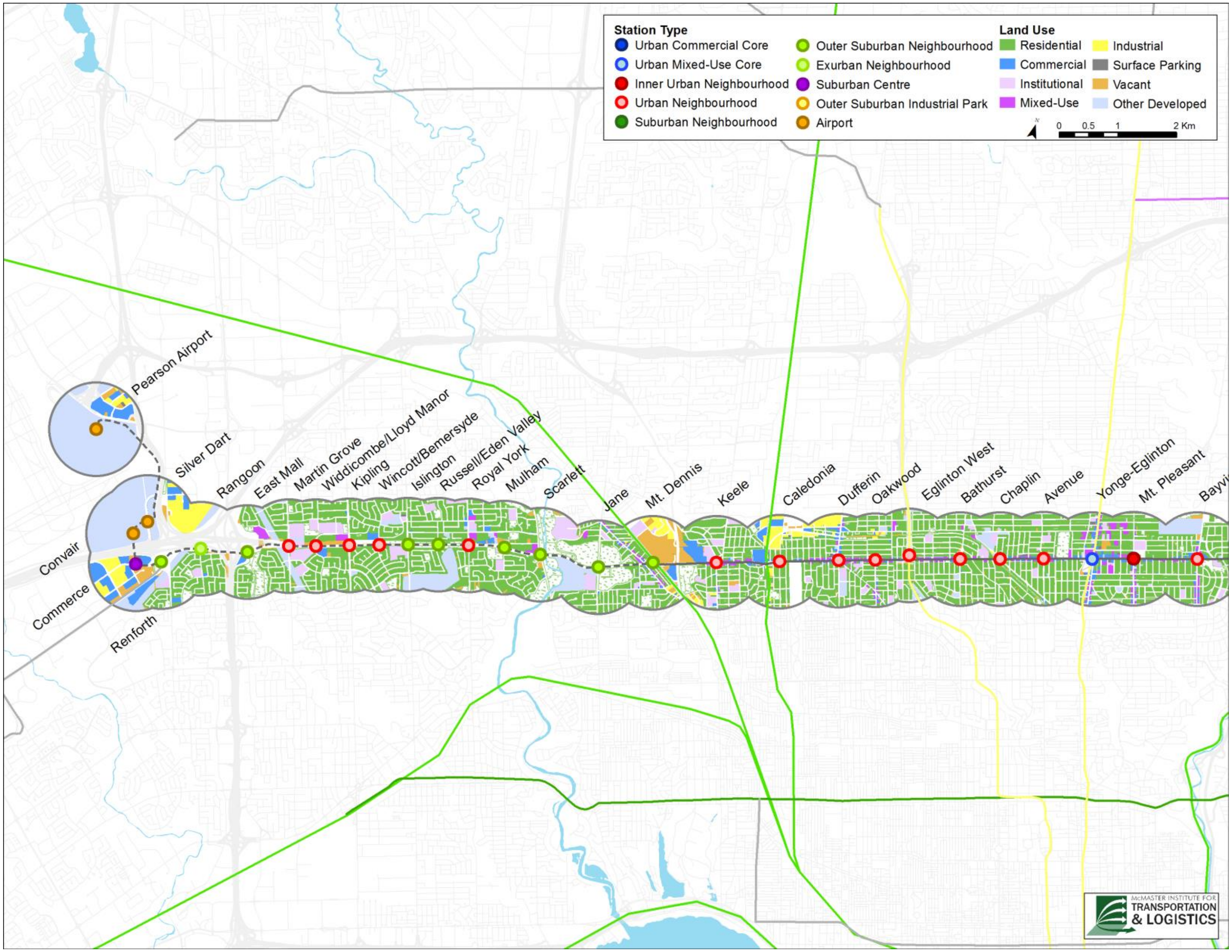


Figure 3-12. Station Area Land Use: Eglinton Crosstown LRT Phase 1 and 3

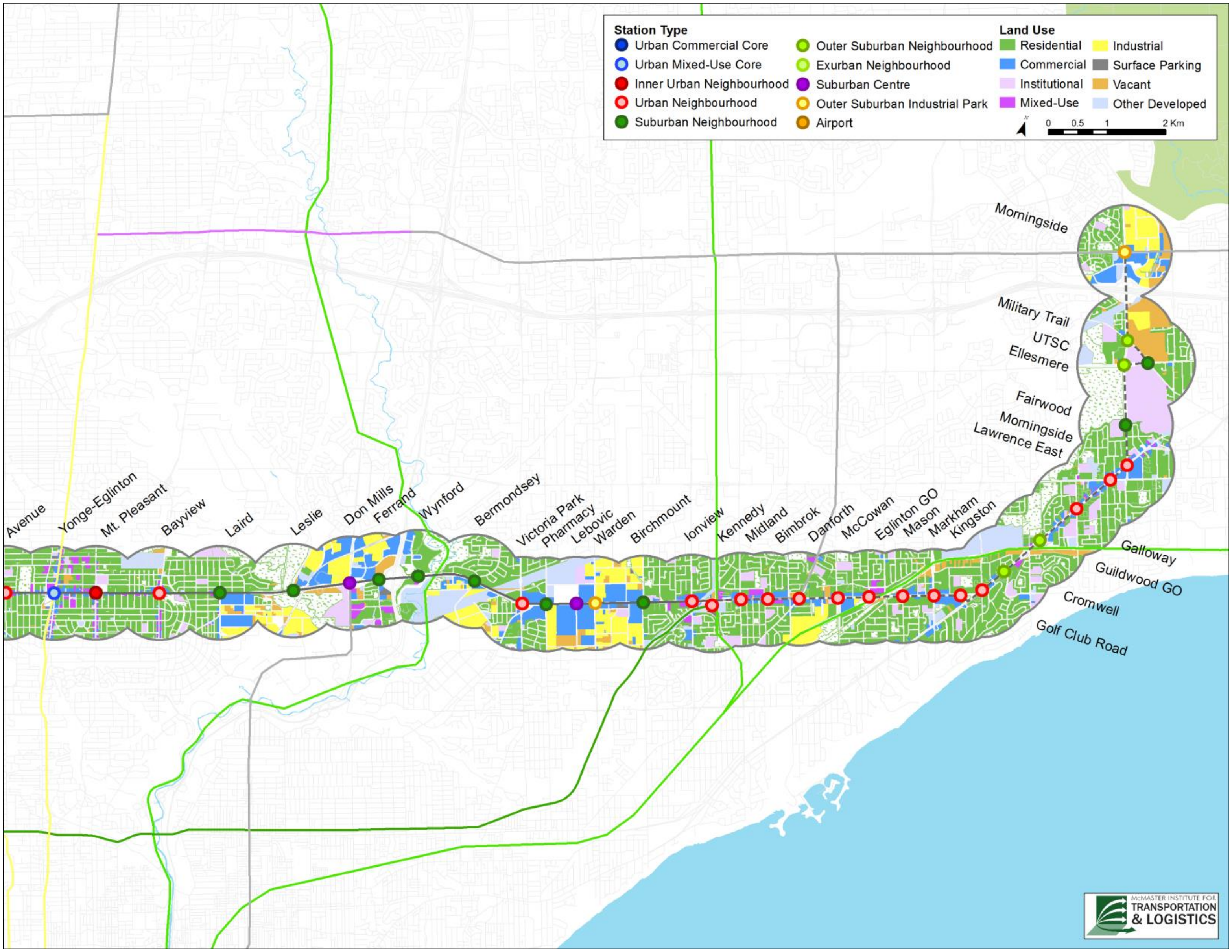


Figure 3-13. Station Area Intensification Designations: Eglinton Crosstown LRT Phase 1 and 2

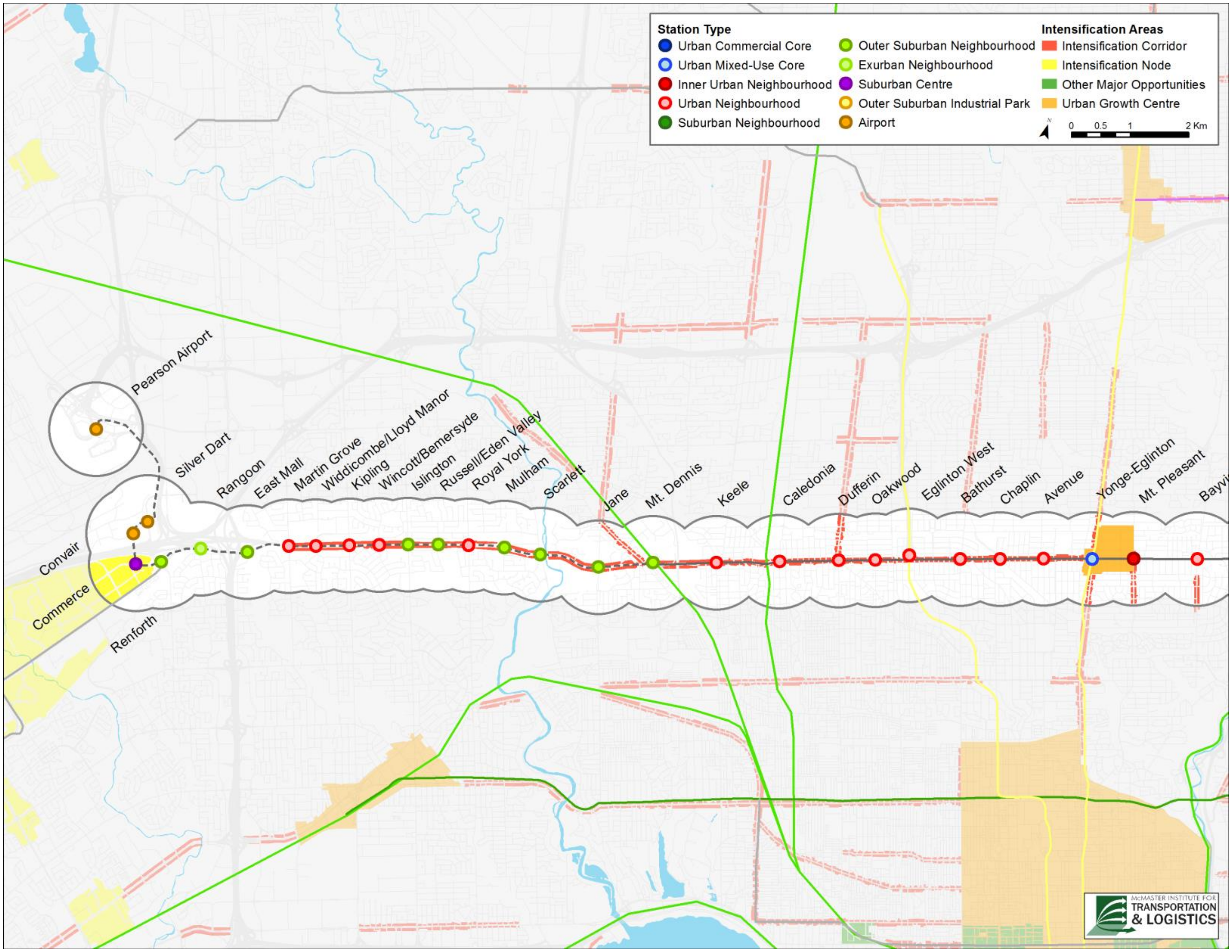


Figure 3-14. Station Area Intensification Designations: Eglinton Crosstown LRT Phase 1 and 3

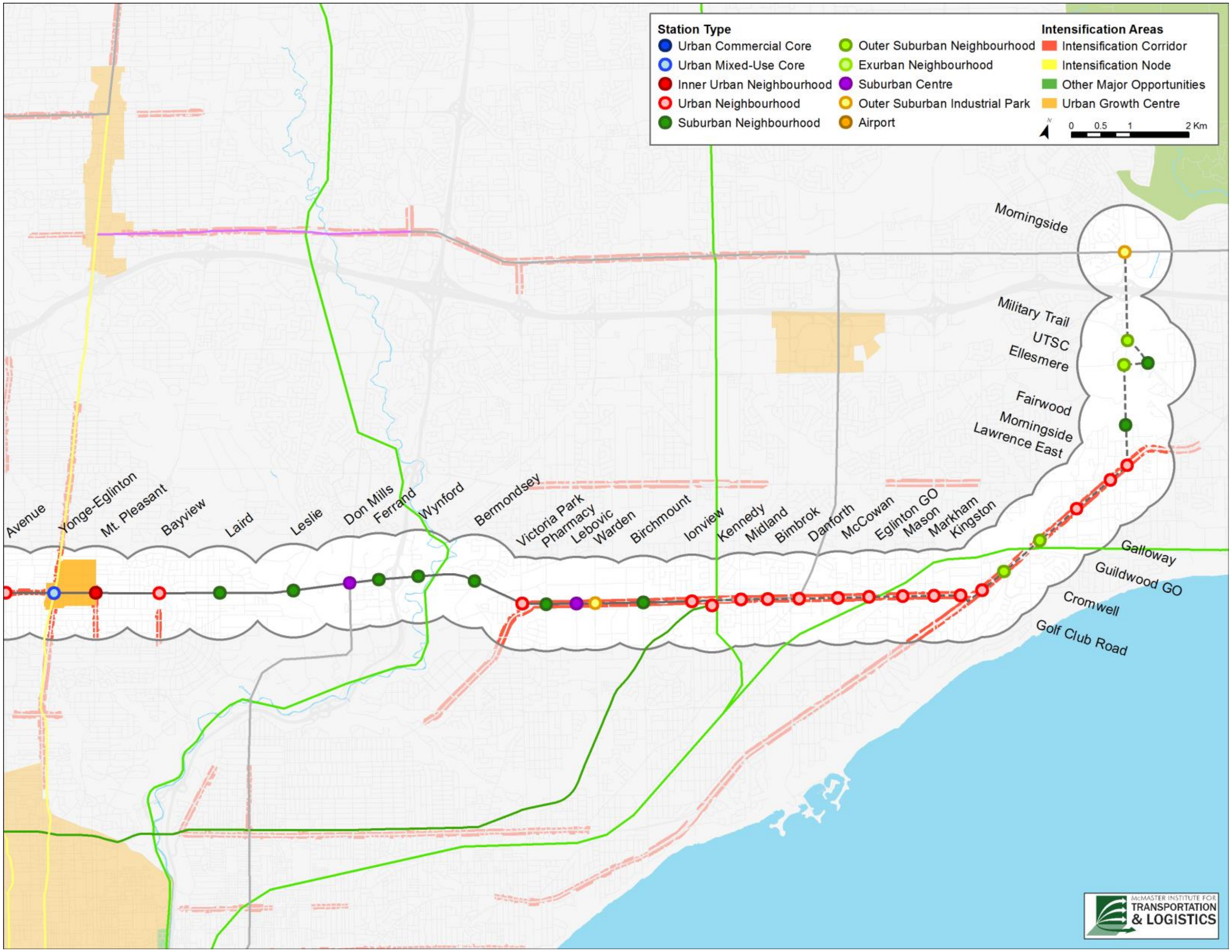
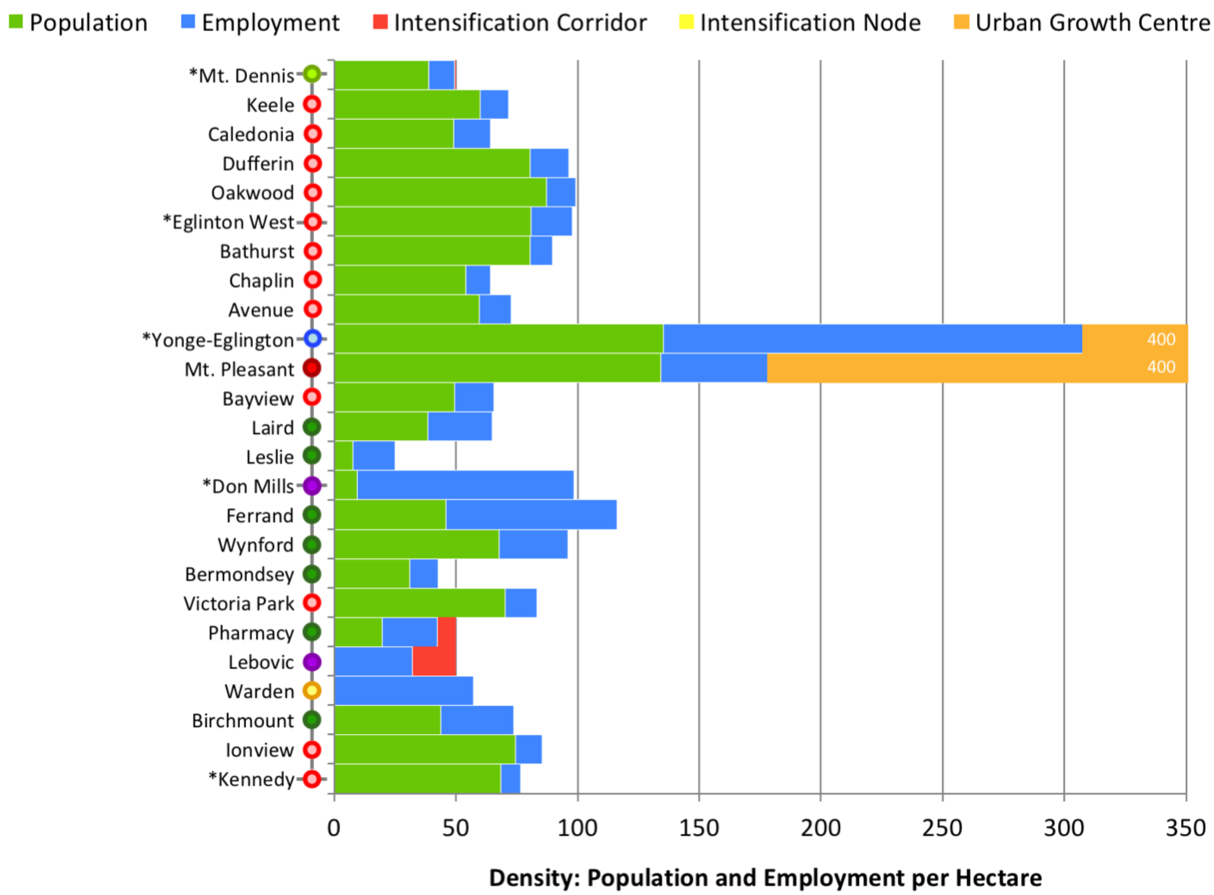


Figure 3-15. Population and Employment Density: Eglinton Crosstown LRT Phase 1



* indicates station is designated as a Mobility Hub by Metrolinx

Figure 3-16. Population and Employment Density: Eglinton Crosstown LRT Phase 2

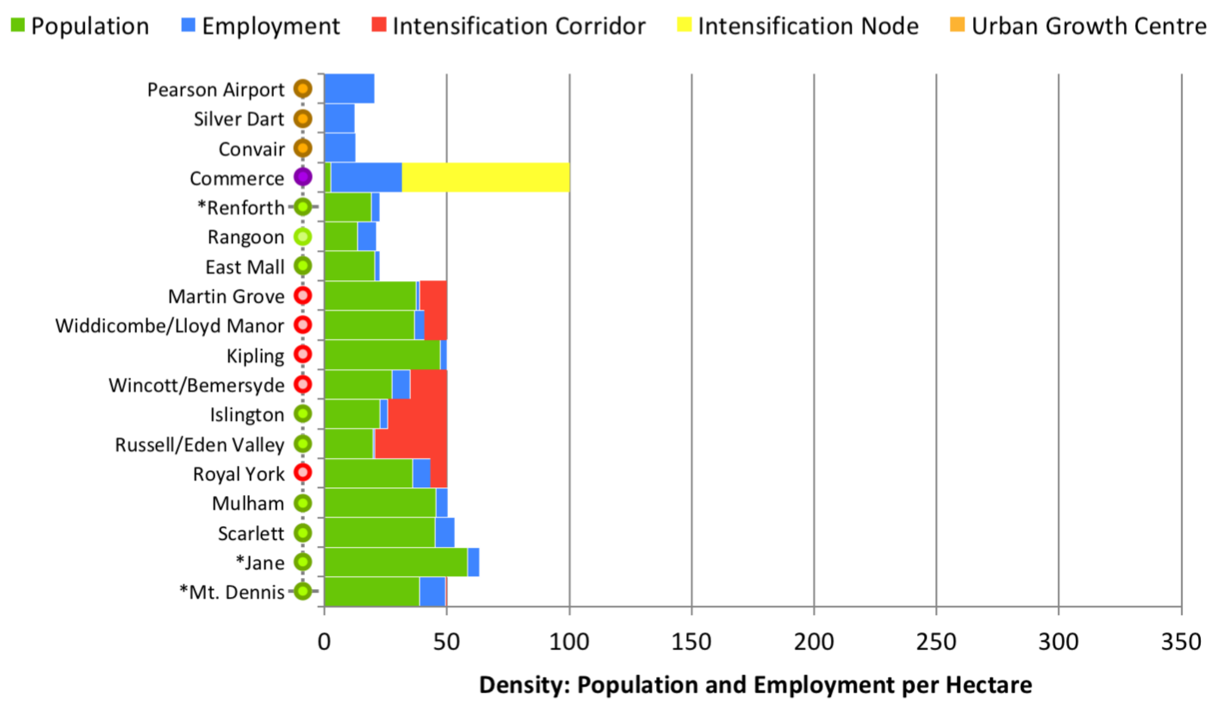
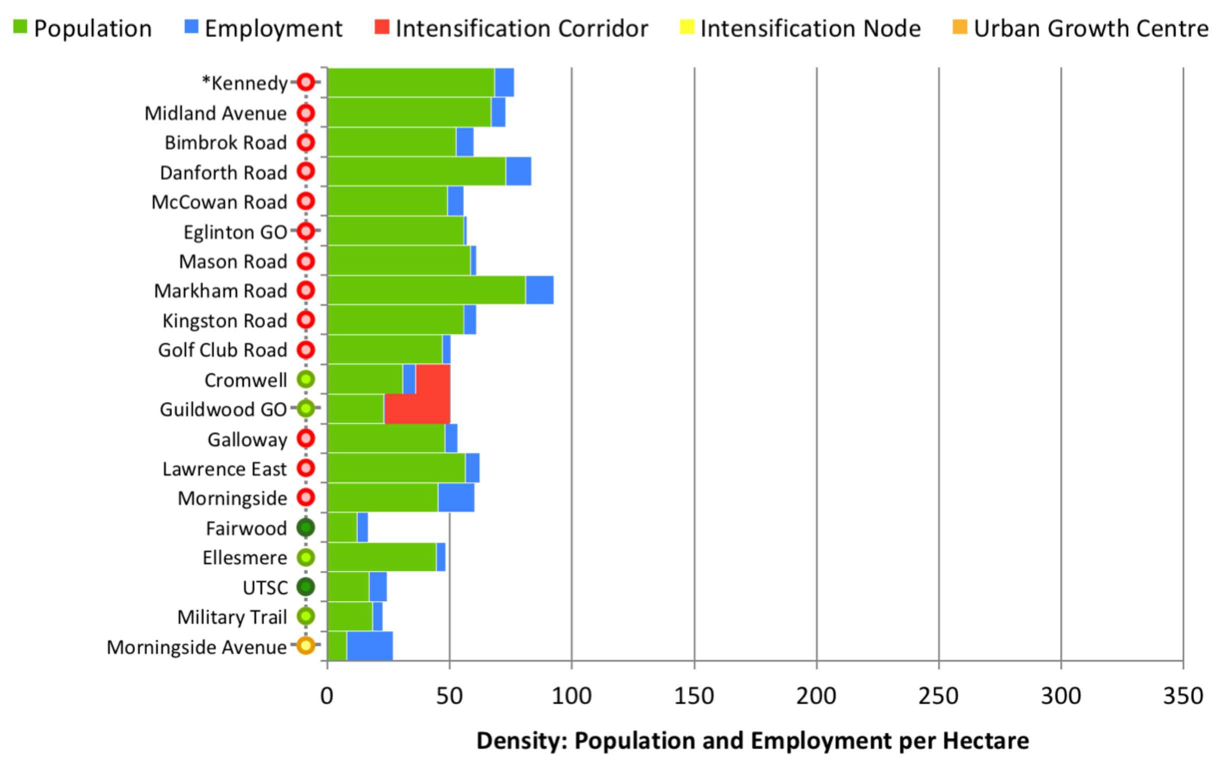


Figure 3-17. Population and Employment Density: Eglinton Crosstown LRT Phase 3



* indicates station is designated as a Mobility Hub by Metrolinx

3.2.2. Finch West LRT Phases 1 and 2

Project Key Information			
Line Length (kilometres)	17	Population	150,305
Average Density (ppl+jobs/ha)	69	Employment	49,288
Total Stations	30		
Urban Commercial Core	-	*Outer Suburban Neighbourhood*	4
Urban Mixed-Use Core	-	*Exurban Neighbourhood*	1
Inner Urban Neighbourhood	2	*Suburban Centre*	-
Urban Neighbourhood	11	*Outer Suburban Industrial Park*	5
Suburban Neighbourhood	7	*Airport*	-

The Finch West LRT is a proposed LRT line in the City of Toronto. Phase 1 of the line is to extend from Finch West station on the Toronto-York Spadina Subway Extension and travel west towards Humber College. As of 2015, Phase 1 is scheduled to start construction in 2016-2017 for an opening in 2021. This segment is approximately 11km in length with 20 stations. The plan for the line is to operate in a separate right of way in the centre of the street, with a tunneled station where it meets Finch West station. A proposed second phase would continue the line west from Finch West station, connecting it to Finch station on the Line 1 subway. It remains unclear if or when this segment will be built. Both phases of the Finch West LRT would serve approximately 150,000 people and 49,000 jobs for an average density of 69 people and jobs per hectare.

From Figures 3-18 to 3-20, Phase 1 of the Finch West LRT will operate in a medium-density corridor. This segment is primarily urban, but is interspersed with Suburban, Outer Suburban, and Exurban Neighbourhoods. This highlights several key areas for promoting transit-oriented intensification that increases population and employment densities, promotes a mixing of land uses, and increases their pedestrian orientation. Phase 2 is similar, with some urban and suburban stations. Outer Suburban Industrial Parks may present an opportunity for transit-oriented land use change. For intensification, the vast majority of stations along both phases do not feature any intensification designation, suggesting that there may be a role for strengthened corridor land use planning.

Figure 3-18. Station Area Land Use: Finch West LRT Phase 1 and 2

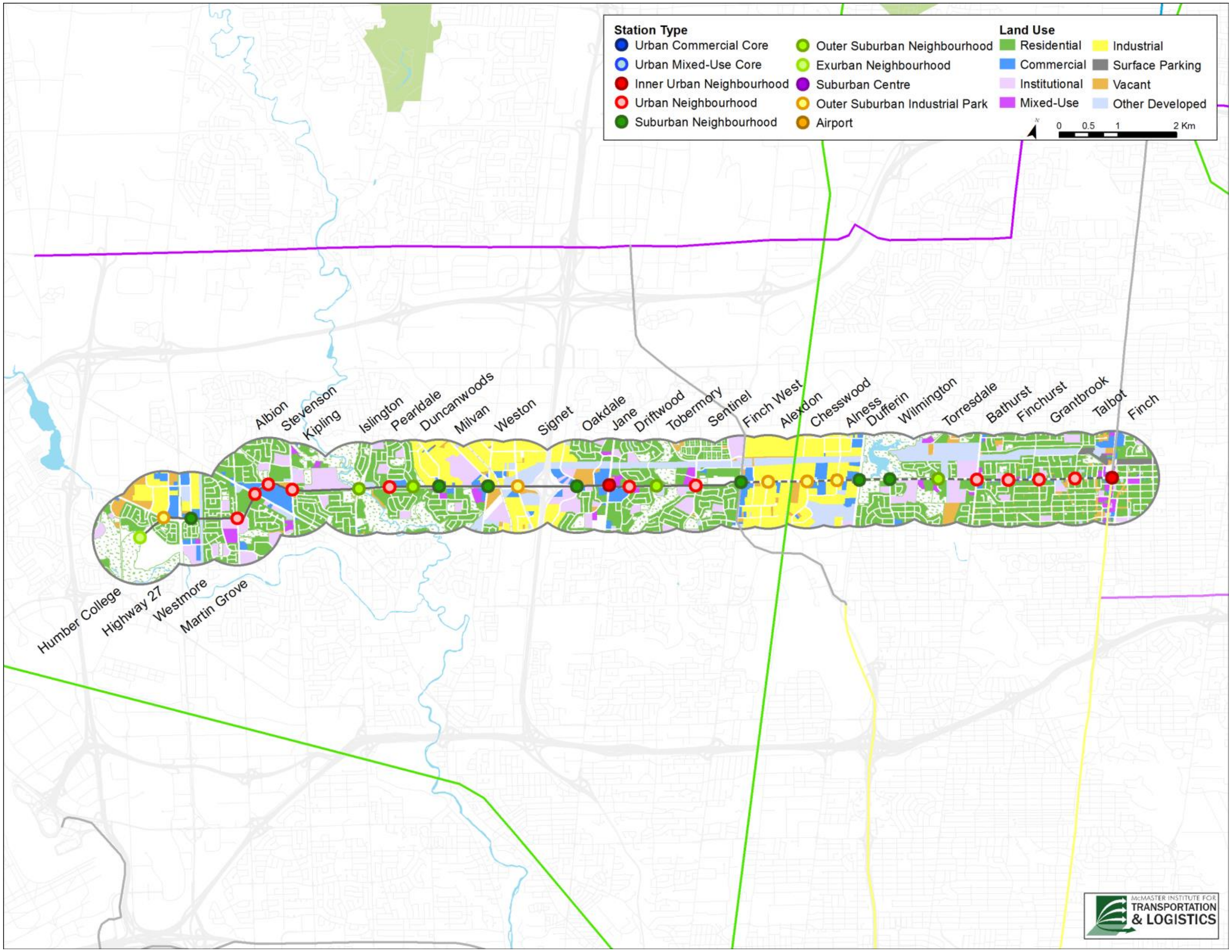


Figure 3-19. Station Area Intensification Designations: Finch West LRT Phase 1 and 2

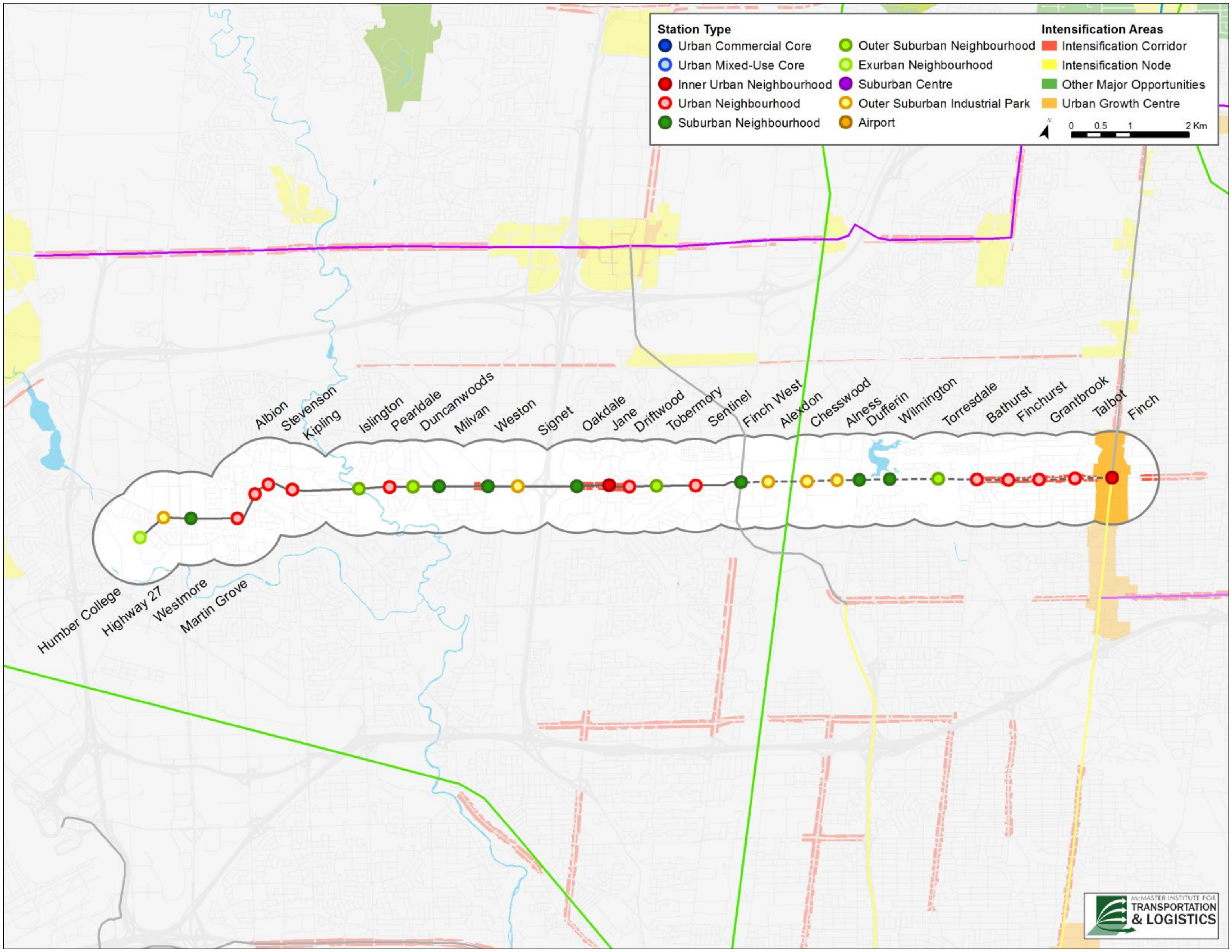
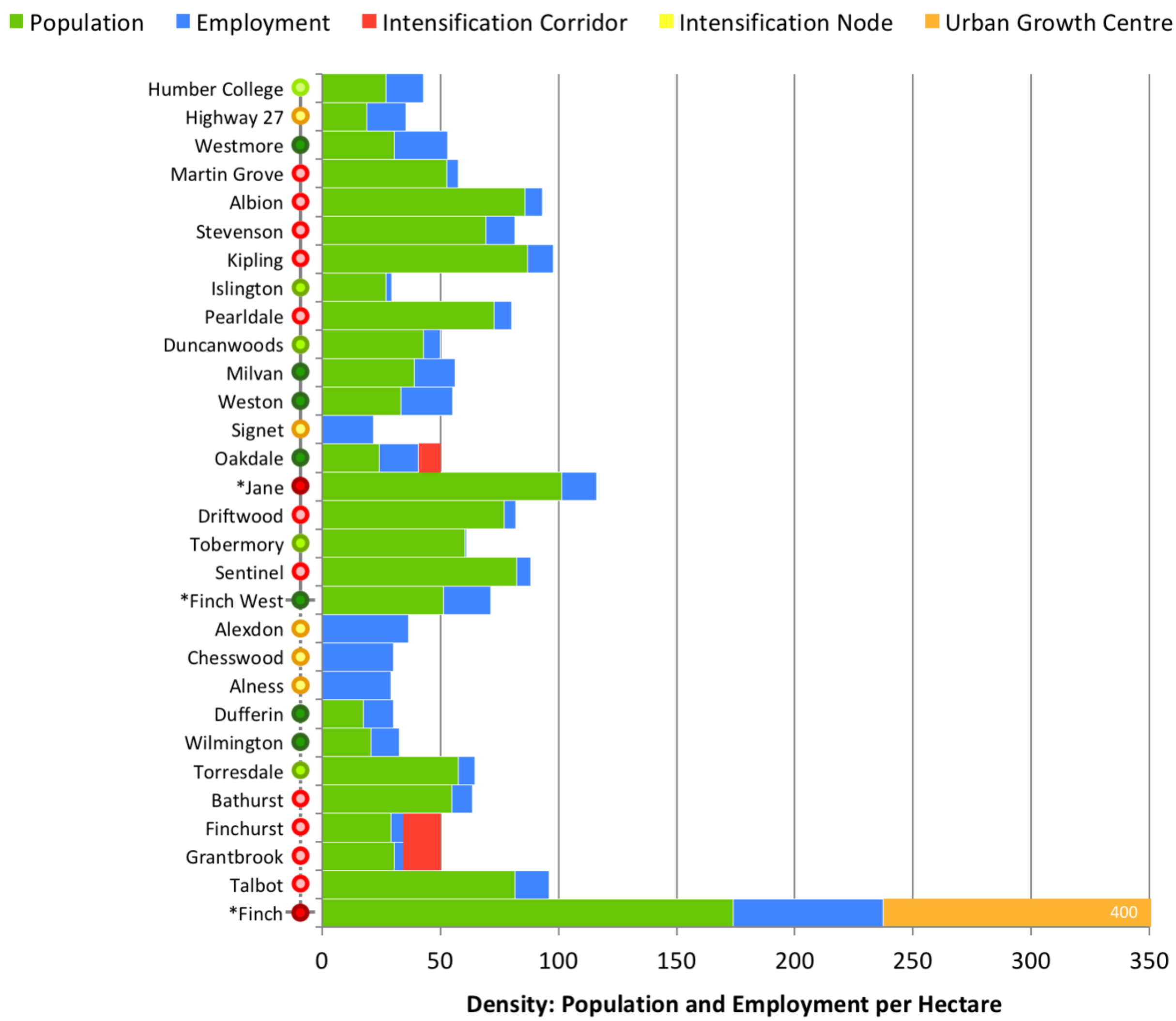


Figure 3-20. Population and Employment Density: Finch West LRT Phase 1 and 2



* indicates station is designated as a Mobility Hub by Metrolinx

3.2.3. Sheppard East LRT Phases 1 and 2 and TTC Line 4 Subway

Project Key Information			
Line Length (kilometres)	17	Population	140,343
Average Density (ppl+jobs/ha)	70	Employment	75,158
Total Stations	30		
Urban Commercial Core	-	*Outer Suburban Neighbourhood*	3
Urban Mixed-Use Core	-	*Exurban Neighbourhood*	-
Inner Urban Neighbourhood	2	*Suburban Centre*	-
Urban Neighbourhood	11	*Outer Suburban Industrial Park*	4
Suburban Neighbourhood	7	*Airport*	-

The Sheppard East LRT is a proposed 15km LRT line in the City of Toronto. The line is split into two phases; the first from Don Mills to Morningside Avenue, with a second phase proposed that consists of an additional three stations further east. The project is to begin construction in 2021 after the completion of the Finch West LRT for an opening in 2024. When finished it will connect with GO Transit at the Agincourt station and the existing 5.5km TTC Line 4 subway at Don Mills station. Between Don Mills station and Consumers Road station, the LRT will run in a tunnel which allows a direct connection to the subway line. The Line 4 subway opened in 2002 with 5 stations and connects to the Line 1 subway at Sheppard-Yonge. Together, Line 4 and the Sheppard East LRT Phases 1 and 2 serve approximately 140,000 people and 75,000 jobs for an average density of 70 people and jobs per hectare.

The Sheppard corridor varies in density from station to station (Figures 3-21 to 3-23). On the Line 4 subway, densities range from low at Bessarion station to high at Don Mills and Sheppard-Yonge stations. Here some stations are intensifying with new condominium projects near several stations. Along the LRT portion of the corridor, stations are predominately *Urban Neighbourhoods*, characterized by medium-density development with some elements of TOD. Farther east, stations become more suburban in character. Here while medium-density, pedestrian accessibility is lower due to cul-de-sac street designs and some stations feature high levels of industrial land use. Many stations are within an intensification corridor, though some *Suburban* stations and could benefit from transit-oriented intensification in the future.

Figure 3-21. Station Area Land Use: Sheppard East LRT Phases 1 and 2 and TTC Line 4 Subway

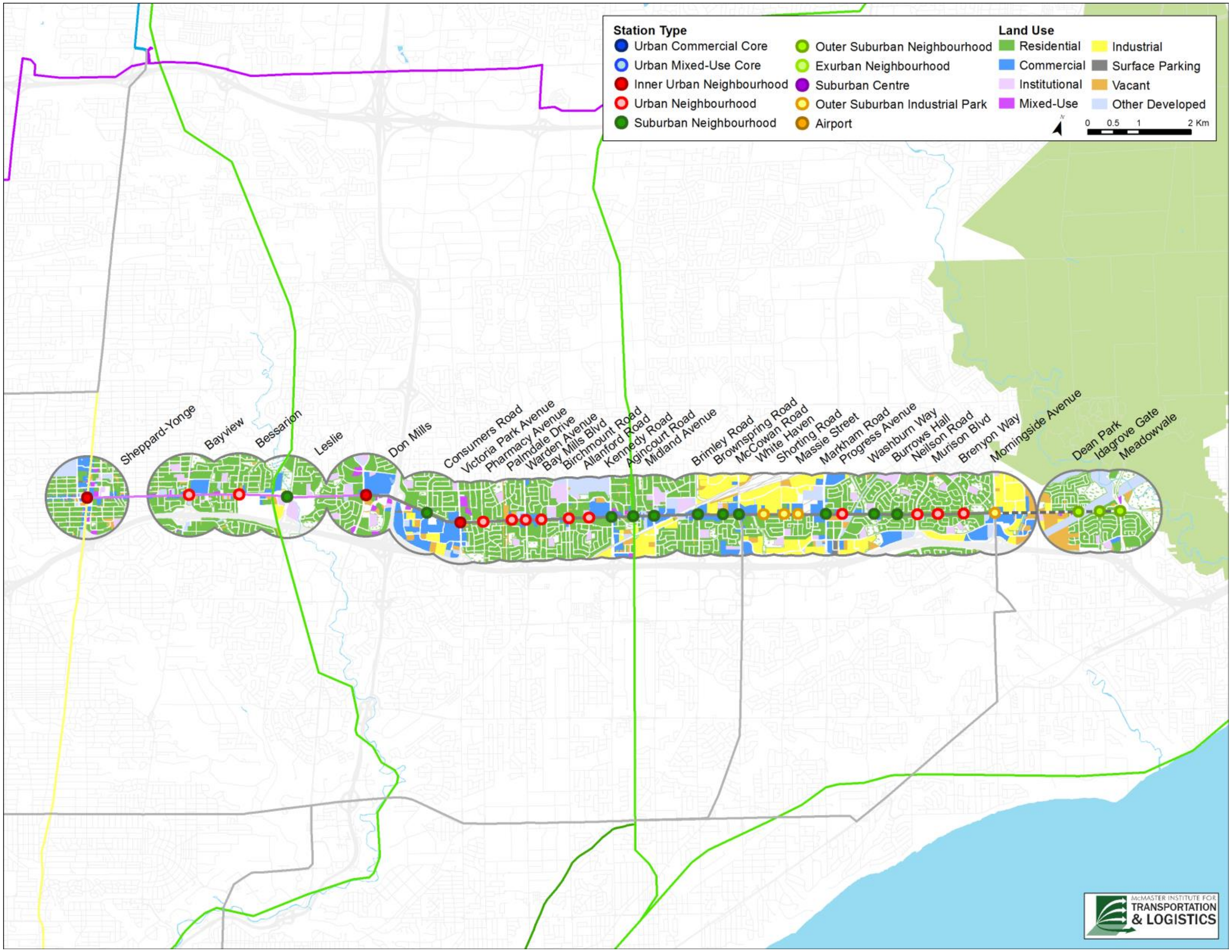


Figure 3-22. Station Area Intensification Designations: Sheppard East LRT Phases 1 and 2 and TTC Line 4 Subway

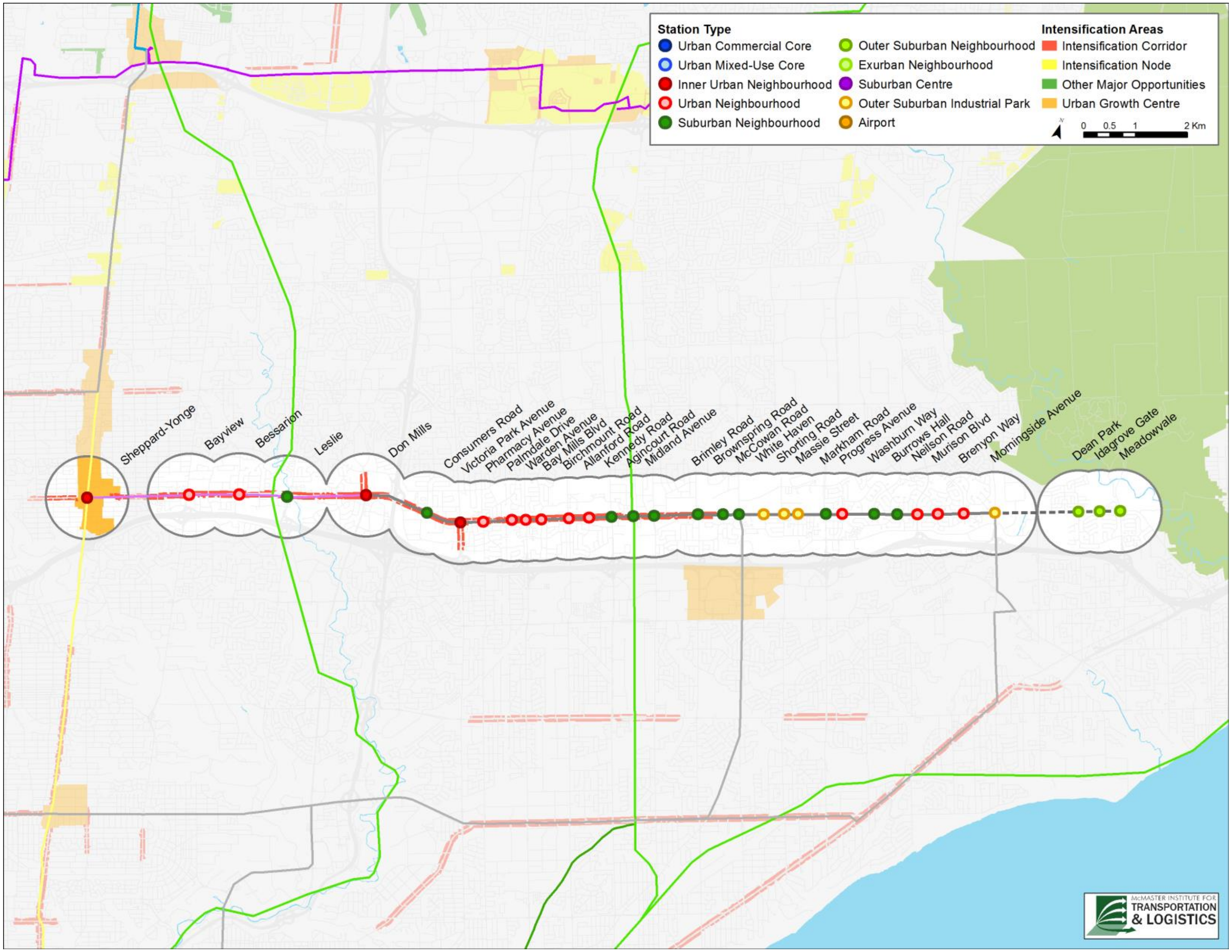
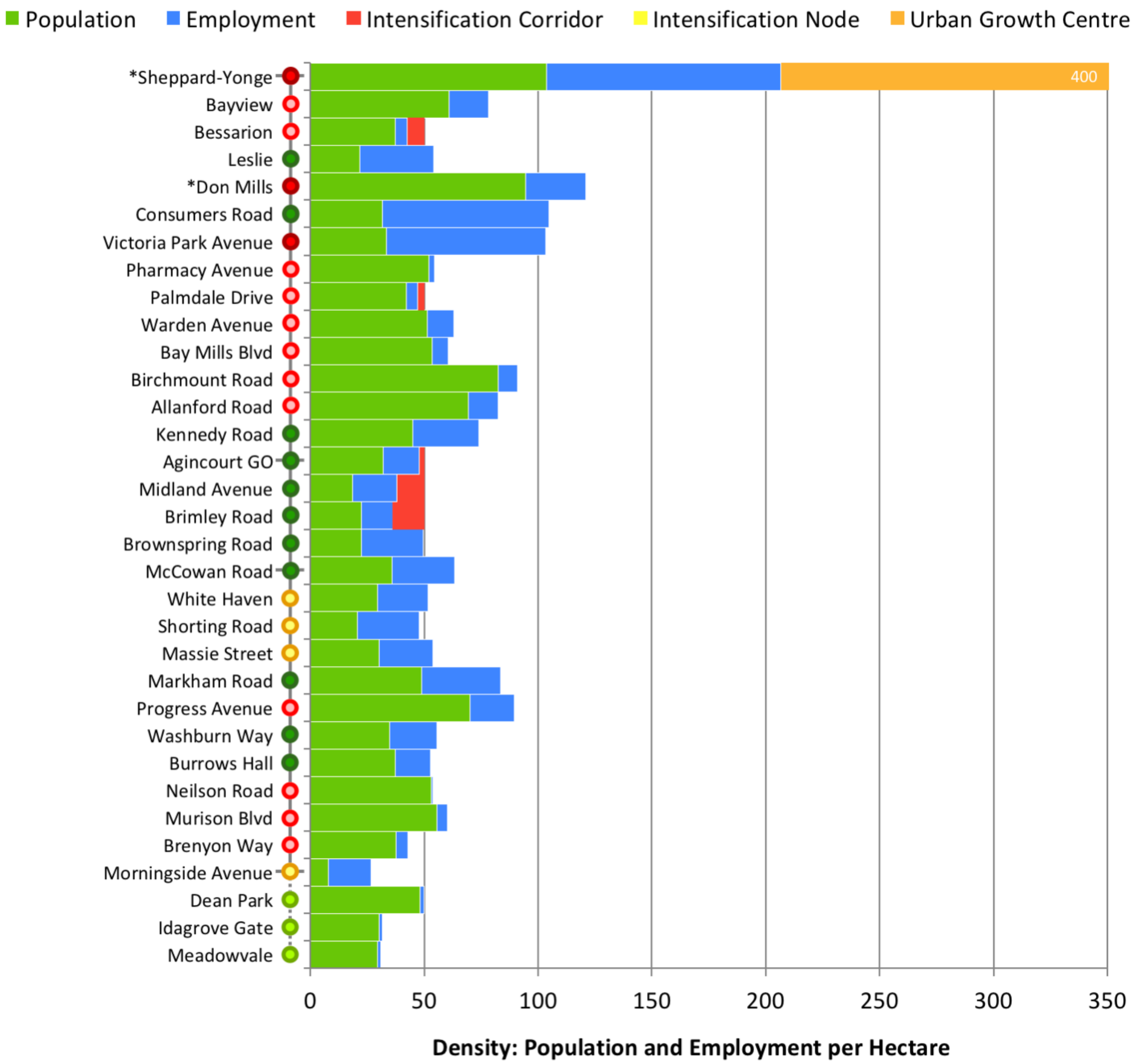


Figure 3-23. Population and Employment Densities: Sheppard East LRT Phases 1 and 2 and TTC Line 4 Subway



* indicates station is designated as a Mobility Hub by Metrolinx

3.2.4. Hamilton A-Line Phase 1 and B-Line LRT Phases 1 and 2

Project Key Information			
Line Length (kilometres)	16	Population	121,267
Average Density (ppl+jobs/ha)	64	Employment	58,480
Total Stations	19		
Urban Commercial Core	1	*Outer Suburban Neighbourhood*	1
Urban Mixed-Use Core	-	*Exurban Neighbourhood*	-
Inner Urban Neighbourhood	3	*Suburban Centre*	-
Urban Neighbourhood	11	*Outer Suburban Industrial Park*	-
Suburban Neighbourhood	3	*Airport*	-

The B-Line LRT is a 14km light rail line in the City of Hamilton. The A-Line is a 2km spur, connecting the B-Line with the West Harbour GO station and the waterfront. In the future this line may travel further south to the Hamilton Mountain and the city's airport. As of 2015, Phase 1 of the B-Line and the A-Line are funded for construction with operations beginning in 2024. Both lines are to run in a dedicated right-of-way, offering rapid transit service to a number of important destinations, such as McMaster University, the McMaster Innovation Park, downtown Hamilton, and Tim Hortons Field. Among all the transit lines in the present study, the B-Line Phase 1 is among the highest-density projects in the region. Phase 2 and the A-Line spur are generally lower, but the A-Line's density in the present study is limited by Hamilton Harbour. If all stations were constructed, they would serve approximately 120,000 people and 58,000 jobs according to our data from the 2011 Canadian Census of Population and National Household Survey. This would give the lines an average density of 64 people and jobs per hectare.

With the A-Line and B-Line LRTs running through the historic urban core and dense inner-city suburbs, the nature of the built environment is quite transit-oriented already (Figures 3-24 to 3-26). The majority of stations are *Inner Urban* and *Urban Neighbourhoods*, with three *Suburban Neighbourhoods* near McMaster University and one *Outer Suburban Neighbourhood* around the Waterfront station. The downtown core is a high density *Urban Commercial Core* station, the only one in the present study outside of the City of Toronto. In general, this means the corridor features medium- to high-densities, good pedestrian accessibility attributable to a grid street pattern, mixing of land uses, and good transit access to people and jobs. In terms of intensification, the entire corridor is within a designated intensification corridor, and several stations are within the city's downtown Urban Growth Centre. In general, the biggest opportunity for growth is in the downtown core, where a number of large parcels presently used for surface parking lots permit larger-scale implementations of TOD. This type of development should help the downtown core reach its targeted density levels and further anchor movements along the lines in the future.

Figure 3-24. Station Area Land Use: A-Line and B-Line LRT

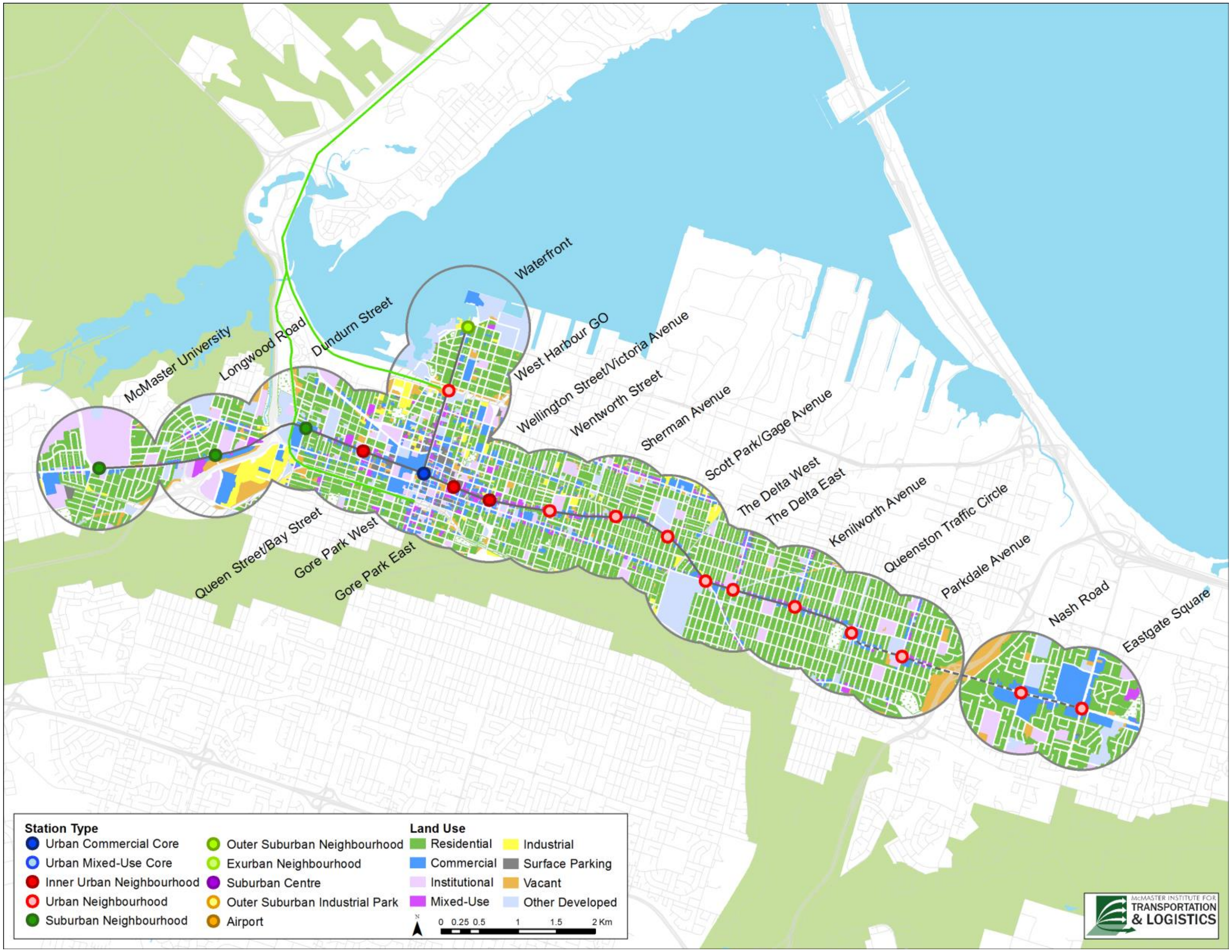


Figure 3-25. Station Area Intensification Designations: A-Line and B-Line LRT

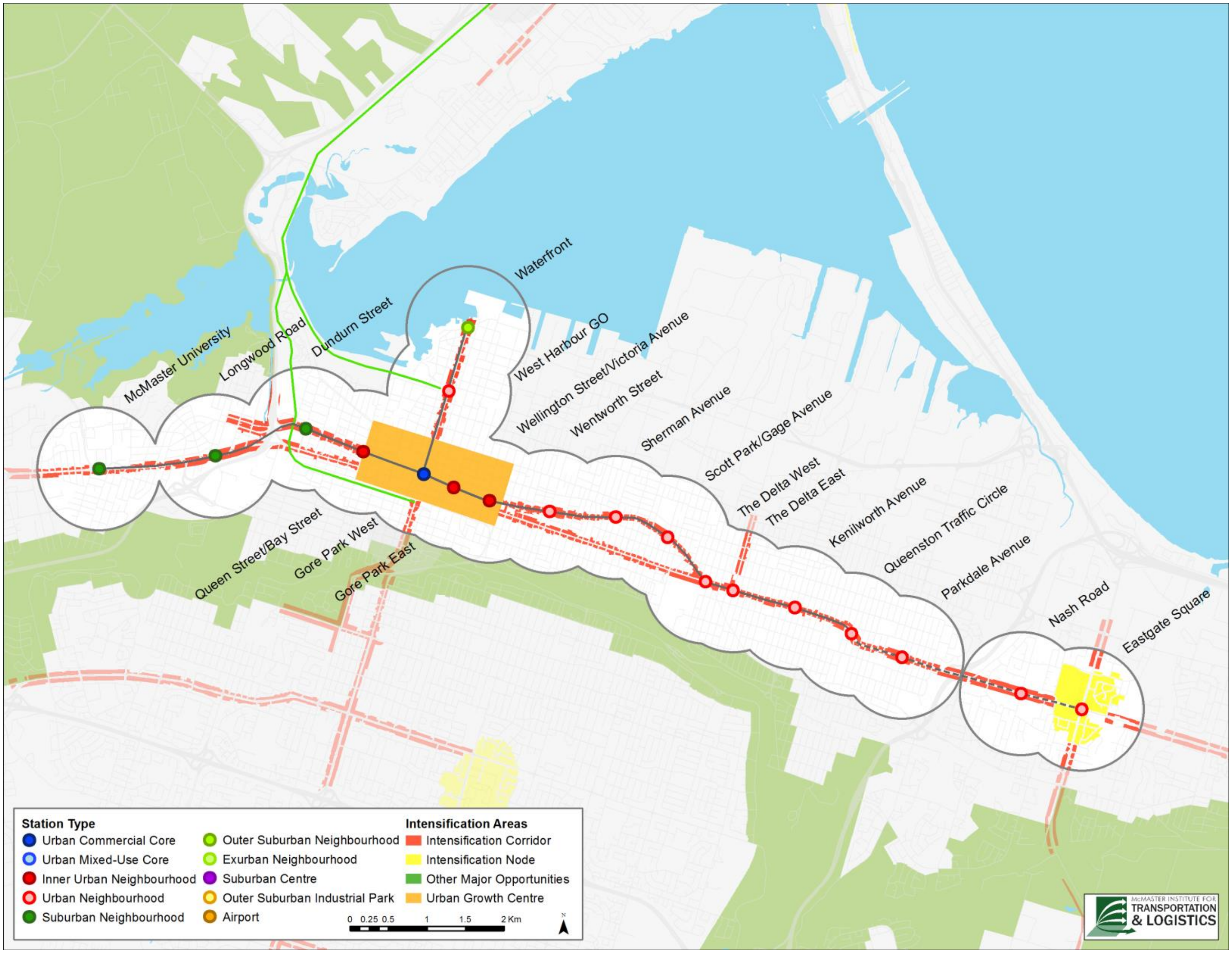
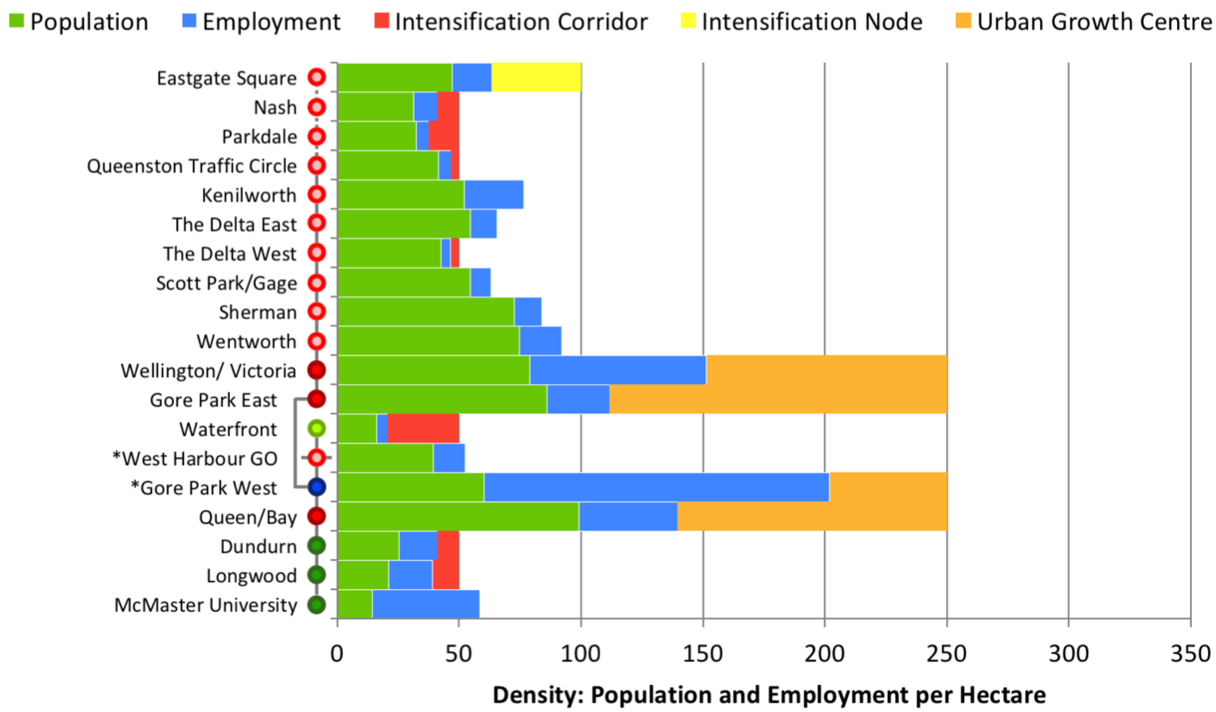


Figure 3-26. Population and Employment Density: A-Line and B-Line LRT



* indicates station is designated as a Mobility Hub by Metrolinx

3.2.5. Hurontario-Main LRT Phases 1 and 2

Project Key Information			
Line Length (kilometres)	23	Population	140,515
Average Density (ppl+jobs/ha)	65	Employment	75,749
Total Stations	33		
Urban Commercial Core	-	*Outer Suburban Neighbourhood*	1
Urban Mixed-Use Core	1	*Exurban Neighbourhood*	-
Inner Urban Neighbourhood	4	*Suburban Centre*	1
Urban Neighbourhood	11	*Outer Suburban Industrial Park*	4
Suburban Neighbourhood	4	*Airport*	-

The Hurontario-Main LRT is a light rail line planned to run from Elizabeth station in Port Credit to Shoppers World in Mississauga, and potentially to downtown Brampton and the nearby GO CRT station. Phase 1 of the line is within the City of Mississauga and is funded and in the early stages of procurement with construction beginning in 2018 and operations beginning in 2022. Until recently the entire project was to be completed at once. However, the 3.5km segment of the line north of Shoppers World was rejected by the City of Brampton in late 2015. As such, this segment is designated as a potential Phase 2. In both cases the line would operate in a separate right of way. Compared to other projects, Phase 1 of the line is relatively high density and Phase 2 is medium relative to others. Together the 33 stations across both phases would serve approximately 141,000 people and 76,000 jobs for an average density of 65 people and jobs per hectare.

A large number of *Urban* stations point to a corridor that is already broadly reflective of TOD (Figures 3-27 to 3-29). Such stations feature a mixing of land uses, medium- to high-densities, good levels of pedestrian accessibility, and high levels of access to people and jobs. However, there is opportunity for intensification in the future, as many stations do not yet meet their density targets. This is particularly the case for Elizabeth stations and those with high proportions of low-density industrial development. The two high-density *Suburban Neighbourhood* stations in the central corridor point to a need to increase the quality of the pedestrian environment around these stops.

Figure 3-27. Station Area Land Use: Hurontario-Main LRT Phases 1 and 2

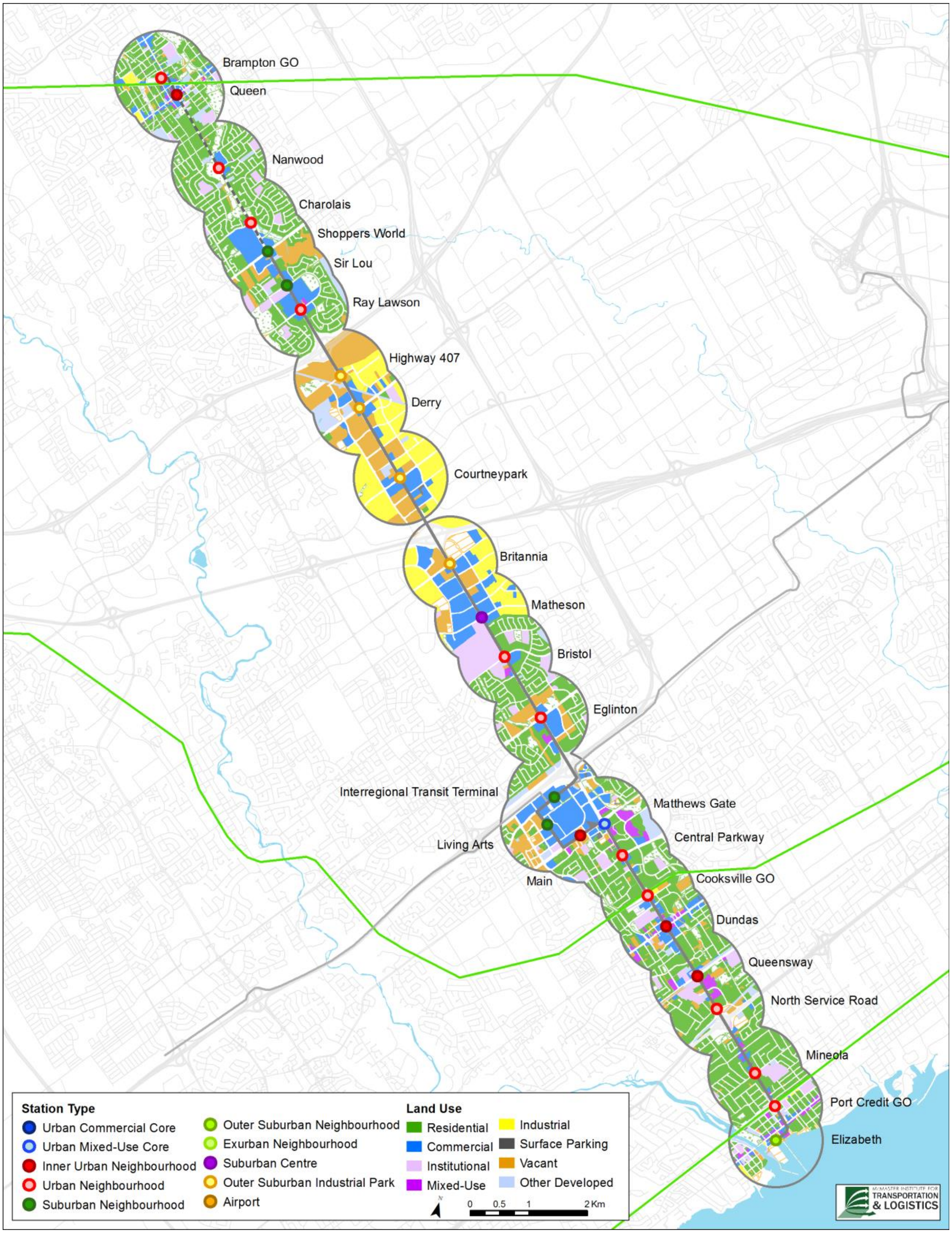


Figure 3-28. Station Area Intensification Designations: Hurontario-Main LRT Phases 1 and 2

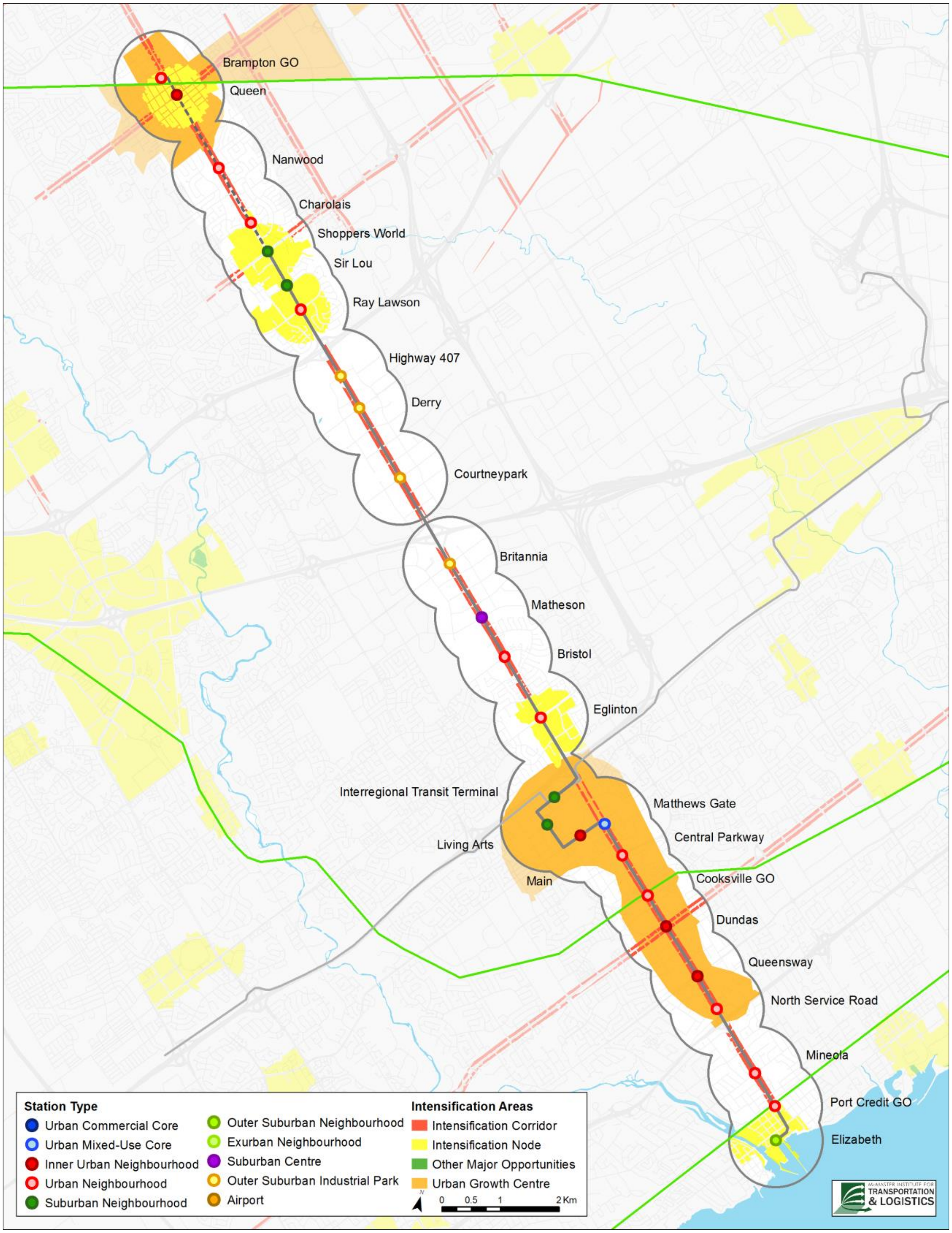
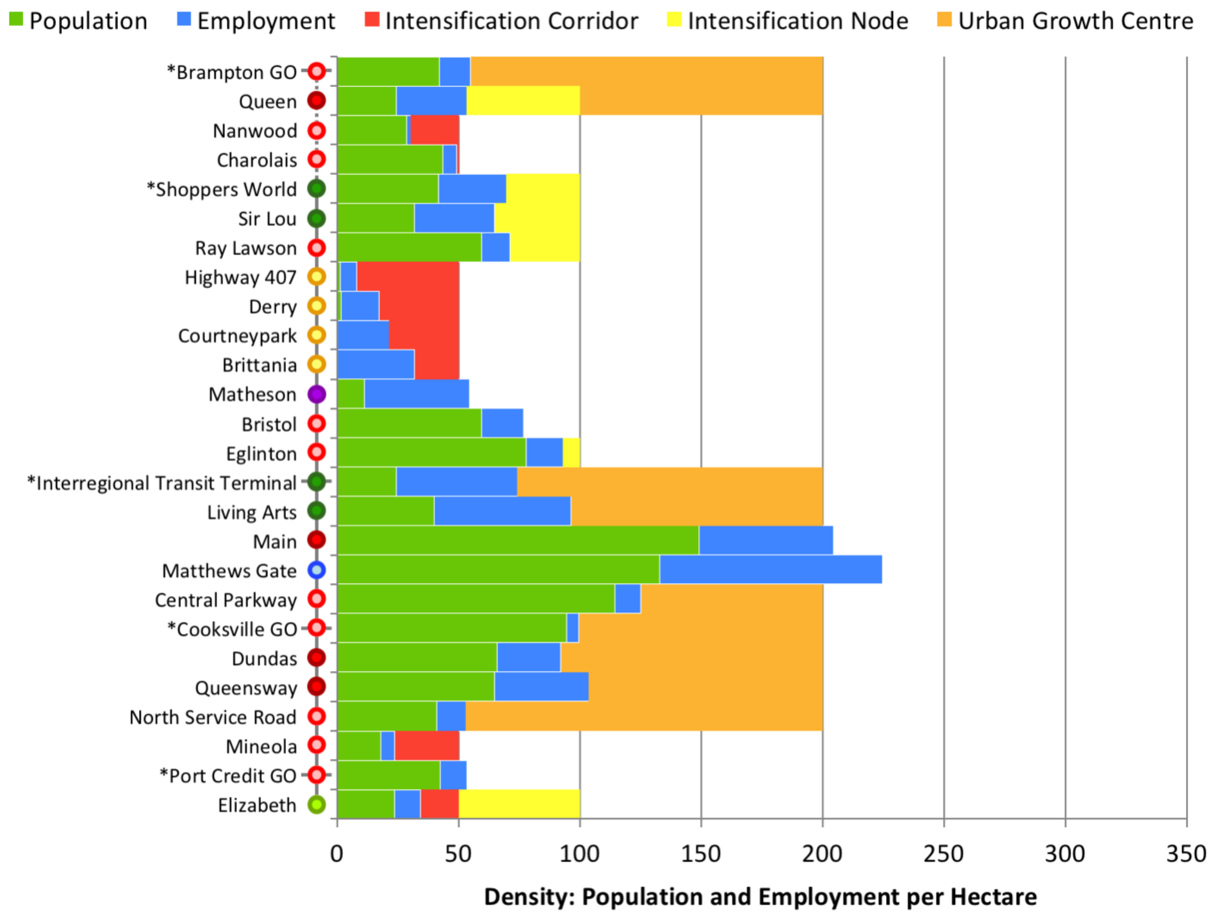


Figure 3-29. Population and Employment Density: Hurontario-Main LRT Phases 1 and 2



* indicates station is designated as a Mobility Hub by Metrolinx

3.2.6. Waterloo ION LRT Phases 1 and 2

Project Key Information			
Line Length (kilometres)	33	Population	61,097
Average Density (ppl+jobs/ha)	40	Employment	81,760
Total Stations	24		
Urban Commercial Core	-	*Outer Suburban Neighbourhood*	2
Urban Mixed-Use Core	-	*Exurban Neighbourhood*	1
Inner Urban Neighbourhood	5	*Suburban Centre*	5
Urban Neighbourhood	1	*Outer Suburban Industrial Park*	3
Suburban Neighbourhood	7	*Airport*	-

The ION LRT is a new LRT line in the Region of Waterloo. Phase 1 of the line runs from Conestoga Mall in the north to Fairview Park Mall in the south, via the University of Waterloo, the Research and Technology Park of the University of Waterloo and Laurier, and downtown Kitchener-Waterloo, which offers a connection to the GO CRT network. Phase 1 is approximately 19km in length and under construction with service scheduled to begin in late 2017. Phase 2 of the project is proposed to run from Fairview Park to downtown Cambridge. Prior to the construction of LRT along Phase 2, the Region of Waterloo will run an adapted BRT line along a parallel route. In both phases, the LRT will operate on a mix of off-street and on-street track. However, on-street segments maintain a separate right-of-way for light rail vehicles. According to our population and employment data, the lines are primarily oriented to employment uses, serving approximately 61,000 people and 81,000 jobs. Average density across both phases would be 40 people and jobs per hectare.

The Waterloo ION LRT connects many medium-density stations (Figures 3-30 to 3-32). The bulk of stations along Phase 1 are Inner Urban and Urban Neighbourhoods, with a large number of Suburban Centre stations in the northern segment of the corridor around the University of Waterloo. This suggests that Phase 1 will operate in a relatively transit-oriented corridor. Outside of downtown Kitchener-Waterloo however, Phase 1 becomes more suburban, and this continues along Phase 2 into downtown Cambridge. To intensify station areas, a large number of stations along both Phases 1 and 2 are located within intensification corridors and nodes and urban growth centres. Most stations do not yet meet their targeted level of population and employment densities. However, Kitchener and Waterloo are both very active in station area TOD planning and view the promotion of TOD as a way to achieve the maximum possible return on investment for the project.

Figure 3-30. Station Area Land Use: Waterloo ION LRT Phases 1 and 2

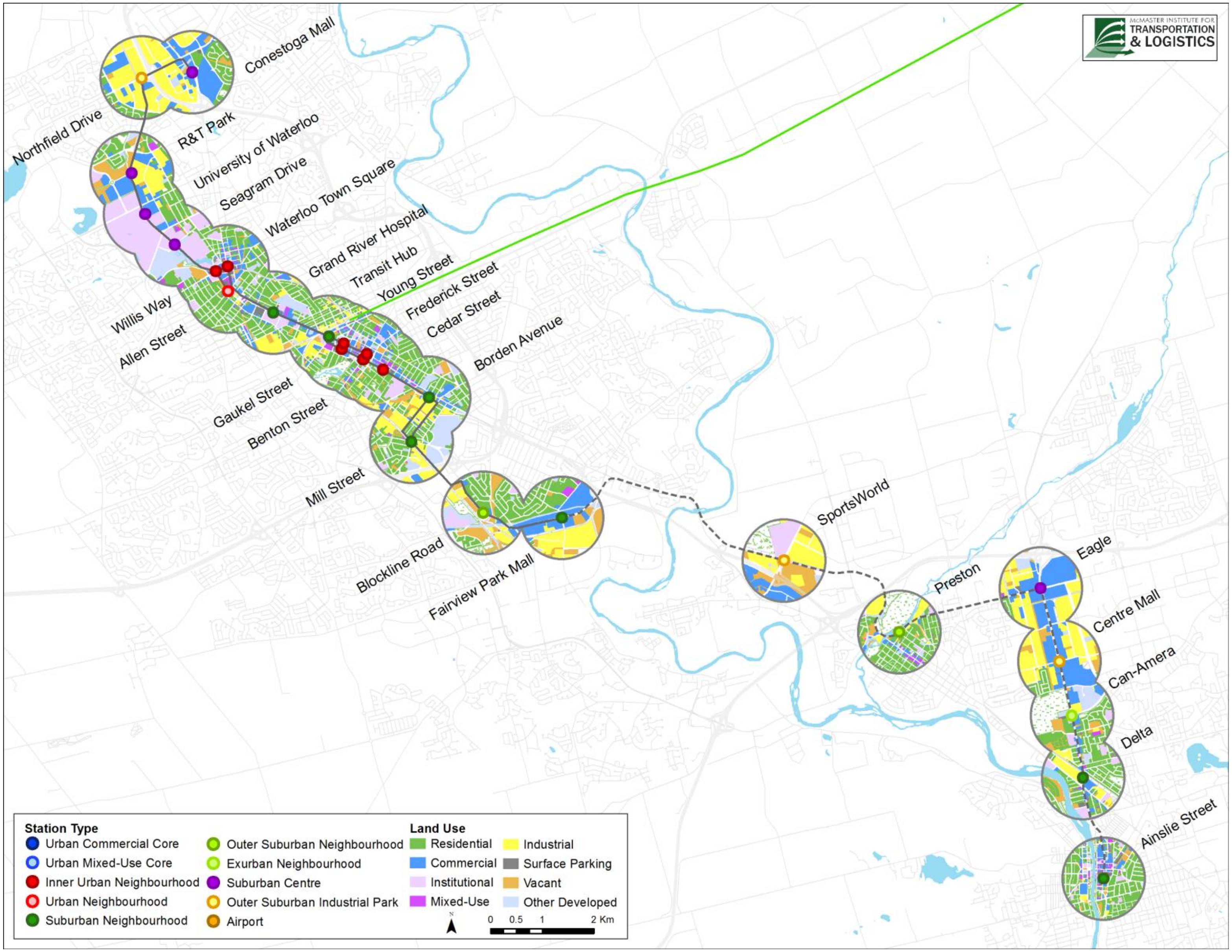


Figure 3-31. Station Area Intensification Designations: Waterloo ION LRT Phases 1 and 2

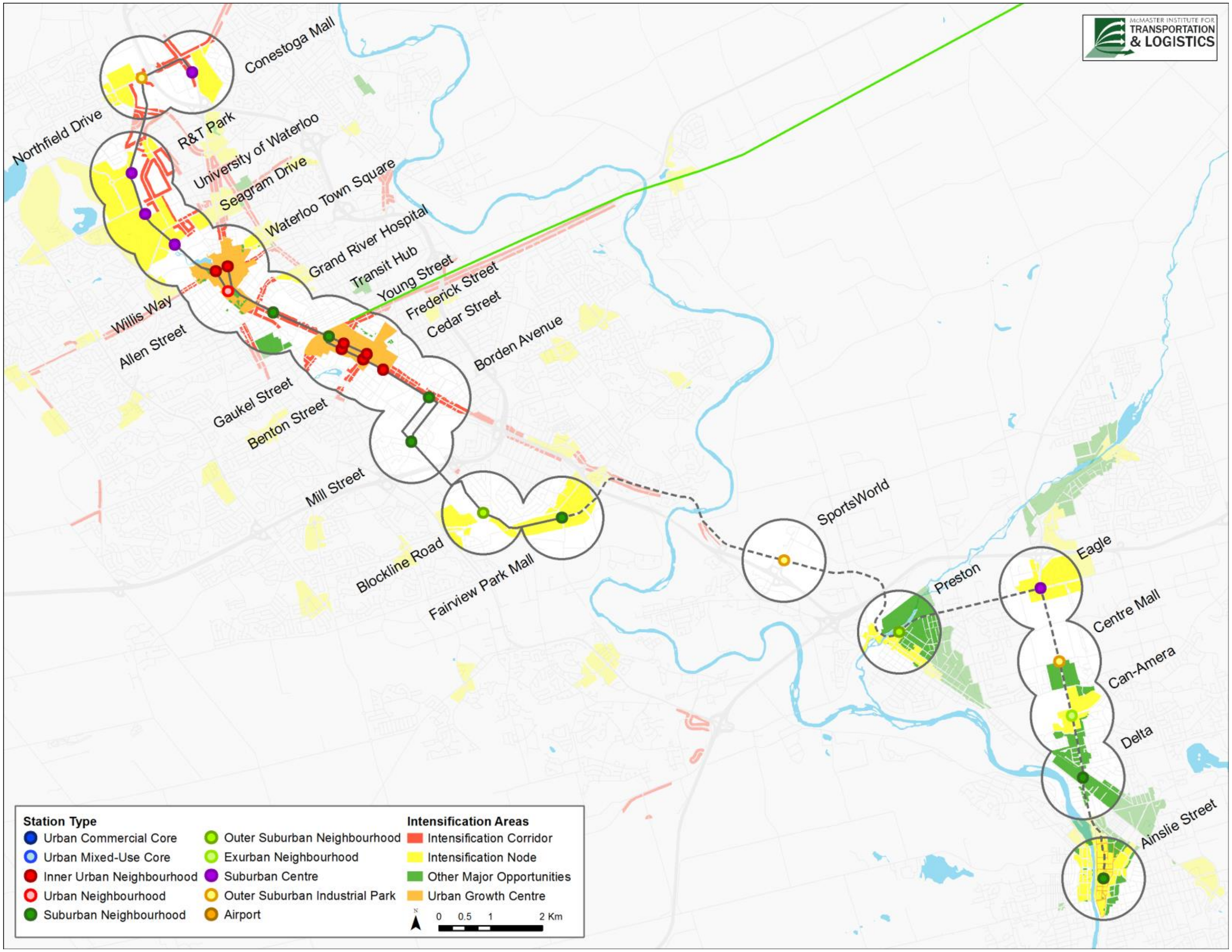
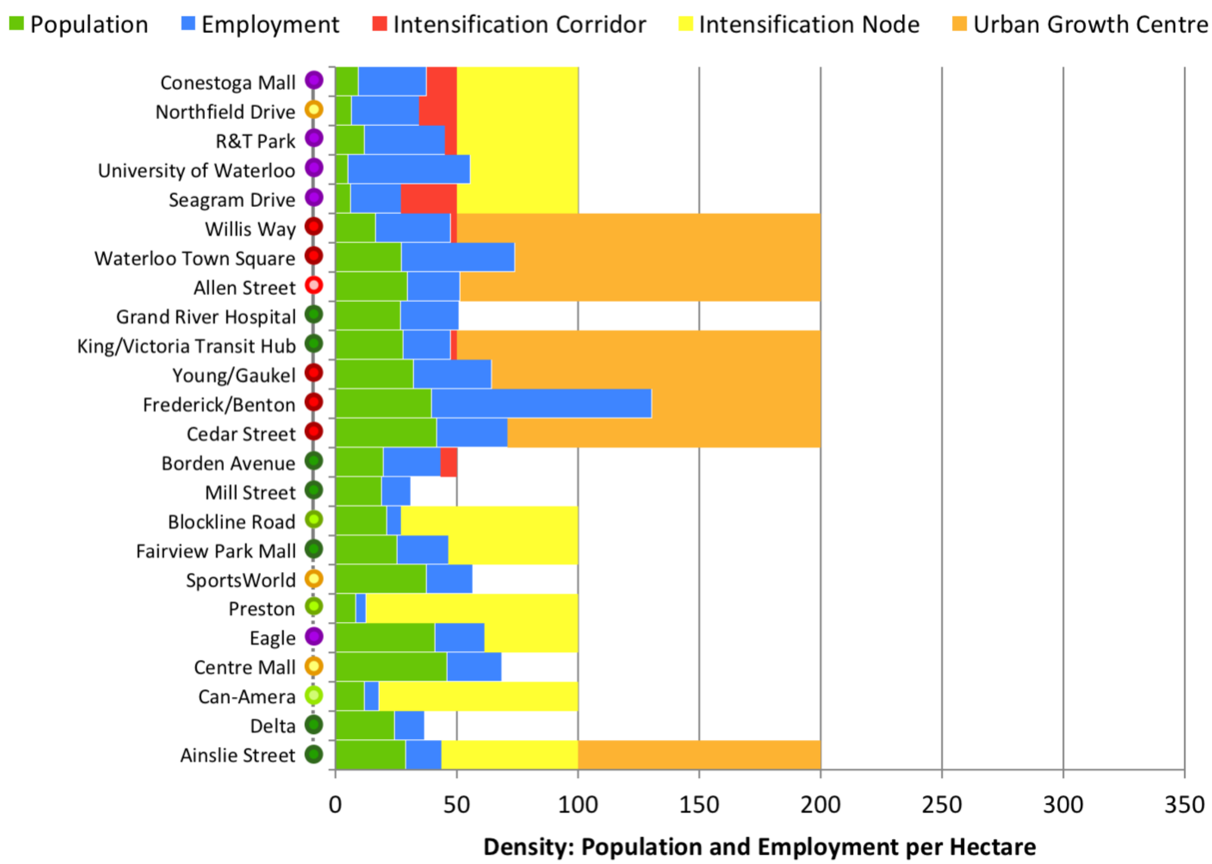


Figure 3-32. Population and Employment Density: Waterloo ION LRT Phases 1 and 2



* indicates station is designated as a Mobility Hub by Metrolinx

3.3. Bus Rapid Transit

3.3.1. Mississauga Transitway

Project Key Information			
Line Length (kilometres)	19	Population	35,313
Average Density (ppl+jobs/ha)	37	Employment	28,282
Total Stations	12		
Urban Commercial Core	-	*Outer Suburban Neighbourhood*	3
Urban Mixed-Use Core	-	*Exurban Neighbourhood*	2
Inner Urban Neighbourhood	-	*Suburban Centre*	3
Urban Neighbourhood	-	*Outer Suburban Industrial Park*	1
Suburban Neighbourhood	3	*Airport*	-

The Mississauga Transitway is a BRT service that is under construction in the City of Mississauga. The line travels from Winston Churchill station in the west to Renforth Gateway in the west, where it can connect to the proposed Eglinton Crosstown LRT Phase 2. The line will eventually interface with Phase 1 of the Hurontario-Main LRT at the Interregional Transit Terminal. As of writing, 8 of the line's 12 stations are open, from Erin Mills to Etobicoke Creek. The remaining stations are expected to open in 2017. Operationally, the line runs in a dedicated transitway with the segment from Erin Mills to the Interregional Transit Terminal making use of a dedicated shoulder lane on Highway 403. GO Transit's bus operations will also make use of the Transitway for limited-stop service for interregional trips. The 12 stations on the Transitway are estimated to serve approximately 35,000 people and 28,000 jobs for an average density of 54 people and jobs per hectare.

Compared to other projects, the Transitway is low- to medium-density overall (Figures 3-33 to 3-35). In general, stations are suburban in character, split between *Suburban*, *Outer Suburban*, and *Exurban Neighbourhoods* oriented to population, and *Suburban Centres* and *Outer Suburban Industrial Parks* oriented to employment. The Interregional Transit terminal is a high-density station in central Mississauga, but its *Suburban Neighbourhood* designation points to a built environment that can benefit from pedestrian improvements. The eastern portion of the corridor, while lower-density at present, is within a designated intensification node. However, the western segment of the line des not feature any intensification designation, highlighting areas for potential intervention to promote transit-oriented intensification in the future.

Figure 3-33. Station Area Land Use: Mississauga Transitway

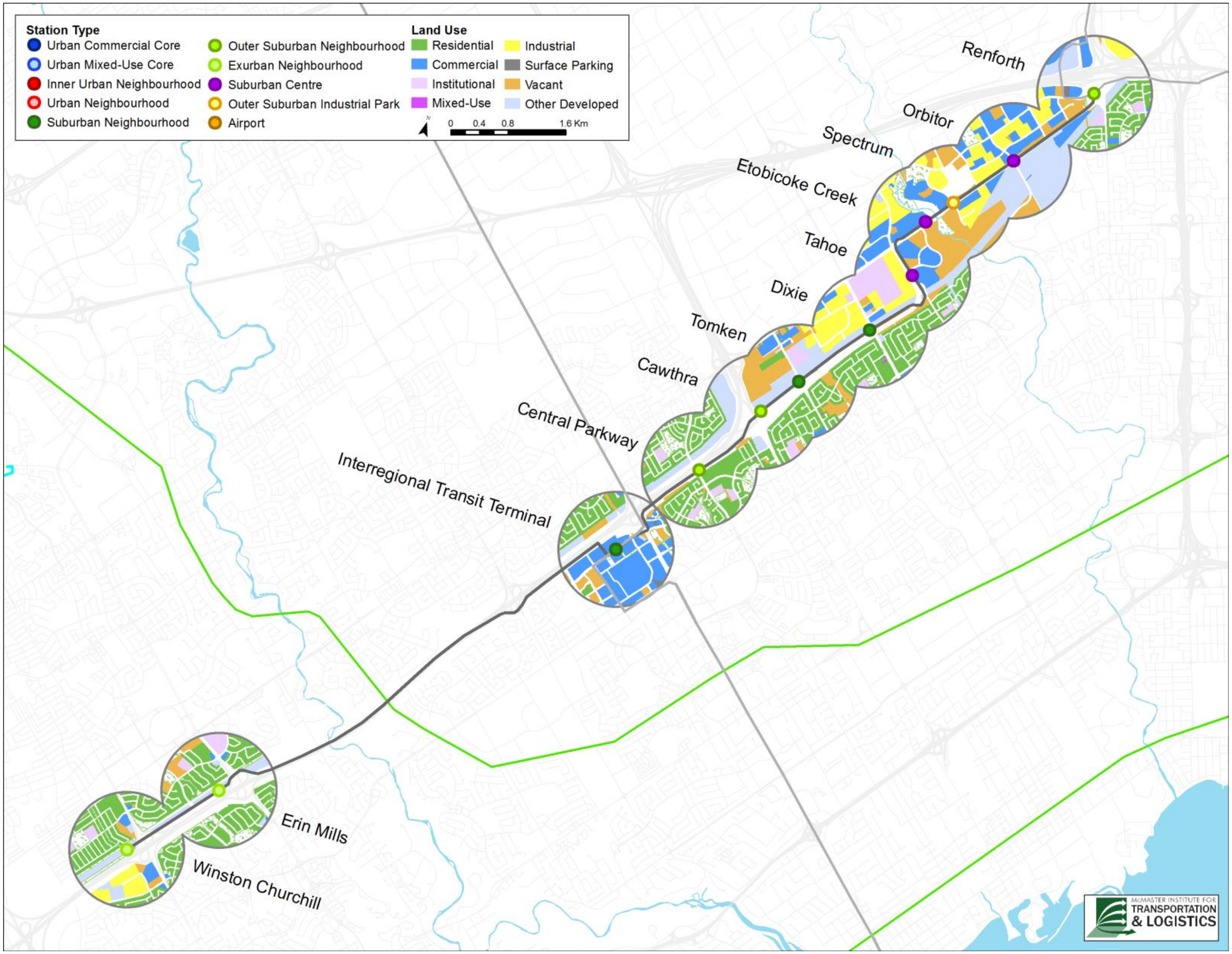


Figure 3-34. Station Area Intensification Designations: Mississauga Transitway

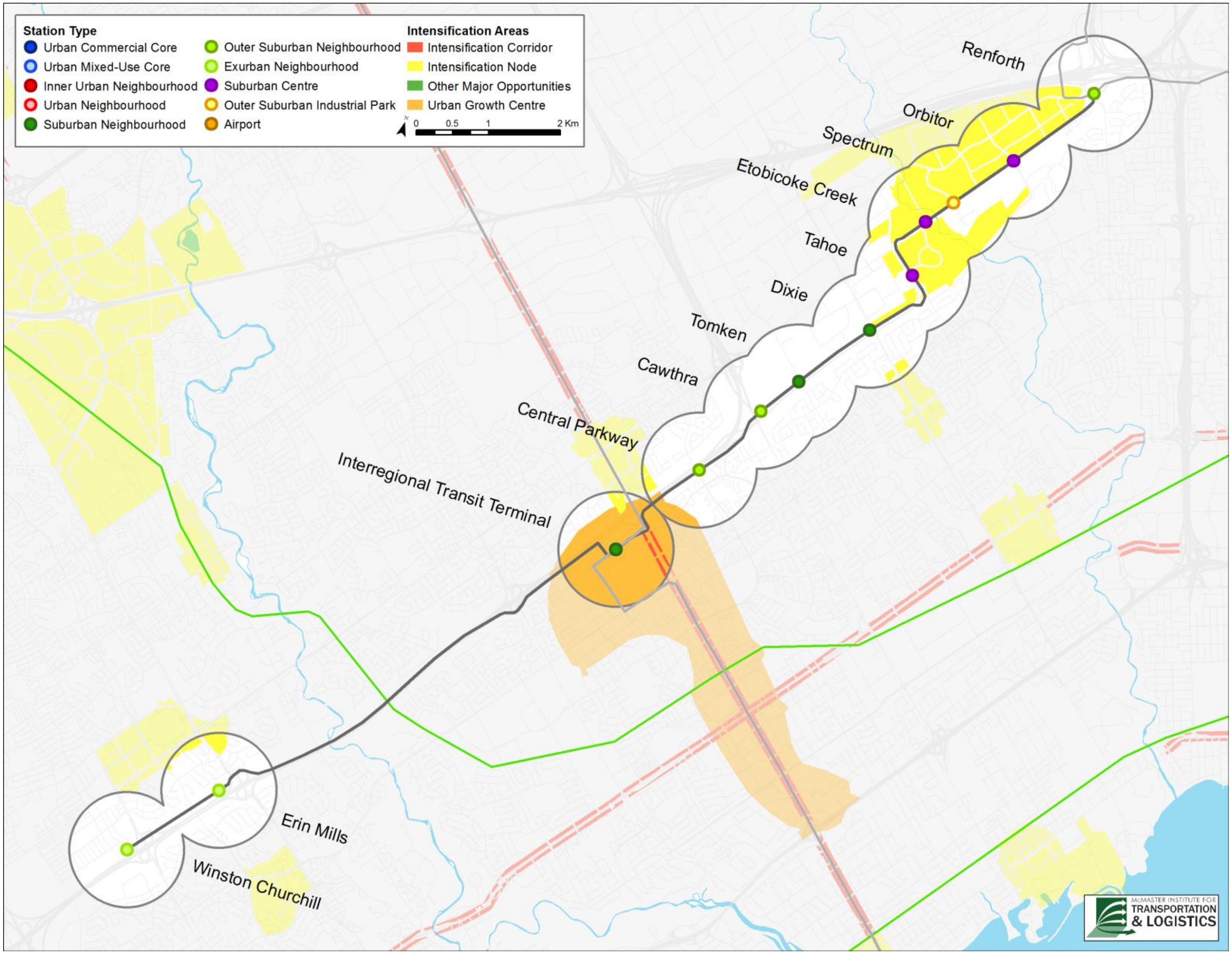
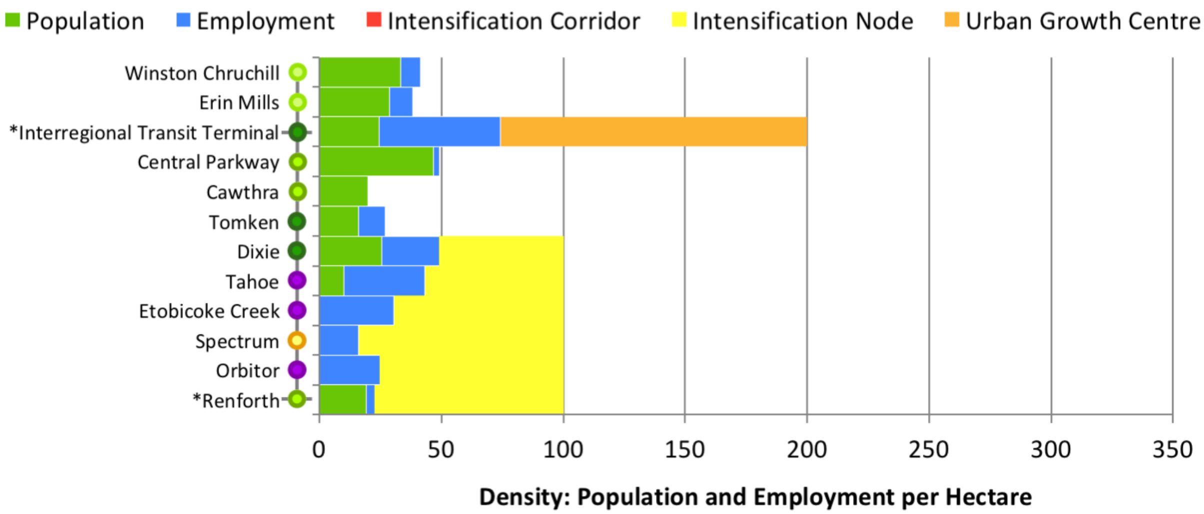


Figure 3-35. Population and Employment Density: Mississauga Transitway



* indicates station is designated as a Mobility Hub by Metrolinx

3.3.2. VIVA Blue BRT

Project Key Information			
Line Length (kilometres)	33	Population	99,224
Average Density (ppl+jobs/ha)	34	Employment	50,927
Total Stations	29		
Urban Commercial Core	-	*Outer Suburban Neighbourhood*	4
Urban Mixed-Use Core	-	*Exurban Neighbourhood*	1
Inner Urban Neighbourhood	-	*Suburban Centre*	2
Urban Neighbourhood	8	*Outer Suburban Industrial Park*	-
Suburban Neighbourhood	14	*Airport*	-

York Region's VIVA transit system opened in 2005, beginning service with buses operating in mixed traffic. This type of operation is a precursor to the VIVA NEXT Rapidways project, which will see the Purple and Blue VIVA lines incrementally upgraded to full BRT service through the construction of segregated bus lanes throughout York region. Presently a section of the VIVA Purple line is already open and the remaining Rapidways will be implemented in a staged process. Together, the Blue Line's 29 stations would serve approximately 99,000 people and 51,000 jobs according to our population and employment estimates. This would give the line an average density of 34 people and jobs per hectare.

The Blue Line corridor features a diverse set of station types (Figures 3-36 to 3-38). The line is predominately suburban in nature, with 65% of its stations either *Suburban*, *Outer Suburban* or *Exurban Neighbourhoods*. The southern portion of the line features *Urban Neighbourhood* stations that are higher density, amenity-rich, and pedestrian friendly. South of Richmond Hill Centre, the Blue Line connects to the Finch Subway, but this segment may eventually be replaced by the Yonge North subway extension.

There is significant potential for intensification along the VIVA Blue BRT line. While the line is generally suburban and lower-density relative to others in the study, many stations are designated as within an intensification corridor or node, with some servicing the Richmond Hill and Newmarket Urban Growth Centres. Others are designated as key Mobility Hubs by Metrolinx. However, many other stations do not have any intensification designation. Overall, TOD planning will be required to increase the provision of TOD inputs in terms of densities, land use mix, and pedestrian friendliness, and TOD outcomes in terms of transit use.

Figure 3-36. Station Area Land Use: VIVA Purple BRT

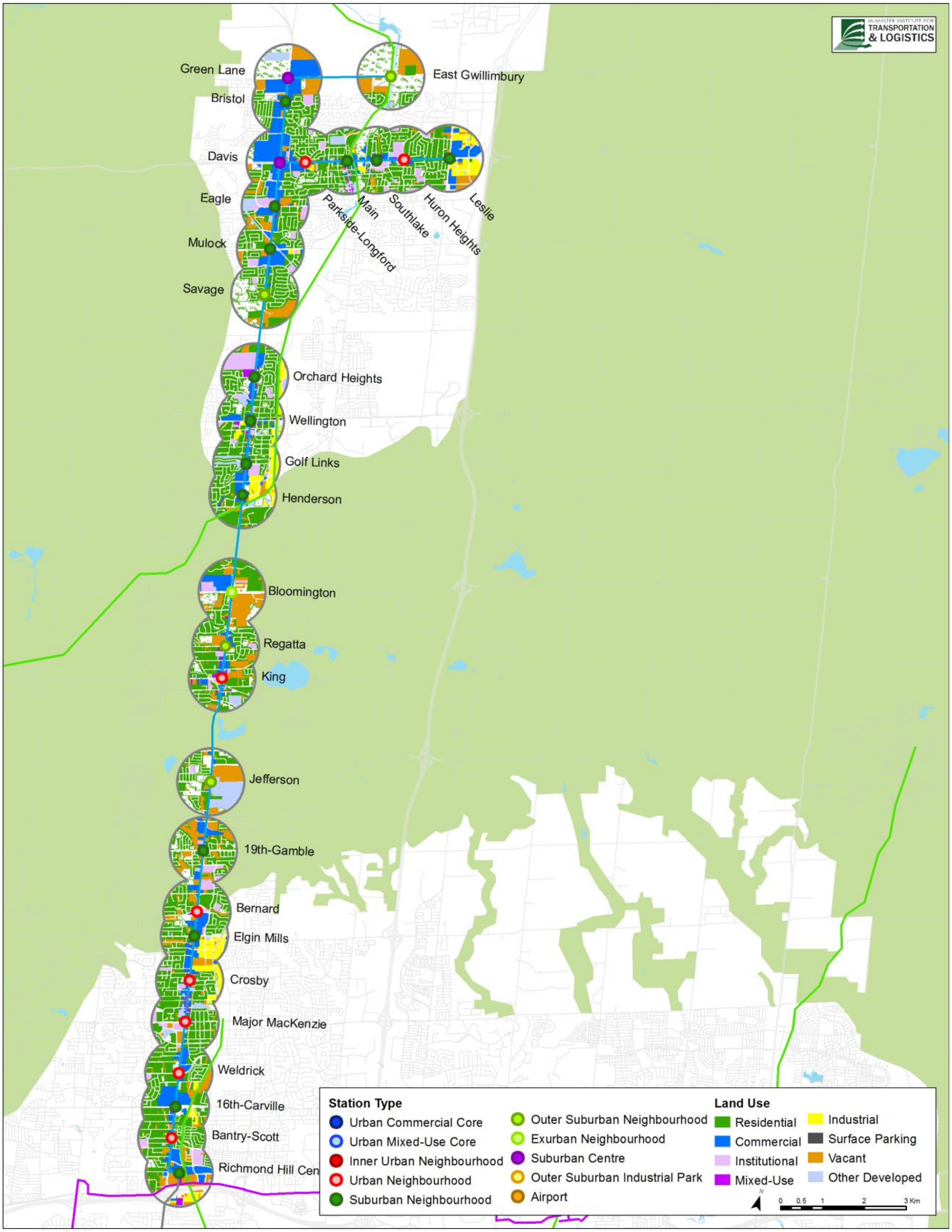
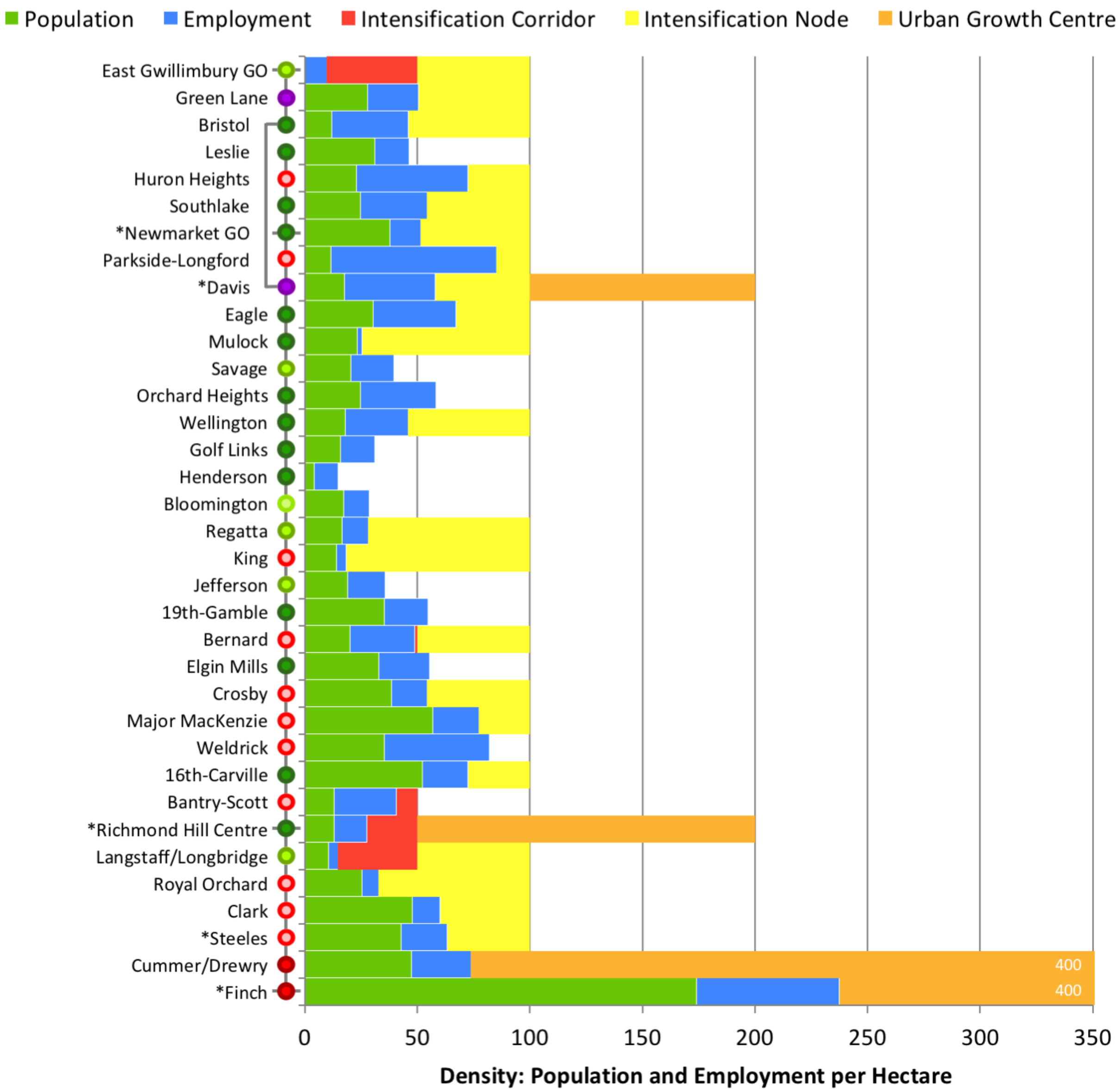


Figure 3-37. Station Area Intensification Designations: VIVA Purple BRT

Figure 3-38. Population and Employment Density: VIVA Blue BRT



* indicates station is designated as a Mobility Hub by Metrolinx

3.3.3. VIVA Purple BRT

Project Key Information			
Line Length (kilometres)	43	Population	88,826
Average Density (ppl+jobs/ha)	32	Employment	88,908
Total Stations	41		
Urban Commercial Core	-	*Outer Suburban Neighbourhood*	8
Urban Mixed-Use Core	-	*Exurban Neighbourhood*	3
Inner Urban Neighbourhood	1	*Suburban Centre*	10
Urban Neighbourhood	6	*Outer Suburban Industrial Park*	6
Suburban Neighbourhood	7	*Airport*	-

The VIVA NEXT Rapidways project will see the Purple and Blue VIVA lines incrementally upgraded to full BRT service through the construction of segregated bus lanes throughout York region. A section of the VIVA Purple line is already open from Richmond Hill Centre station to Warden station in the east, and the remaining Rapidways will be implemented in a staged process into the 2020s. The entire Purple Line project is approximately 43km in length from Western Gateway to Cornell station and connects with two GO lines, the TYSSE subway, and the proposed Yonge North subway extension. The line's 41 stations would contain approximately 89,000 people and 89,000 jobs within their station areas for an average density of 32 people and jobs per hectare.

In terms of overall density, the line is low, reflective of its generally suburban character (Figures 3-39 to 3-41). Among individual station contexts, the Purple line corridor is at present varied in the types of stations it travels through. East of Richmond Hill Centre features a large number of *Suburban Centre* stations oriented to employment uses, which are important regional destinations. This is followed by residential suburban development further east. The portion of the line west of Richmond Hill Centre roughly mirrors that of the east, with a large number of *Outer Suburban Industrial Parks* followed my more suburban residential development. As shown below, the density of individual stations is low outside of the central part of the corridor. Many stations are within designated intensification corridors and nodes and two Urban Growth Centres, which provides ample opportunity to promote more transit-oriented intensification to support BRT as the system build-out continues.

Figure 3-39. Station Area Land Use: VIVA Purple BRT

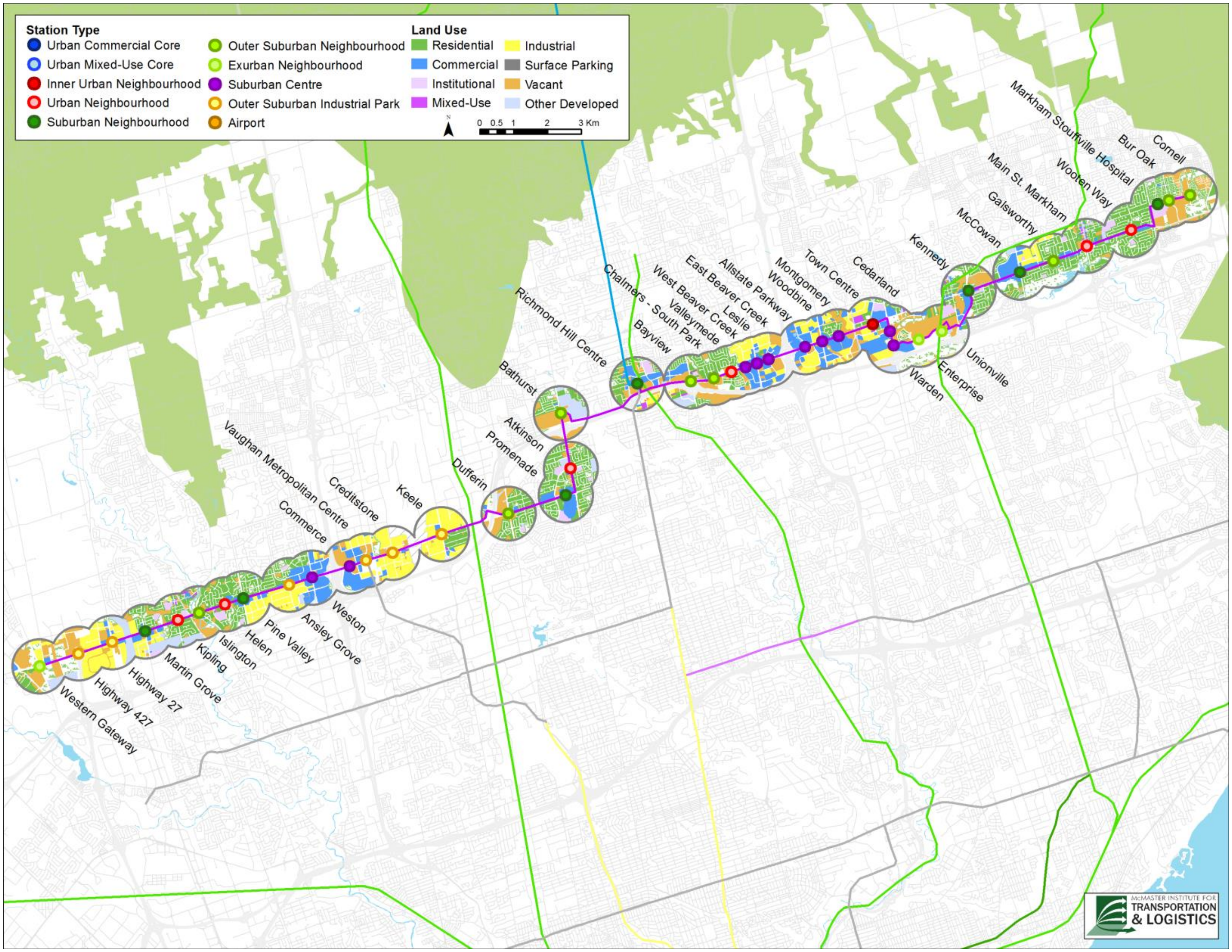


Figure 3-40. Station Area Intensification Designations: VIVA Purple BRT

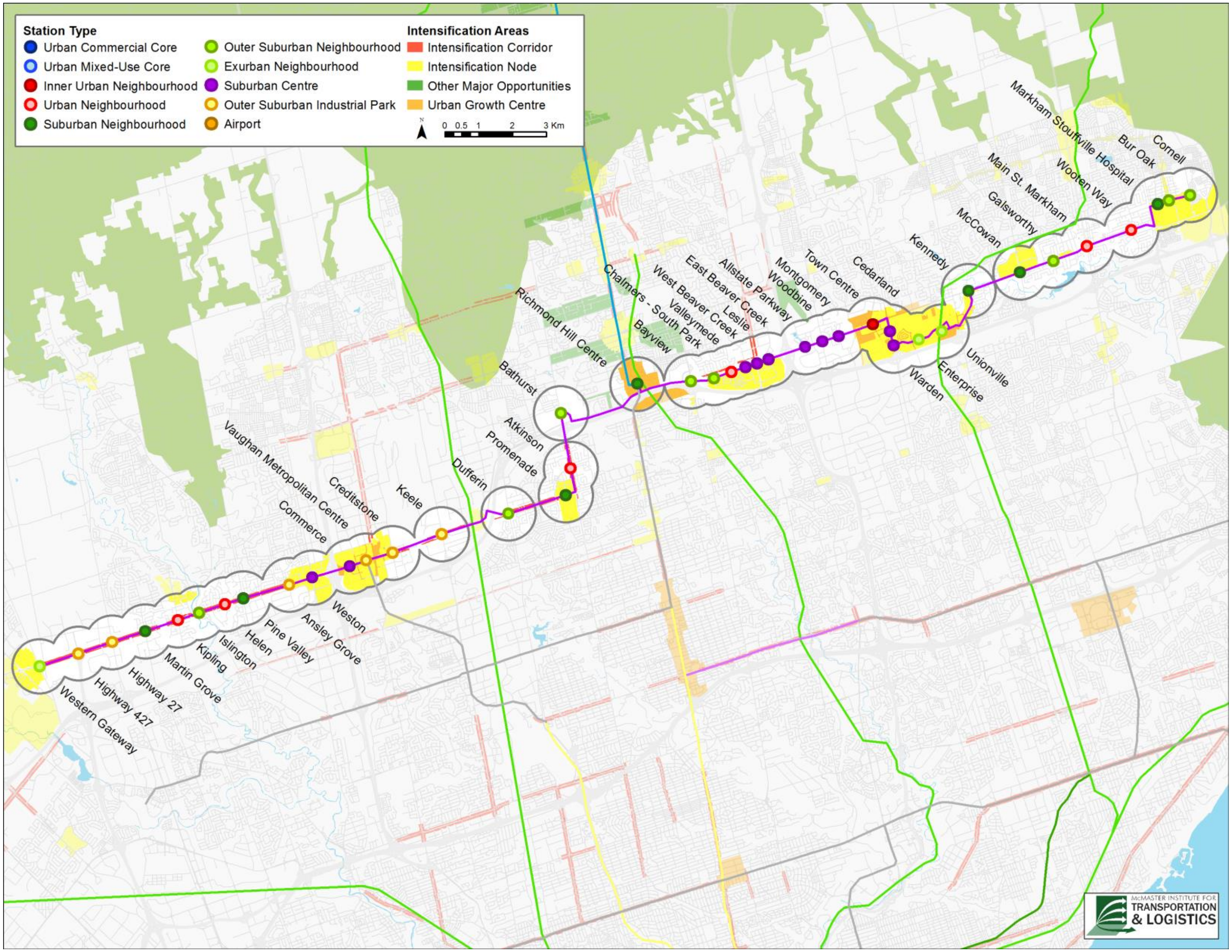
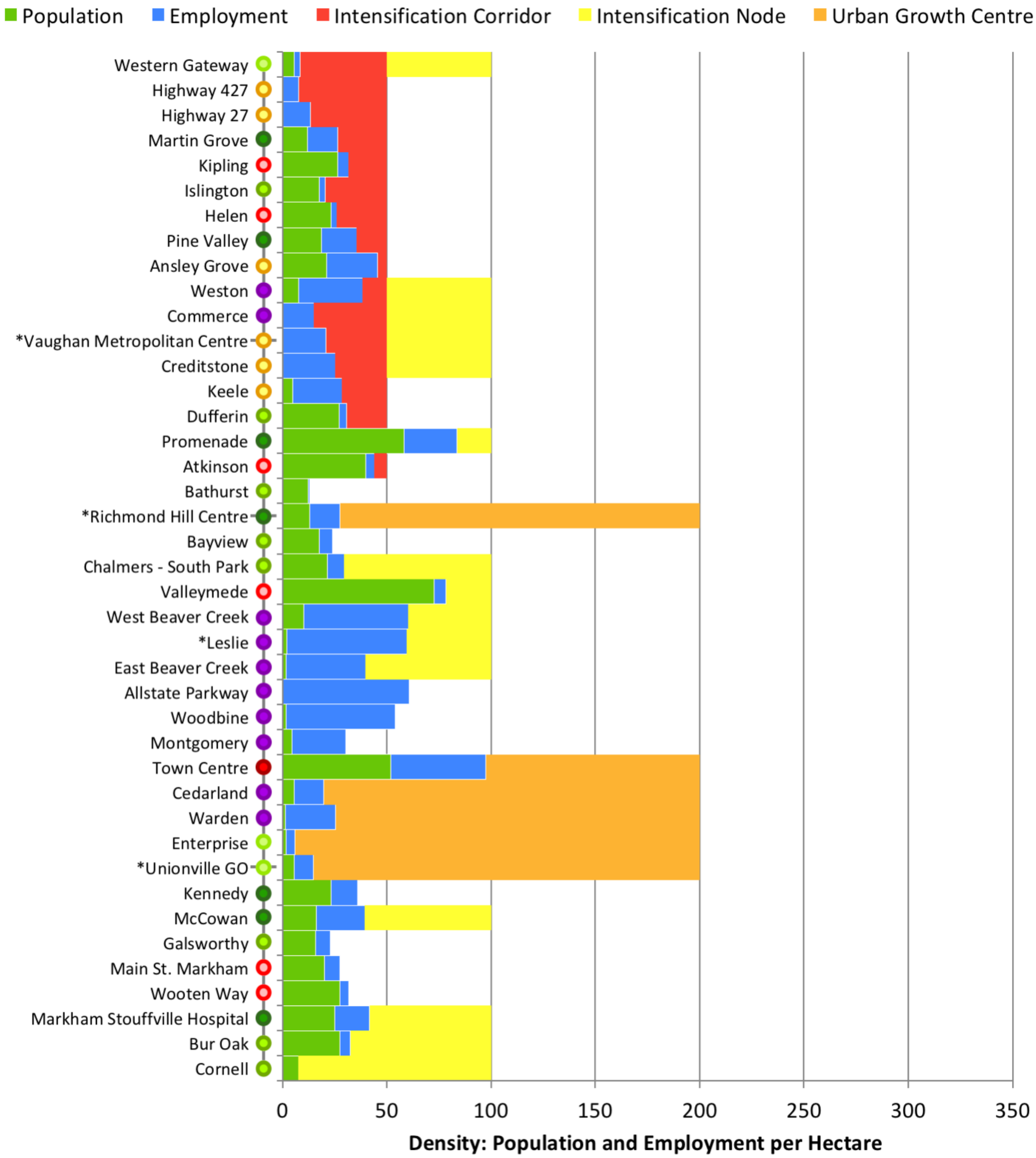


Figure 3-41. Population and Employment Density: VIVA Purple BRT



* indicates station is designated as a Mobility Hub by Metrolinx

3.4. Commuter Rail Transit

3.4.1. GO Transit

Project Key Information			
Line Length (kilometres)	452	Population	353,293
Average Density (ppl+jobs/ha)	58	Employment	351,307
Total Stations	65		
Urban Commercial Core	1	*Outer Suburban Neighbourhood*	14
Urban Mixed-Use Core	-	*Exurban Neighbourhood*	13
Inner Urban Neighbourhood	3	*Suburban Centre*	-
Urban Neighbourhood	10	*Outer Suburban Industrial Park*	8
Suburban Neighbourhood	11	*Airport*	-

GO Transit operates a large network of CRT lines in the Greater Golden Horseshoe. The system began operations along the Lakeshore East and West lines in 1967 and has grown to encompass 452km of track across 7 lines. The network is geographically diverse, spanning the cities of Hamilton and Waterloo in the west to Barrie in the North, Oshawa in the east, and Toronto in the centre. Recent expansions have been the new West Harbour station in Hamilton and an increase in service levels across many lines to feature two-way and all-day service at 15 minute intervals. Future plans for the GO network include electrification and the move towards the GO's Regional Express Rail model of all-day rapid transit. Another key initiative is the renovation of Union Station to accommodate more passengers and an improved customer experience. Across its 65 stations, the GO network's station areas contain approximately 353,000 people and 351,000 jobs for an average density of 58 people and jobs per hectare.

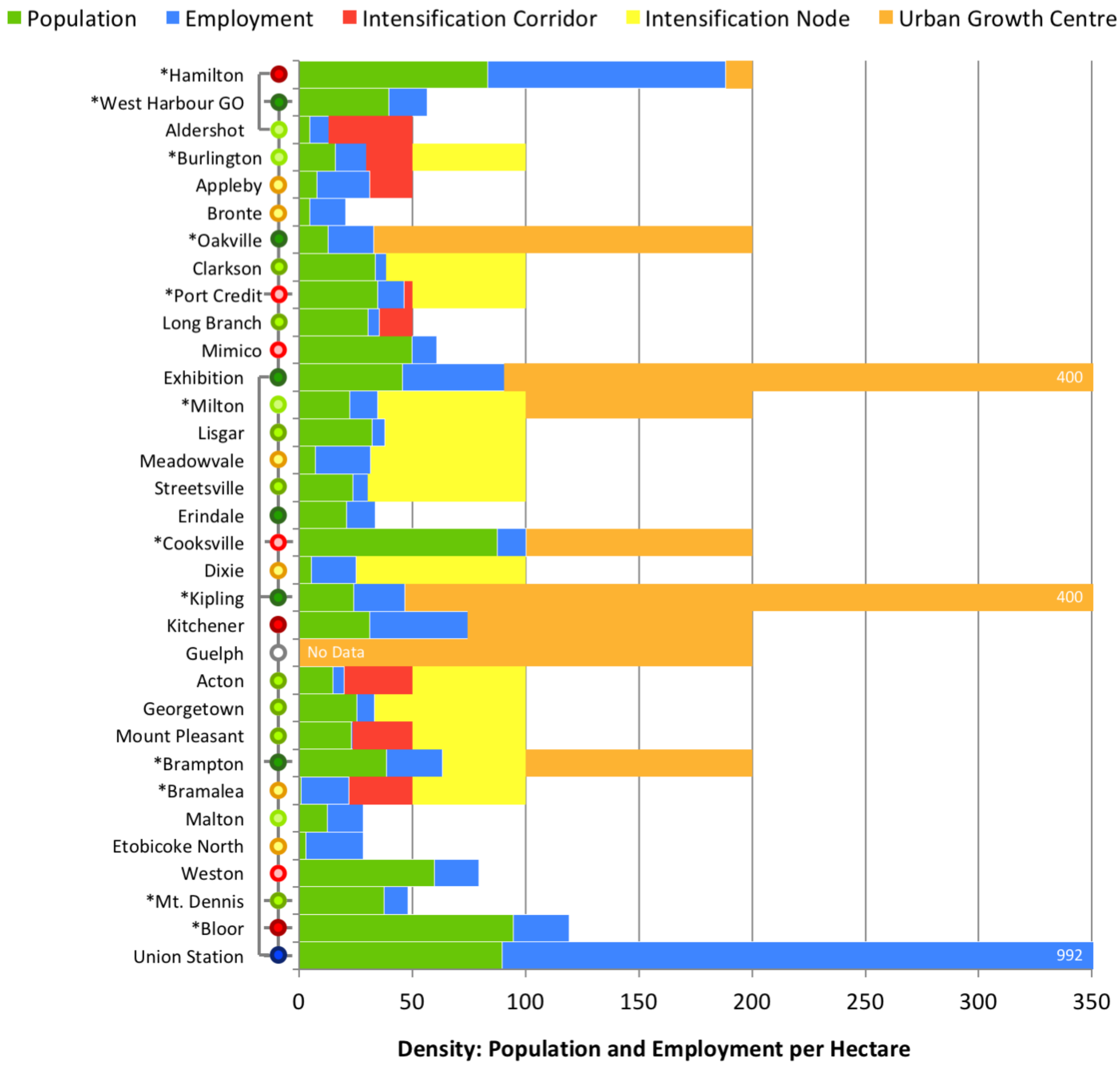
In line with its geographically diverse service area, individual GO lines and stations show significant variance in terms of their levels of TOD (Figures 3-42 to 3-44). Of the lines, the Lakeshore West, Georgetown, and Stoufville lines are medium-density, while the Milton, Richmond Hill, Lakeshore East, and Barrie lines are medium- to low-density. For TOD, individual stations along these lines show dramatic variation in their station area contexts. Union Station, which is the shared terminus of all 7 lines, is a very high density *Urban Commercial Core*. Others are *Urban* in character, featuring characteristics associated with TOD. These stations tend to be located in the City of Toronto and developed areas in other regional municipalities.

However, the predominant station types for all lines are *Suburban*, *Outer Suburban*, and *Exurban Neighbourhoods*, as well as a large number of *Outer Suburban Office Parks*. In many ways this is expected as GO Transit began its service on existing freight rail lines which tend to service more suburban areas of the region and a number of industrial parks. As well, the operation of most GO stations is oriented to park-and-ride commuter flows that arrive to the station largely by car rather than on foot. Because of this, the built environment around such stations features large parking lots.

This model has worked well for attracting riders to the GO network. However, looking forward, future plans call for significant intensification around these stations. A large number are located within designated intensification corridors and nodes and others are within important regional Urban Growth Centres. Others are designated as Mobility Hubs by Metrolinx as they are located at the nexus of several different existing and future rapid transit lines. In that sense, the suburban and park-and-ride character of many stations offers an opportunity for larger-scale implementations of TOD.

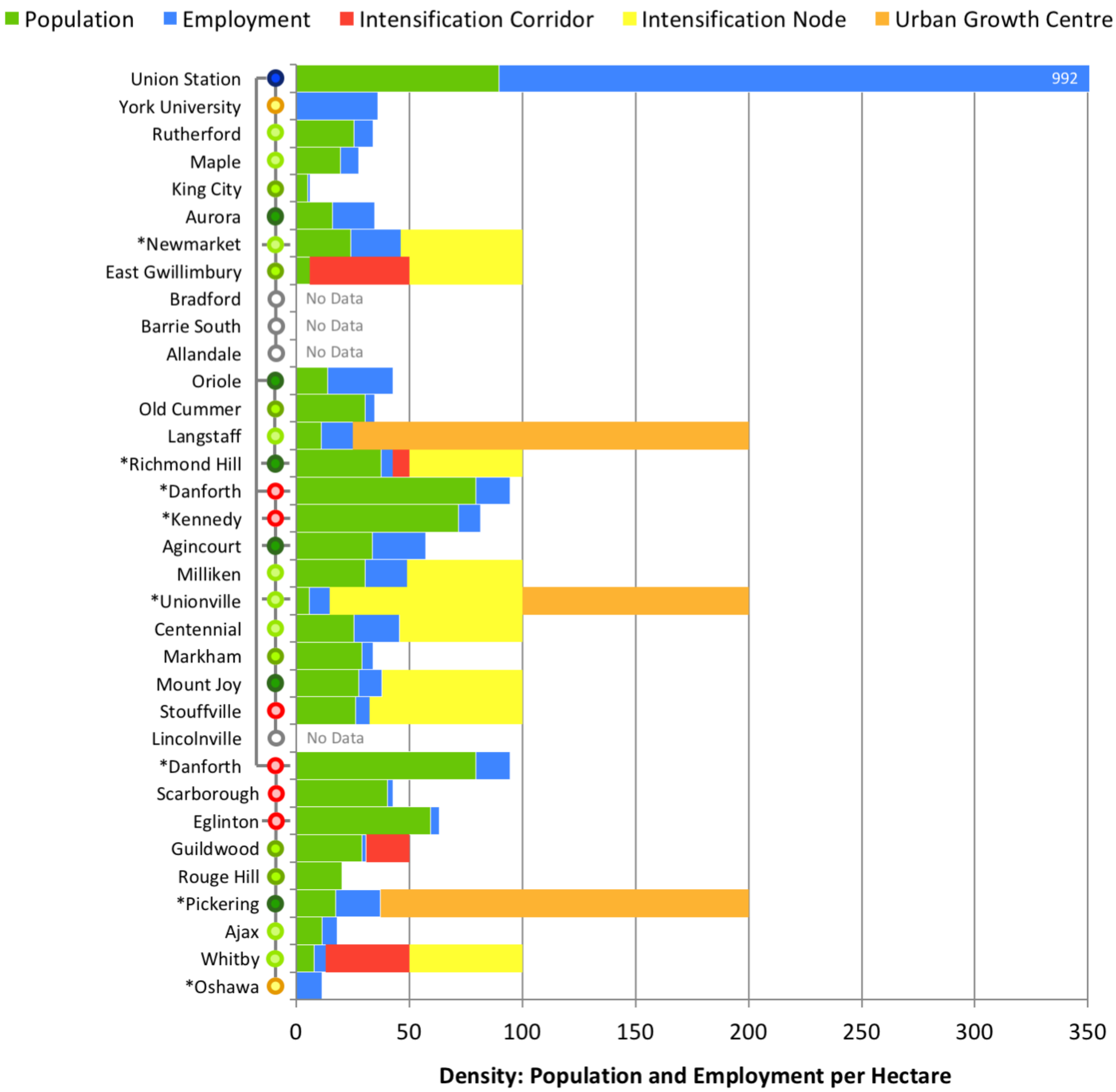
Figure 3-42. Station Designations on the GO CRT Network

Figure 3-43. Population and Employment Density: Lakeshore West, Milton, and Kitchener GO Lines



* indicates station is designated as a Mobility Hub by Metrolinx

Figure 3-44. Population and Employment Density: Barrie, Richmond Hill, Stouffville, and Lakeshore East GO Lines



* indicates station is designated as a Mobility Hub by Metrolinx

3.4.2. SmartTrack

Project Key Information			
Line Length (kilometres)	41	Population	189,192
Average Density (ppl+jobs/ha)	133	Employment	278,288
Total Stations	19		
Urban Commercial Core	2	*Outer Suburban Neighbourhood*	1
Urban Mixed-Use Core	-	*Exurban Neighbourhood*	2
Inner Urban Neighbourhood	4	*Suburban Centre*	-
Urban Neighbourhood	3	*Outer Suburban Industrial Park*	-
Suburban Neighbourhood	4	*Airport*	-

SmartTrack is a 41km CRT line in the City of Toronto proposed by Toronto mayor John Tory. The project would use existing GO Transit route alignments on the Georgetown and Stouffville lines to connect Mt. Dennis and Unionville to Toronto's Union Station, but with more frequent service and the addition of several new stations. Originally a link from Mt. Dennis to the Pearson Airport was included in the proposal, but this has since been eliminated due to feasibility issues. Together the project has 19 stations and together their catchment areas contain approximately 189,000 people and 278,000 jobs for a high average density of 133 people and jobs per hectare. Like the Toronto Relief Line, SmartTrack is proposed as a solution for relieving crowding on the Yonge portion of the Line 1 subway. The operational characteristics of the proposal share many aspects with GO Transit's plans for electrification and increased service as part of the Regional Express Rail project.

Stations along the proposed SmartTrack alignment vary significantly in their degree of transit-orientation (Figures 3-45 to 3-47). The central portion of the corridor, from Bloor to Kennedy, is very urban and features stations high in TOD. One exception is the area around Unilever station, which is part of Toronto's Port Lands and presently undeveloped. Outside of the central corridor, the eastern portion of the line in particular services a number of stations that are *Suburban* in character. While densities are medium to low, and several stations have intensification designations, this portion of the line can benefit from plans that increase transit-oriented intensification.

Figure 3-45. Station Area Land Use: SmartTrack

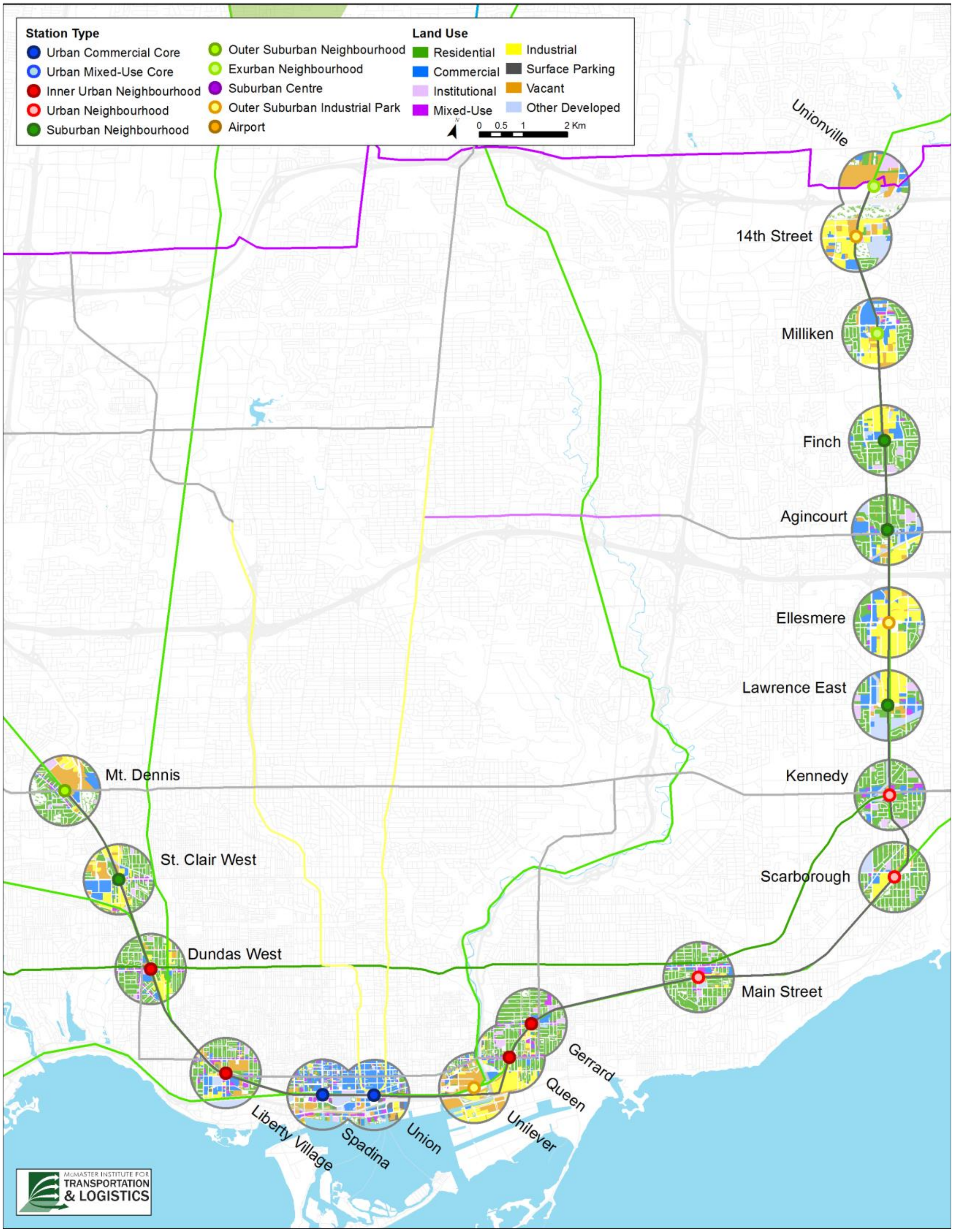


Figure 3-46. Station Area Intensification Designations: SmartTrack

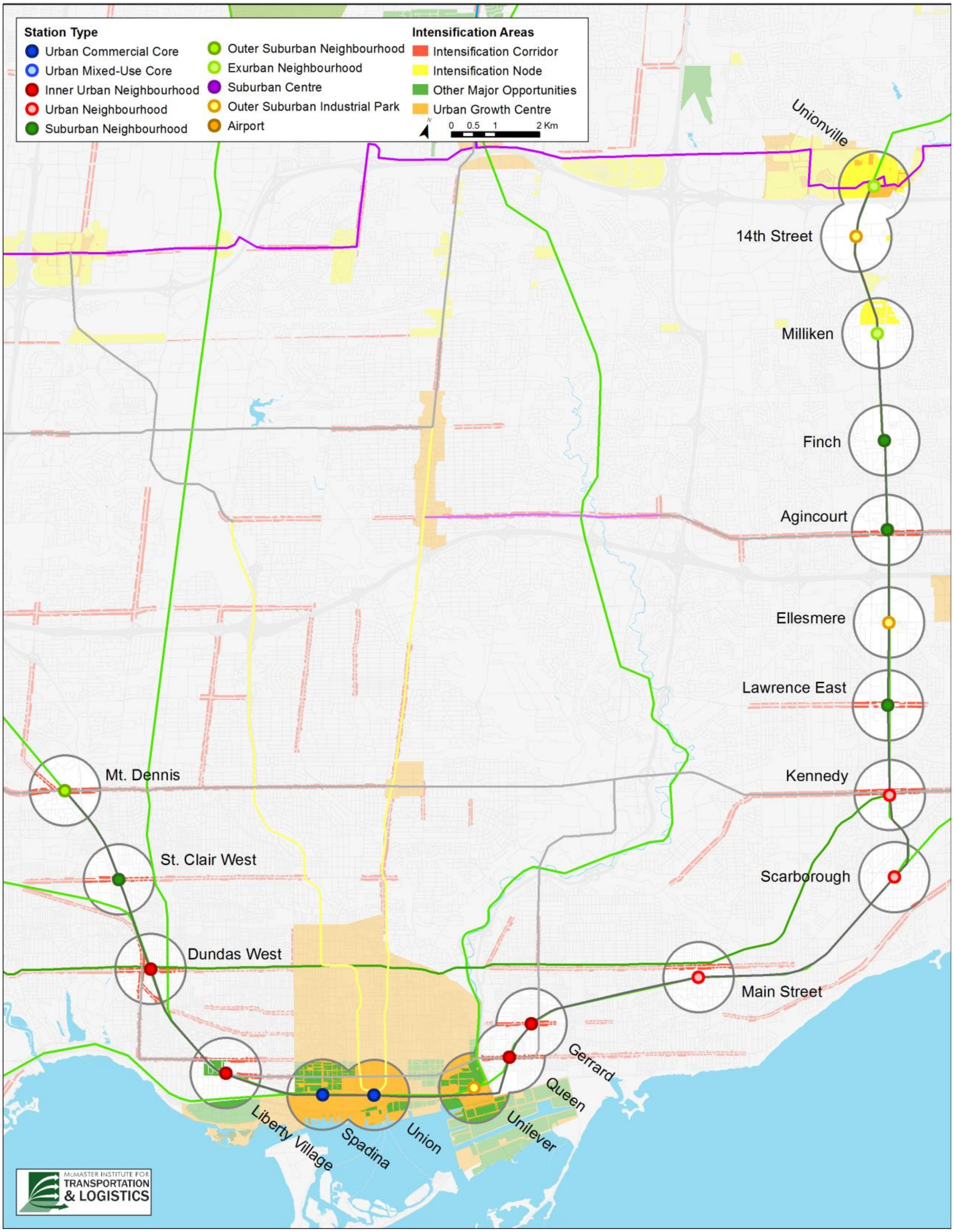
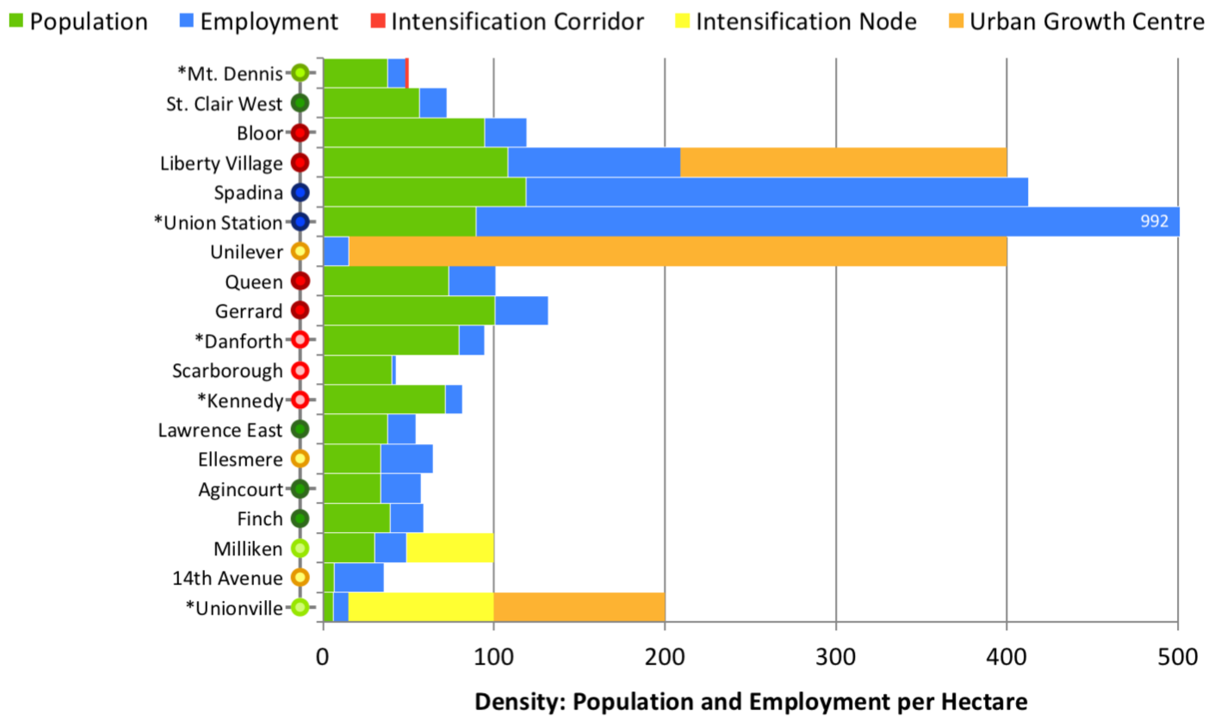


Figure 3-47. Population and Employment Density: SmartTrack



* indicates station is designated as a Mobility Hub by Metrolinx

3.5. Conclusions

Results from the individual analyses above illuminate the general character of each line. In many cases, results reflect expectations. Among existing infrastructure, GO Transit's CRT lines tend to serve *Suburban* and *Outer Suburban* locations and terminate at the very high density Toronto CBD. Several stations closer to the CBD are also urban in character, while others reflect the low-density industrial development that would be expected given that many of GO's service corridors are shared with commercial freight rail operations. In contrast, the Toronto Transit Commission's (TTC) HRT lines serve mainly higher-density urban and suburban areas as well as the CBD and the high-density mixed-use neighbourhoods surrounding it, all of which exemplify TOD.

However, where the typology is particularly useful is in conceptualizing the characteristics of future station areas along proposed rapid transit lines. If present conditions persist, the Scarborough Line 2 subway extension for example will serve a *Suburban Neighbourhood* station area. The Toronto-York Spadina Subway Extension (TYSSE), which is scheduled to open in 2017, serves two *Suburban Centre* stations, but also four low-density *Outer Suburban Commerce* and *Industrial Parks*. While this may not appear to be the most immediately complimentary context for operating HRT subway service, there are plans to transform several stations into a high-density 'new' downtown for Vaughan.

Nevertheless, the typology makes clear that greater TOD around these stations, both in terms of supportive policy and planning and the actual construction of such development, will be required to achieve the greatest return on investment for such transit infrastructure. In contrast, the proposed Toronto Relief Line is designed to serve many high density and transit-oriented *Inner Urban* and *Urban*

Neighbourhoods as well as two *Urban Commercial Core* stations in the Toronto CBD, offering an immediate market for TOD if constructed.

Among future LRT and BRT lines, the Eglinton LRT Phase 1, Sheppard LRT Phase 1, Hurontario-Main LRT, Hamilton B-Line, and Waterloo LRT traverse some segments that connect several *Urban* station types. Still, when considering all station area contexts these lines are generally more suburban in character, which is amenable to the choice of transit technology and also supports the planned phased implementation of some lines wherein the most urban and immediately transit-supportive areas are served first. Pockets of *Suburban* stations suggest that there are station areas along these lines that can benefit from transit-oriented land use planning. However, in general, it is interesting to note that based on their 2011 population and employment counts, a significant number of existing and future rapid transit station areas in the region would not meet the new minimum density targets in the proposed Growth Plan for the Greater Golden Horseshoe in Table 3-2. As such, greater land use planning will be required to ensure that stations intensify in a manner that is more transit supportive and maximizes the potential return on investment for these projects.

The analyses above also highlight an uneven distribution of intensification areas. Although many stations are within Urban Growth Centres, intensification nodes, or intensification corridors, and others are designated Mobility Hubs, it is interesting to see that many more do not have any intensification designation at all. Of course, the MTSA designation should theoretically make up for this, as all rapid transit stations should be considered MTSAs around which municipalities should intensify. However, it is interesting to see that many municipal Official Plans have not yet explicitly delineated any MTSAs for their future projects.

To ensure the region grows and intensifies in a manner that is transit-oriented, and that new infrastructure projects begin operations in corridors that offer a high return on investment, greater emphasis should be placed on coordinated transit and transit-oriented land use planning for future infrastructure. This should include first delineating MTSAs that encompass an area corresponding to a 10-minute walk from stations (about 800m), second, designating them in advance of rapid transit being built, and third, designing complimentary land use policies and plans to meet or exceed the mode-specific density targets outlined in Table 3-2.

While the proposed Growth Plan for the Greater Golden Horseshoe, 2016 does include mode-specific density targets to be achieved in MTSAs by 2041 or earlier, the location, size, and shape of the MTSAs themselves are designated by municipalities. There is a proposed mechanism by which the Province may designate priority transit corridors to be incorporated in municipal official plans and set planning requirements for them, including timelines and their spatial boundaries. This would be an important addition to the Province’s growth planning framework for promoting coordinated transit-oriented growth planning in Ontario. But in general, to achieve the maximum benefit of transit-oriented intensification, all levels of government should work together to ensure Ontario grows and intensifies around key investments in rapid transit.

Case Study: Hamilton A-Line and B-Line LRT

The TOD typology presented in Chapters 2 and 3 is a useful tool for providing a high-level contextual overview of rapid transit station areas across the GGH. However, because it is based on distilling a number of quantitative measures of TOD into station types, it omits more qualitative factors that may influence the nature of existing TOD and an area's future TOD potential.

For example, two station catchment areas that are similar in terms of featuring high population and employment densities, mixed land uses, and a pedestrian-friendly street design may be classified by the latent class model as *Urban Neighbourhoods*. But although they are similar in such quantitative measures of TOD, these two stations could be remarkably different in terms of the quality of these and other TOD characteristics not captured by the typology. For example, while a grid street pattern and small block sizes lend themselves to greater quantities of overall pedestrian access, the quality of the pedestrian environment may be hindered by the effects of smaller-scale factors such as road and sidewalk widths, traffic speeds, or street landscaping. Furthermore, an area's TOD potential may depend on factors other than just the presence of a new rapid transit line, such as its relative accessibility characteristics, social conditions in station areas, and complimentary TOD policy and planning.

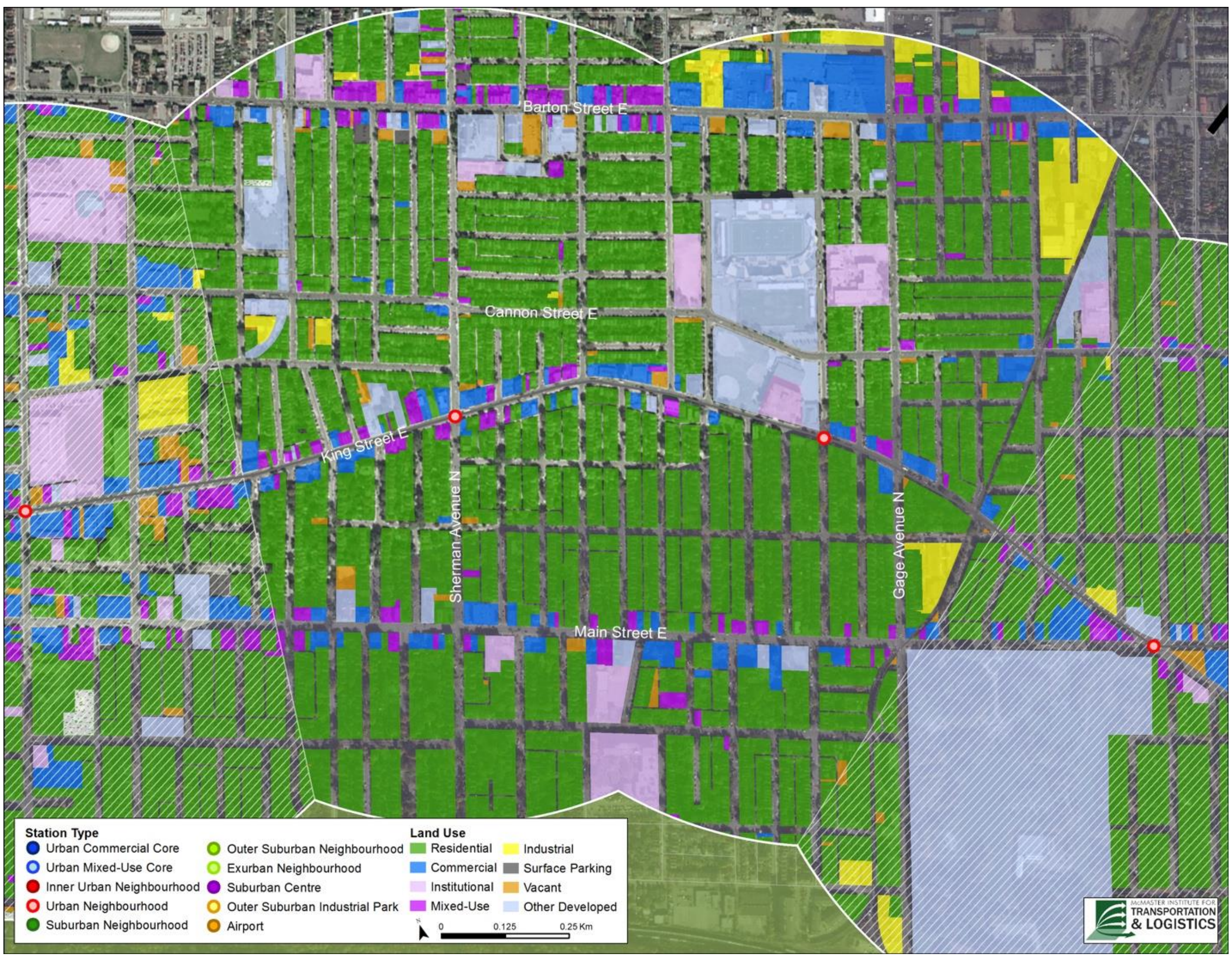
To explore such qualitative factors further, Chapter 4 applies and expands on the information from the previous chapters to a detailed case study of two stations along the eastern portion of Hamilton's B-Line LRT.

4.1. Case Study Area and Station Context

For Hamilton, the A-Line and B-Line LRT project is viewed not only as a piece of important transportation infrastructure, but a catalyst for achieving economic uplift and development in LRT station areas across the lower city (City of Hamilton, 2010). To examine how the information from the typology and additional qualitative information can be used to help achieve these goals, we have selected two stations on the eastern B-Line LRT for a more detailed case study. Station names and their approximate locations are derived from the B-Line Key Plan (City of Hamilton, 2011).

The stations selected are the Sherman Avenue and Scott Park stations (Figure 4-1). These stations were selected based on several factors: their character as *Urban Neighbourhoods* as quantified by the TOD typology, qualitative built environment characteristics, proximity to important trip generators in the central and eastern lower city, and location within two of Hamilton's priority neighbourhoods.

Figure 4-1. Case Study Area: Sherman Avenue and Scott Park Stations



4.2. TOD Challenges and Opportunities

Previous work by Higgins et al. (2014) delineated six key factors that contribute to the ability of a rapid transit project to promote new development and redevelopment in station areas: an improvement in accessibility, positive regional growth trends, positive social conditions in station areas, positive physical conditions in station areas, available land, and complimentary planning and policy. We offer a brief description of each of these factors and highlight their relevance to the station areas in the present case study.

4.2.1. Improvement in Accessibility

One way to promote TOD in the selected study areas is through an increase in transit accessibility offered by the A-Line and B-Line LRTs. In the standard urban model based on the work of Alonso (1964), Muth (1969), and Mills (1972), accessibility is a key determinant of a city's urban form. Briefly, in the urban land market, high levels of accessibility can create locational advantages for certain parcels of land relative to others. More accessible land should in turn be valued or priced higher in the land market, and this should incentivize higher-density uses of this land to offset the greater costs associated with locating there.

For TOD, the attractiveness of higher-density and mixed-use development is dependent on transit offering a high level of accessibility to important regional trip generators and attractors. While the present section is examining two stations in greater detail, accessibility depends on the rapid transit network, so we discuss accessibility characteristics of the lines on the whole. In the case of the A-Line and B-Line LRTs, the lines connect a large number of important origins and destinations. This includes McMaster University, the McMaster Innovation Park, and several other institutional land uses and neighbourhoods in the west end, two GO CRT stations and the intensive commercial and emerging residential development of the Central Business District and waterfront in the central portion of the corridor, and the older established neighbourhoods and stadium in the eastern portion of the corridor. With estimated average speeds of 33-35 kilometres per hour and a service frequency of 4 minutes (Metrolinx, 2010), the line should offer exemplary transit service along the corridor.

However, the ability of LRT to generate a locational advantage for station areas is dependent on not only offering an improvement in transit accessibility, but an overall improvement in *relative accessibility* compared to other modes. Essentially, if Hamilton's A-Line and B-Line LRT are to incentivize TOD through accessibility benefits, they must offer a competitive alternative to other modal options including the personal automobile. A major part of this is travel time between origins and destinations. If rapid transit can offer a shorter overall travel time, a cheaper trip cost, or a less stressful trip compared to other travel options, more individuals should choose to use transit.

For the present case, the lower city's extensive one-way street network presents a constraint to the achievement of relative transit accessibility benefits. Coinciding with the removal of Hamilton's electric streetcars in the 1950s, traffic planners enacted a large-scale conversion of many of the lower city's main roads into one-way, high-speed, and multi-lane arterials designed to expedite automobile travel to and from the City's downtown and north-end industrial core (Ferguson et al., 2015). Today, a system of timed traffic signals and multi-lane thoroughfares continues to allow automobiles to travel parallel to the LRT corridor with relative ease.

However, other factors such as the availability of free or cheap parking for automobiles are also important. Hess (2001) for example has shown that free parking is a significant factor influencing automobile commuting rates to the CBD in Portland, Oregon. Hamilton's downtown core features a large number of surface and structured parking lots (Figure 4-2), and public rates are low compared to other municipalities in Ontario (Van Dongen, 2016). As such, higher parking rates and further transit-oriented land use change on existing surface parking lots that removes parking capacity along the corridor should further incentivize transit use. Reduced parking requirements for new TOD should also help to ensure such development is also oriented to transit use.

Figure 4-2. Surface and Structure Parking in Downtown Hamilton

4.2.2. Positive Regional Growth Trends

Rapid transit projects often do not generate *new* growth, rather they redistribute growth that would have occurred anyhow, intensifying it in the transit corridor. From this, new TOD in rapid transit corridors is dependent on regional economic, population, and employment growth that can translate into market demand for jobs and residences in higher-density locations. A 'soft' real estate market can mean higher risks for developers and lenders, and may require intervention in the form of development incentives to promote new development and redevelopment (see Section 4.2.6 below). Incentives however do little for fueling market demand for such development.

Achieving the relative accessibility benefits noted above can help to improve demand for locations in light rail station areas. Furthermore, other macro-scale factors such as demographics, the number empty-nesters and echo boomers (who are particular target markets for TOD), taxation policies, and interest rates are also important for shaping market demand for TOD.

In terms of economic trends in Hamilton, the city on the whole is experiencing a period of growth and transformation with the city hailed as a 'city of opportunity' by Colliers International and the fourth-fastest growing city in Canada in 2015 (MacLeod, 2015). News articles such as that by Freeman (2016) detail the city's economic diversification from heavy industry to life sciences, information technologies, arts and creative industries, and advanced manufacturing over the past decade. In concert with these trends, real estate values across the city have risen to new highs, increasing by 10% over 2015 alone, making Hamilton one of Canada's hottest real estate markets and fueling new construction.

The spatial extent of Hamilton's built-up area has not yet reached the Greenbelt urban growth boundary and many new homes are being built in suburban areas. However, Hamilton's downtown core is also home to a number of new high-rise commercial and residential towers that are planned, approved, or presently under construction, signifying market demand for locations along the LRT corridor. In terms of specific segments of the LRT lines, data from the Realtors Association of Hamilton-Burlington shows that average selling prices for homes are lower in the eastern section of the line compared to the central and western sections (RAHB, 2016), which may reflect smaller homes or lots compared to other areas, but also some of the physical and social conditions below.

4.2.3. Positive Physical Conditions in Station Areas

The built environment around each of the stations in this case study is generally urban in nature. From Section 3.2.4 in Chapter 3, we can see that both stations are medium density, with approximately 84 people and jobs per hectare around the Sherman Avenue station and 63 people and jobs per hectare around the Scott Park station. In both cases, development mix is skewed towards population and their pedestrian orientation is high, indicative of their urban character and *Urban Neighbourhood* designation in the TOD typology.

The evidence from the typology is confirmed by each station's approximate location in the B-Line Key Plan (City of Hamilton, 2011). In both cases, Sherman Avenue (Figure 4-3) and Scott Park (Figure 4-4) stations are going to be constructed in the urban setting of King Street East. In both cases, the B-Line Key Plan shows each station being constructed on the southern two lanes, shown as the lanes on the left-hand side in each figure. However, recent indications from the City of Hamilton are that this will be changed to an alignment in the centre of the street.

Figure 4-3. Approximate Location of Sherman Avenue Station

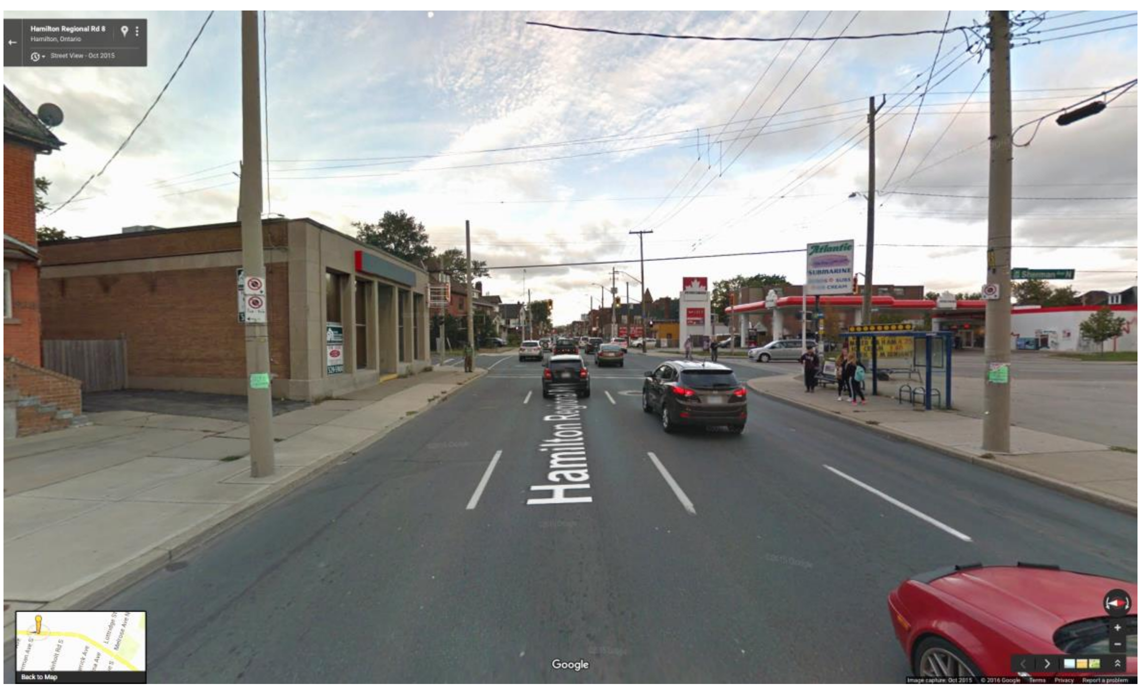


Figure 4-4. Approximate Location of Scott Park Station

The quality of the physical environment around these stations can present an obstacle to promoting TOD. Because transit trips typically start and end on foot, an area's orientation to transit requires a physical environment that is friendly to pedestrians and features amenities in terms of neighbourhood goods and services. Streetscape enhancements can make an area more welcoming to pedestrians, increase market demand for an area, and make it more attractive to developers and lenders. Much of this is related to the implementation of 'Complete Streets', which is a concept used to describe street designs that aim to make streets safer, more appealing, economically vibrant, and accessible for all users of the road, which includes drivers, transit users, cyclists, and pedestrians of all ages.

Achieving this goal involves striking a balance among competing demands for limited road space, and street designs out of balance are said to place an emphasis on one use thereby potentially suppressing others. Like implementations of TOD, there is no one-size-fits-all approach to Complete Streets and design interventions must be made on the basis of the context of particular areas in terms of present and latent mobility patterns, accessibility needs, an area's existing and potential vibrancy, and, most importantly, user safety.

For the present case study stations, previous work by Ferguson et al. (2015) examined some of the streets in the study area and found elements of their design to be lacking. In general, many of the smaller side streets in the area are narrow, follow a pedestrian friendly grid pattern, and handle slower-speed locally-oriented traffic. However, the greatest potential for new TOD in the area is along the area's major arterials, and is also where Complete Street implementations stand to have the greatest impact.

Major east-west thoroughfares in the area include Main Street East, King Street East, Cannon Street East, and Barton Street East, as well as Sherman Avenue North and Gage Avenue North in the north-south direction. Main and King Streets in particular are designed for one-way travel, featuring a large number of lanes and timed traffic lights that expedite flow. West of Sherman Avenue North, Cannon Street East also becomes one-way. This type of design negatively affects the pedestrian environment in the present study area. In addition to high speeds, Hamilton's one-way streets often produce convoys, or 'platoons' of vehicles that make their way down the street in periodic bursts (Figure 4-5). According to Ferguson et al. (2015), this can create an 'unsettling' feeling for all users of the road, particularly for pedestrians as a platoon of vehicles passes at speed, interspersed by a period of time when the street is all but barren of traffic. For pedestrians, these streets also feature narrow sidewalks and a general lack of streetscaping.

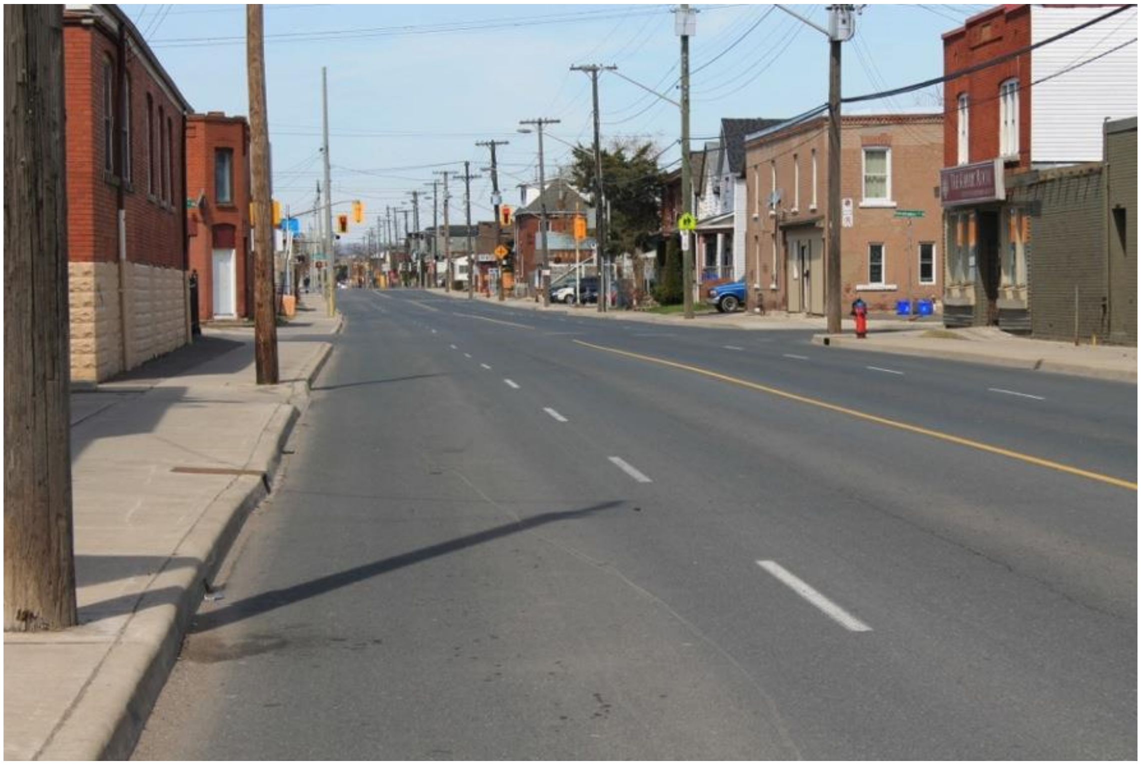
In terms of the outcomes of one-way streets, while excellent at moving large numbers of vehicles, research has shown adverse impacts of one-way streets on street livability in general (Appleyard, 1981; Jones, 1986). Later studies have noted that high-speed one-way streets can have a negative impact on commercial land uses as such roads tend to present a hazard to pedestrian movement, eroding confidence in the physical environment, and discouraging shopping (Edwards, 1998; Walker et al., 1999). In Hamilton specifically, a previous study has also found that one-way streets have higher rates of child pedestrian injuries than the city's two-way streets, highlighting a negative safety impact for some of the street's most vulnerable users (Wazana et al., 2000).

Figure 4-5. 'Platooning' of Vehicles on Main Street

Source: Ferguson et al. (2015)

Furthermore, the one-way twinned nature of Main and King means that much of the area's automobile traffic is funneled to these arterials, leaving others largely devoid of traffic flows for much of the day. This is certainly the case for Cannon Street East where it becomes a two-way street east of Sherman Avenue North. In Figure 4-6 for example, taken at 11AM on a weekday, there are no cars to be found. Despite this, the street is largely oriented to accommodating large automobile flows with narrow sidewalks and no streetscaping or dedicated cycling infrastructure.

Figure 4-6. Cannon Street East near Gage Avenue North



Source: Ferguson et al. (2015)

The design of the lower city's major arterials was implemented to handle very large commuting flows to and from the city's north-end industrial core, and although such flows have largely disappeared from their highs over the past few decades, their legacy continues to impact the built environment of the lower city. Previous research by Ferguson et al. (2015) has argued that such street designs are likely having a negative effect on the safety, economic vibrancy, and social inclusiveness of these areas.

However, in terms of promoting future TOD as part of the LRT project, the quality of the pedestrian environment along these streets should be viewed as a hindrance to promoting new development and redevelopment oriented to LRT for three reasons. First, such a design makes transit use less likely due to a poor walking environment, hurting an area's orientation to transit. Second, current parcels designated as within the intensification corridor front onto Main Street East and King Street East, and this pedestrian environment can negatively impact market demand for TOD among individuals and the potential supply of TOD from developers and their lenders. Finally, as per Section 4.2.1 above, these street designs also permit high levels of automobile access (at the cost of other modes), diminishing the relative accessibility benefits afforded by LRT, thereby reducing the locational advantage of land within station areas and the associated market forces that promote higher-density development on them.

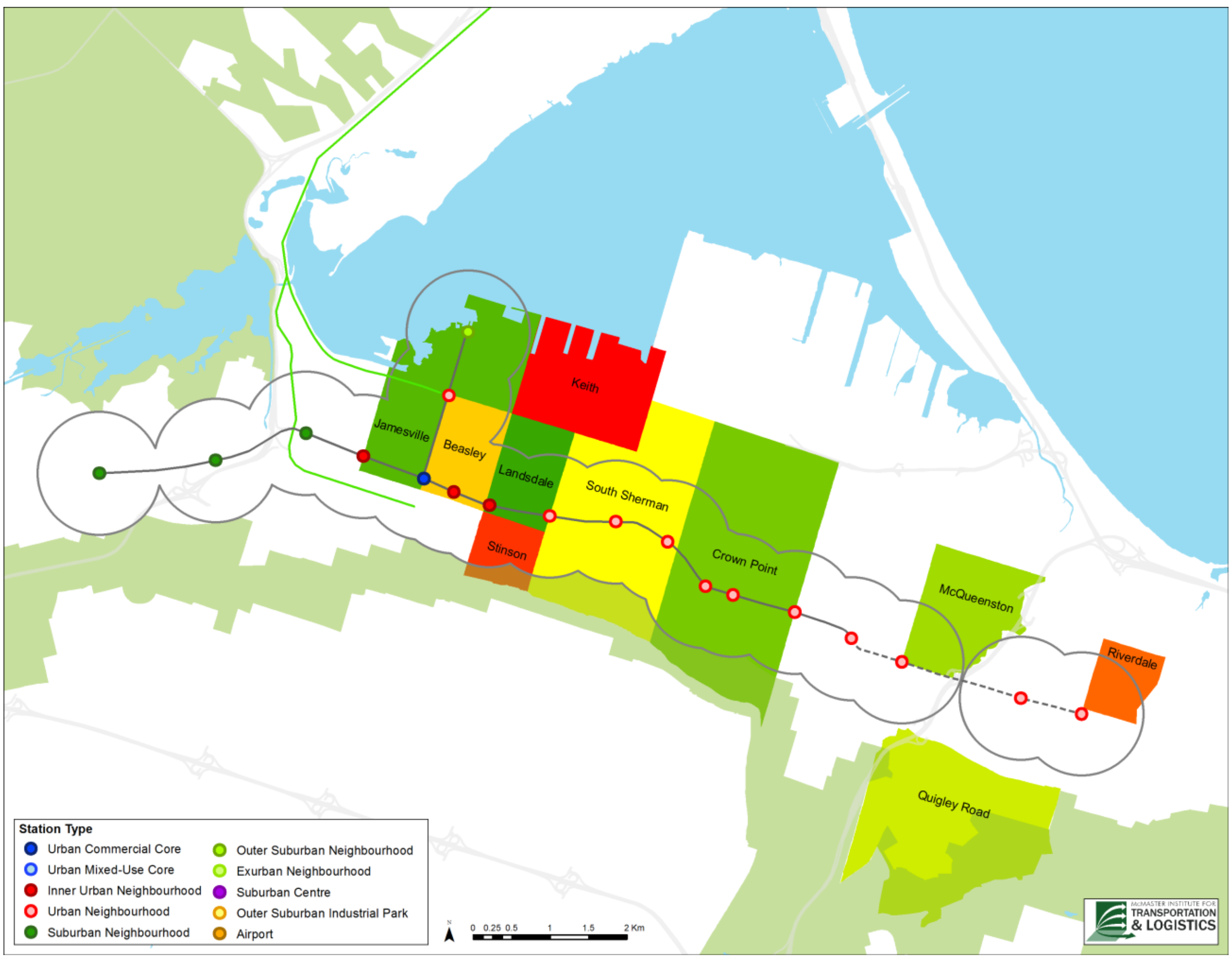
In this regard, the Complete Streets tools reviewed in Ferguson et al. (2015) can improve the physical environment around these stations, as well as others along the A-Line and B-Line LRTs. Such measures should be considered as an important, if not fundamental element in ensuring these areas achieve the greatest possible return on investment in terms of promoting transit use and TOD.

4.2.4. Positive Social Conditions in Station Areas

Despite the best intentions of planners and policymakers, the TOD literature notes that social challenges, both real and perceived, can have a negative effect on the potential for transit-oriented land use change along a rapid transit corridor. Positive social conditions play a vital role in the attractiveness of station areas for development for developers, financers, and prospective residents. Criminal activity can contribute to a perception of insecurity and other social issues such as poverty, unemployment, the quality of schools, or a general perception of disadvantage can reduce market demand for TOD.

For the A-Line and B-Line corridors in Hamilton, the lines bisect a diverse set of neighbourhoods. As part of its Neighbourhood Action Strategy, the City of Hamilton has identified a number of city neighbourhoods that are targets for priority policies and plans to build social capital, promote investment, and improve health outcomes. As shown in Figure 4-7, Hamilton's A-Line and B-Line LRT project traverses a number of these neighbourhoods, and the two stations for the present case study are located entirely within the South Sherman and Crown Point neighbourhoods.

Figure 4-7. Priority Neighbourhoods along the Hamilton A-Line and B-Line LRT



In terms of the socioeconomic and demographic characteristics of these neighbourhoods, the Hamilton Social Planning and Research Council has produced helpful profiles of each (Mayo et al., 2012). While the age structure of both neighbourhoods is roughly comparable with city-wide averages, other key findings include higher rates of male and female lone parent families, higher proportions of residents with activity limitations, higher proportions of owners and renters living in unaffordable housing, lower levels of education, lower life expectancy, and higher rates of child, senior, and overall poverty.

These factors can manifest themselves into lower market demand for new development and redevelopment, and TOD policy and planning should be sensitive to the challenges and opportunities such a development context presents. However, while this may present challenges for new TOD, there is also a risk that constructing rapid transit and promoting TOD can negatively affect the population of these neighbourhoods. LRT and TOD have been shown to raise property values in many cities across North America (Higgins & Kanaroglou, 2016a). If experiences with light rail in Hamilton are similar, higher levels of transit accessibility and new TOD can increase land values and negatively affect housing affordability within these station areas.

Nevertheless, this should not obscure the significant benefits that LRT can offer to the A-Line and B-Line corrirors on the whole, and these neighbourhoods in particular. In the Standard Urban Model for example, land values increase because transportation costs for those living in an area have *decreased*. This offset is key, as it might mean that a family presently reliant on one or more automobiles for their transportation needs may find that light rail now meets their travel requirements and allows them reduce the number of vehicles they own and maintain. New neighbourhood amenities that come with TOD can also reduce the number and length of trips required to carry out daily activities. From this, it is important to remember that changes in land values correlate to increased locational efficiency or locational advantage, and such characteristics can be particularly beneficial for the residents of Hamilton's priority neighbourhoods. This notion is backed up by recent research on affordable housing in 15 regions across the United States, where more remote locations were associated with a decrease in housing aforidability attributable to increaed transportation costs (Hamidi et al., 2016). Should property values increase, planning and policy that provides affordable housign as part of new TOD can help to ensure such benefits continue to reach these neighbourhoods into the future.

4.2.5. Available Land

Transit-oriented development and redevelopment is much more straightforward and profitable for developers if large parcels of land in rapid transit station areas are already available and suitable for development. In contrast, areas that feature smaller parcels that require land assembly and existing structures that require demolition can raise risks and costs associated with TOD.

For the stations in the study area, the built environment largely matches the latter scenario. As shown in Figure 4-1, parcel sizes tend to be small and there is little in the way of vacant land or surface parking lots. One of the largest parcels ripe for development in the area is that the area south of Tim Horton's Field near Scott Park Station, which was previously home to Scott Park High School. However, early plans from the Hamilton Wentworth District School Board (HWDSB) detail a new North Secondary School and Bernie Morelli Recreation Centre that is to be constructed on this property, complementing the development that has occurred during the construction of the stadium (Figure 4-8).

Adjacent to the stadium on its eastern side is King George school at 77 Gage Avenue North, which has been designated as a heritage building, but could see redevelopment into other uses in line with the TOD concept. There may also be other opportunities on sites that feature industrial land uses or low-density and automobile-oriented commercial uses, such as gas stations along King Street. However, large-scale TOD in these two station catchment areas will likely have to occur on already-developed sites. In the absence of vacant land, the promotion of such development and redevelopment would benefit from complimentary planning and policy in the section below.

Figure 4-8. Bernie Morelli Recreation Centre and North Secondary School Plan

Source: Coleman (2016)

4.2.6. Complimentary Planning and Policy

Complimentary policy and planning is viewed as an integral part of promoting TOD. This can include a package of zoning, financing, and planning policies designed to promote new transit-oriented land use change. However, it can also include policies that attempt to alter travel behavior, such as travel demand management initiatives that bolster the relative accessibility benefits for transit (see section 4.2.1).

On the land use side, complimentary land use policies have gained considerable attention, becoming an important part of the US Federal Transit Administration's evaluation criteria for New Starts projects in 1998 (Deakin et al., 2002). Since that time, TOD planning is now an integral part of the transit planning process in the vast majority of cities planning, constructing, or operating new rapid transit infrastructure in North America. Many studies by academics and planning professionals have sought to illuminate the policies and strategies required to implement TOD successfully, such as that by Cervero et al. (2004) and Dunphy et al. (2003; 2004).

In the present case, the A-Line and B-Line LRTs on the whole benefit from the extensive regional planning framework in place at the provincial level. The Government of Ontario's Greenbelt and Growth Plan for the Greater Golden Horseshoe provide an urban growth boundary and high-level growth management directives for the GGH region. Under this plan, the City of Hamilton's urban growth is subject to the boundaries of the Greenbelt, and the city is mandated to accommodate at least 40 per cent of its new growth within the existing built-up area through intensification.

At the local level, the City of Hamilton's Urban Official Plan is committed to achieving these targets by promoting medium- and high-density mixed-use development in designated intensification nodes and intensification corridors. In terms of TOD, the City of Hamilton (2010a; 2010b) has previously released a background paper and design guidelines for development in the city's transit corridors. The City's downtown zoning also promotes elements of TOD through factors such as reduced parking minimums and development incentives.

However, for the remainder of the corridor, including the station areas in this case study, no explicit policy or zoning changes have yet been implemented to promote TOD. Still, reviewing the city's existing zoning regulations at this time is premature. In late 2015 the City instituted a one-year moratorium on new development and demolition along the LRT corridor until new transit-oriented zoning can be put in place, and at the time of writing, this zoning review remains an ongoing exercise.

As for the elements this new zoning package should include, a comprehensive review of TOD policies, plans, and outcomes is beyond the scope of the present analysis. But to ensure this new package of zoning regulations promotes TOD in station areas along the A-Line and B-Line LRTs, this should include elements such as:

- Zoning that promotes the implementation of Complete Streets concepts.
- Parking maximums instead of minimums to lower the costs of redevelopment for developers and ensure projects are oriented to transit and alternative mode use.
- Density allowances that ensure projects are financially viable and ensure a large population base that can utilize transit and support new commercial and retail development.
- Density bonuses and other incentives for developer contributions to the public realm around TOD projects via Section 37 of the planning act.
- Development assistance tools such as fast-tracked review and an extension of the City's existing financial incentive programs to the LRT corridor catchment area, such as façade improvement, brownfield remediation grants, and other improvement and development grants.
- Affordable housing incentive programs to ensure station areas feature not only a mix of land *uses*, but also land *users*.

Previous research has found that while individual TOD policies are important, their ultimate success in promoting TOD depends on the overall ‘package’ or combination of these policy tools (Loukaitou-Sideris, 2010). In this sense, the package of TOD policies should be customized according to the existing development context captured by the TOD typology, but also the market realities of individual station areas. For example, Dunphy et al. (2004) argue that market considerations are especially important for the retail component of TOD, as although TOD calls for a mixing of land uses, there must be enough market demand to support these businesses and prevent vacant storefronts in station areas.

Land assembly by the City of Hamilton could also help promote TOD over the longer-term. In reviewing TOD policies to support TOD around Phoenix’s LRT line, the Environmental Protection Agency has also argued that in areas of softer real estate market demand, “tools like re-zoning and area specific design guidelines will probably be insufficient to catalyze new development. In these areas, more direct actions may be required, like acquiring strategic parcels, assembling land that could be sold at a reduced price or held until market demand is stronger, or both. This land could be used to leverage higher density projects and encourage a greater mix of uses.” (EPA, 2009, p. 3)

Recognizing the diversity of existing station area TOD contexts, market conditions, and the need for context-sensitive packages of TOD policies, the City of Hamilton can utilize this information as an input into a larger TOD Strategic Plan. This can consider all of the city’s existing and future station areas, their existing land use characteristics, ridership potential, market demand, and future TOD opportunities. One example of this is the Portland Metro’s Transit-Oriented Development Strategic Plan (Thorne-Lyman et al., 2011).

5

Conclusions

The promotion of transit-oriented development, which is high-density, mixed-use, and pedestrian-friendly development oriented to rapid transit stations, has been championed as a way to ensure high levels of transit use, farebox returns, and less reliance on the private automobile. From this, TOD is a great way to maximize the return on investment for new rapid transit infrastructure. However, the typology shows that not all implementations of TOD within existing and future rapid transit station areas are the same across the GGH region. Our typology has revealed 10 distinct station types among 418 separate stations, and each can be placed on a scale of TOD. More *Urban*-type stations exhibit characteristics that are reflective of the concept, featuring higher densities, greater land use mixing, high levels of pedestrian connectivity and transit access. From this, these stations also feature higher levels of transit and alternative mode use and an appeal to certain cohorts of the population. In contrast, more *Suburban*-type stations feature elements of their built environment that can be improved to better exemplify TOD inputs and produce more transit-oriented outcomes.

With this information, the present project highlights the diversity of station areas in the region, and shows how their characteristics compare against other stations and the goals of the Growth Plan more broadly. Furthermore, the typology identifies individual stations that are already transit-oriented and reveals those that can benefit from more targeted interventions. The results of this approach can be used to guide and advance the design and implementation of more context-sensitive growth planning policies throughout the region.

One potential solution identified in Chapter 3 that can help to ensure rapid transit station areas intensify in advance of rapid transit is to institute density targets for MTSAs. Presently there is no set level for MTSAs and many municipalities have not designated this type of intensification area for future rapid transit projects. In response, the strengthened and mode-specific MTSA intensification targets and priority transit corridor planning outlined by the proposed Growth Plan for the Greater Golden Horseshoe, 2016 combined with greater coordination between all levels of government can help to ensure that key intensification corridors and MTSAs are designated in advance of rapid transit. This should help promote a built environment in transit station areas that intensifies to accommodate new growth and maximizes the return on investment for new rapid transit infrastructure in the region.

Still, an important finding in our benchmarking of population and employment densities is that a majority of existing and future rapid transit station areas will require significant increases in development intensity to meet their mode-specific 2041 targets in the proposed 2016 Growth Plan. This highlights a general need for greater transit-oriented policy and planning among regional municipalities to focus more growth in MTSAs over the next 25 years.

Finally, it is important to note the limitations of the approach. First, the scale of TOD implementations revealed by the typology does not mean that larger values of particular indicators are always better. Instead, not all types of TOD are appropriate in every station area. For example, while a station may be an *Outer Suburban Neighbourhood* in our typology, it does not have to intensify to match the scale seen in an *Urban Mixed-Use Core* or *Inner Urban Neighbourhood* to become transit-oriented. Determining the appropriate intervention required to make a station intensify in a manner that is oriented to transit will require an analysis of the type of development that is appropriate and feasible for an area given the views of planners, policymakers, and local residents public.

Furthermore, the TOD typology operationalized the concept in a quantitative way, and stations that are more reflective of TOD according to the model may still benefit from more micro-scale interventions that seek to improve the quality of TOD in an area. This was exhibited in the Hamilton case study, where the promotion of greater TOD will have to be undertaken while recognizing the challenges and opportunities present within existing station areas individually.

Nevertheless, the Government of Ontario continues to invest in new rapid transit infrastructure in the GGH region to ensure it grows in a manner that is environmentally sustainable, equitable, and economically prosperous. To that end, TOD can bring with it many important social, environmental, and economic benefits, and the growth planning framework in place at the provincial level and within individual municipal Official Plans is set to achieve these growth goals by promoting greater levels of intensification around key pieces of rapid transit infrastructure. This research can be used to help the region better understand the contextual diversity of these rapid transit station areas and tailor policies and plans to ensure these goals become reality.

6.0 References

Alonso, W. (1964). *Location and Land Use.* Cambridge, MA: Harvard University Press.

Appleyard, D. (1981). *Livable Streets.* Berkeley: University of California Press.

Atkinson-Palombo, C. (2010). Comparing the Capitalisation Benefits of Light-rail Transit and Overlay Zoning for Single-family Houses and Condos by Neighbourhood Type in Metropolitan Phoenix, Arizona. *Urban Studies, 47*(11), 2409-2426.

Atkinson-Palombo, C., & Kuby, M. J. (2011). The Geography of Advance Transit-oriented Development in Metropolitan Phoenix, Arizona, 2000–2007 . *Journal of Transport Geography, 19*, 189-199.

Bertolini, L. (1999). Spatial Development Patterns and Public Transport: The Application of an Analytical Model in the Netherlands. *Planning Practice and Research, 14*(2), 199-210.

Calthorpe, P. (1993). *The Next American Metropolis: Ecology, Community, and the American Dream.* Princeton, NJ: Princeton Architectural Press.

Cervero, R., & Kockelman, K. (1997). Travel Demand and the 3Ds: Density, Diversity, and Design. *Transportation Research Part D, 2*(3), 199-219.

Cervero, R., Murphy, S., Ferrell, C., Goguts, N., Tsai, Y. H., Arrington, G. B., . . . Witenstein, N. (2004). *Transit-Oriented Development in the United States: Experiences, Challenges, and Prospects.* Transit Cooperative Research Program. Washington, DC: Transportation Research Board.

Chorus, P., & Bertolini, L. (2011). An Application of the Node Place Model to Explore the Spatial Development Dynamics of Station Areas in Tokyo. *Journal of Transport and Land Use, 4*(1), 45-58.

City of Denver. (2014). *Transit Oriented Denver: Transit Oriented Development Strategic Plan.* Denver, CO: City of Denver.

City of Hamilton. (2010). *Moving Hamilton Forward with LRT.* Public Works Department. Hamilton, ON: City of Hamilton.

City of Hamilton. (2010a). *Transit Oriented Development Guidelines for the City of Hamilton: Volume 1.* City of Hamilton.

City of Hamilton. (2010b). *Transit Oriented Development Guidelines for Hamilton: Volume 2.* City of Hamilton.

City of Hamilton. (2011). *B-Line Key Plan.* Hamilton, ON: City of Hamilton.

Coleman, J. (2016, January 2). *First Look at Renderings and Plans for New HWDSB Lower City High School and Bernie Morelli Recreation Centre.* Retrieved February 15, 2016, from The Public Record: https://www.thepublicrecord.ca/2016/01/first-look-at-renderings-and-plans-for-new-lower-city-high-school-and-bernie-morelli-recreation-centre/

Deakin, E., Ferrell, C., Mason, J., & Thomas, J. (2002). Policies and Practices for Cost-Effective Transit Investment: Recent Experiences in the United States. *Transportation Research Record, 1799*, 1-9.

Dittmar, H., & Poticha, S. (2004). Defining Transit-Oriented Development: The New Regional Building Block. In H. Dittmar, & G. Ohland (Eds.), *The New Transit Town: Best Practices in Transit-Oriented Development* (pp. 19-40). Washington, DC: Island Press.

Dunphy, R., Cervero, R., Dock, F., McAvey, M., Porter, D., & Swenson, C. (2004). *Developing Around Transit.* Washington, DC: Urban Land Institute.

Dunphy, R., Myerson, D., & Pawlukiewicz, M. (2003). *Ten Principles for Successful Development Around Transit.* Washington, DC: Urban Land Institute.

Edwards, J. D. (1998, September). Traffic Issues for Smaller Communities. *ITE Journal*, 30-33.

EPA. (2009). *Strategic Package of Tools: Transit Oriented Development in Metropolitan Phoenix.* Washington, DC: Environmental Protection Agency.

Ewing, R., & Cervero, R. (2010). Travel and the Built Environment: A Meta-Analysis. *Journal of the American Planning Association, 76*(3), 265-294.

Ewing, R., Greenwald, M., Zhang, M., Walters, J., Fedlman, M., Cervero, R., . . . Thomas, J. (2011). Traffic Generated by Mixed-Use Developments—Six-Region Study Using Consistent Built Environmental Measures. *Journal of Urban Planning and Development, 137*(3), 248-261.

Ferguson, M. R., Higgins, C. D., Lavery, T. A., & Abotalebi, E. H. (2015). *Shaping Hamilton with Complete Streets.* Hamilton, ON: McMaster Institute for Transportation and Logistics.

Foot, D. K. (1998). *Boom Bust & Echo 2000.* Toronto, ON: Macfarlane Walter & Ross.

Freeman, S. (2016, February 19). Hamilton Ready for Post-Steeltown Boom as Loonie Continues to Sink. *The Toronto Star*.

Guerra, E., Cervero, R., & Tischler, D. (2013). Half-Mile Circle: Does It Best Represent Transit Station Catchments? *Transportation Research Record, 2276*, 101-109.

Hamidi, S., Ewing, R., & Renne, J. (2016). How A ordable Is HUD A ordable Housing? *Housing Policy Debate*, 1-19.

Hess, D. B. (2001). Effect of Free Parking on Commuter Mode Choice: Evidence from Travel Diary Data. *Transportation Research Record* (1753), 35-42.

Higgins, C. D., & Ferguson, M. R. (2012). *The North American Light Rail Experience: Insights for Hamilton.* Hamilton, ON: McMaster Institute for Transportation and Logistics.

Higgins, C. D., & Kanaroglou, P. S. (2016a). Forty Years of Modelling Rapid Transit's Land Value Uplift in North America: Moving Beyond the Tip of the Iceberg. *Transport Reviews*.

Higgins, C. D., & Kanaroglou, P. S. (2016b). A Latent Class Method for Classifying and Evaluating the Performance of Station Area Transit-Oriented Development in the Toronto Region. *Journal of Transport Geography*, 52, 61-72.

Higgins, C. D., Ferguson, M. R., & Kanaroglou, P. S. (2014). Light Rail and Land Use Change: Rail Transit's Role in Reshaping and Revitalizing Cities. *Journal of Public Transportation, 17*(2), 93-112.

Jones, B. (1986). One Way to Neighborhood Deterioration? *Journal of Planning Education and Research, 5*(3), 154-163.

Kamruzzaman, M., Baker, D., Washington, S., & Turrell, G. (2014). Advance Transit Oriented Development Typology: Case Study in Brisbane, Australia. *Journal of Transport Geography, 34*, 54-70.

Loukaitou-Sideris, A. (2010). A New-Found Popularity for Transit-Oriented Developments? Lessons from Southern California. *Journal of Urban Design, 15*(1), 49-68.

MacLeod, M. (2015, May 14). Conference Board of Canada Forecast Says it Will be Fourth-Fastest Growing City in Canada This Year. *The Hamilton Spectator*.

Masyn, K. E. (2013). Latent Class Analysis and Finite Mixture Modeling. In P. Nathan, & T. Little (Eds.), *The Oxford Handbook of Quantitative Methods* (pp. 551-611). New York: Oxford University Press.

Mayo, S., Klassen, C., & Bahkt, L. (2012). *Neighbourhood Profiles.* Hamilton, ON: Social Planning and Research Council of Hamilton.

Metrolinx. (2010). *Hamilton King-Main Benefits Case.* Toronto, ON: Metrolinx.

Metrolinx. (2011). *Mobility Hub Guidelines for the Greater Toronto and Hamilton Area.* Toronto, ON: Metrolinx.

Mills, E. S. (1972). *Studies in the Structure of the Urban Economy.* Baltimore: John Hopkins Press.

Muth, R. F. (1969). *Cities and Housing.* Chicago: University of Chicago Press.

Pucher, J., Buehler, R., & Seinen, M. (2011). Bicycling Renaissance in North America? An Update and Re-appraisal of Cycling Trends and Policies. *Transportation Research Part A: Policy and Practice, 45*(6), 451-475.

RAHB. (2016). *Seller's Market to Continue in 2016.* Hamilton, ON: Realtors Association of Hamilton-Burlington.

Renne, J. L. (2009b). Measuring the Success of Transit-Oriented Development. In C. Curtis, J. L. Renne, & L. Bertolini (Eds.), *Transit-Oriented Development: Making it Happen* (pp. 241-255). Burlington, VT: Ashgate.

Reusser, D. E., Loukopoulos, P., Stauffacher, M., & Scholz, R. W. (2008). Classifying Railway Stations for Sustainable Transitions – Balancing Node and Place Functions. *Journal of Transport Geography, 16*(3), 191-202.

Thorne-Lyman, A., Wood, J., Zimbabwe, S., Belzer, D., Breznau, N., Brennan, T., . . . Yake, C. (2011). *Transit-Oriented Development Strategic Plan.* Portland, OR: Center for Transit-Oriented Developement.

Van Dongen, M. (2016, February 16). Should Hamilton Hike Public Parking Prices. *The Hamilton Spectator*.

Walker, G. W., Kulash, W. M., & McHugh, B. T. (1999). Downtown Streets: Are We Strangling Ourselves on One-Way Networks? *TRB Circular E-C019: Urban Street Symposium*, 1-18.

Wazana, A., Rynard, V. L., Raina, P., Krueger, P., & Chambers, L. W. (2000). Are Child Pedestrians at Increased Risk of Injury on One-way Compared to Two-way Streets? *Canadian Journal of Public Health, 91*(3), 201-206.

Zemp, S., Stauffacher, M., Lang, D. J., & Scholz, R. W. (2011). Classifying Railway Stations for Strategic Transport and Land Use Planning: Context Matters! *Journal of Transport Geography, 19*(4), 670-679.

7.0 List of Tables and Figures

Figures

Tables