Transit Access and Social Equity in the Greater Toronto and Hamilton Area

Background Paper to the 2041 Regional Transportation Plan

March 2018

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1 Introduction

Equity in transportation has been gaining awareness as a social issue that needs to be addressed by transportation planners, builders and operators. The transportation system plays a role in contributing to overall social equity in society. As described by Hertel and Keil,

> *… in a transportation system based on a principle of equity, transit is planned, prioritized, funded, constructed and operated in a way that is responsive to people's abilities (financial, physical, mental) and needs (travel patterns). At a regional scale, equity can manifest itself as a connected network that provides a range of travel options to provide the greatest number of choices possible for the greatest number of people, and at a price that all people can afford* (Hertel, Keil, & Collens, 2016).

Significant research on equity and transportation in the Greater Toronto and Hamilton Area (GTHA) has been carried out in recent years (Hertel, Keil, & Collens, 2016; Walks, 2013; El-Geneidy, et al., 2014; Paez, Farber, Mercado, Roorda, & Morency, 2013). This paper draws on previous work and supports the Regional Transportation Plan for the GTHA, providing a basis for an approach to incorporating equity considerations into regional transportation planning. The focus is on access to transit and mobility for low income households, while recognizing that the benefits of an equity-conscious approach to transportation planning, building and operations would be a benefit to all residents and employers in the region.

Public transit plays an important role in providing low income households with access to jobs, educational opportunities, and other services. Low-income households are more likely than others to rely on transit (see Figure 2) to get to work and meet their daily needs overall, and they are less likely to own a car than higher-income households (see Figure 1). Further, low income people are more likely to hold precarious employment, work multiple jobs and work irregular hours, which can be particularly challenging for people who are dependent on transit.

This background paper presents the findings of preliminary research into the how well public transit serves low income areas in the region and identifies opportunities to improve transit access for low-income groups. The work in this study focuses on the level of service provided, destinations served, and the location of the transit network. It discusses several aspects of public transit that have equity implications, including the frequency and reliability of the service; access to transit stations and their proximity to residential and employment areas; the cost of the service, fare structure and payment options; and the transit network itself, including the route locations, coverage, and connectivity it provides throughout the region.

There are many other factors that influence why low-income groups can have difficulty accessing transit and why they are often more transit-dependent than other income groups that are not addressed in detail in this paper.

1.1 Background

The Greater Toronto and Hamilton Area (GTHA) has been one of the largest and fastest growing urban regions in North America in recent decades, and by 2041 it will grow to a population of 10.1 million and 4.8 million jobs (Ministry of Municipal Affairs, 2017). The GTHA is a vast area (8,000 km^2) with 30 municipalities served by ten transit agencies.

The region's rapid transit network is currently oriented primarily around serving office employment destinations located in downtown Toronto. Travel patterns are shifting, however, with increasing suburb-to-suburb travel, and while much of the office employment growth is continuing to concentrate in downtown Toronto, other employment is becoming increasingly dispersed in lower-density suburban areas that are difficult to serve with transit and have a built form that is not conducive to transit use, such as the large suburban employment areas near the Pearson Airport area and highway 404 and highway 7. Combined with the significant population growth in suburban areas that is expected to occur over the next 25 years, it will be necessary to re-think how the transit network is designed and operated in the future.

Housing affordability is also an increasing concern in the GTHA. Housing prices are highest and rising the fastest in urban areas with better access to quality transit, which can drive lower income families that are not able to access social housing into suburban areas where housing is more affordable (Hertel, Keil, & Collens, 2016). This can increase commute times and reduce access to employment, services and other opportunities for people who rely on transit. In particular, lower density suburban areas are less likely to provide quality off-peak transit service, which low-income households are more likely to rely on for their daily shopping and other needs. Poverty rates are increasing among GTHA households (Hertel, Keil, & Collens, 2016; Walks, 2013), and access to social housing in urban areas is becoming more challenging.

Since *The Big Move* regional transportation plan was released in 2008, some 350 kilometres of new rapid transit is in operation or has been committed for construction across the GTHA, including the GO Rail Regional Express Rail (RER) program, Eglinton Crosstown Light Rail Transit, the Toronto-York Spadina Subway Extension, the York Region Viva BRT, and the Hurontario LRT. These and other rapid transit projects will help to address growth and changing travel patterns in the region, but more will need to be done to fully address issues of equity and access to quality transit throughout the GTHA.

Metrolinx has recently updated the Regional Transportation Plan (RTP) that provides recommendations for transit and transportation in the GTHA, reflecting where and how growth will occur in the region to 2041. This paper is one of several background papers undertaken to support the recommendations made in the updated RTP. Together with the *Regional Transit Network Planning Study* (IBI Group, 2017) and *Transit Needs and Opportunities* (IBI Group, 2016) background papers, which identified serving low-income areas among a number of transit needs in the GTHA, this work informed the development of a Frequent Rapid Transit Network (FRTN) that will improve access to fast, reliable transit throughout the GTHA. Other equity considerations in the RTP include recommending a 24-hour regional transit network, improved reliability for local transit services, and strategies to advance fare and service integration across municipal boundaries.

1.2 Approach

This paper looks at the level of transit service currently available in low-income areas of the GTHA in order to identify areas that are in need of transit service improvements, using metrics that measure an area's *access to transit*, and *access to destinations*.

Access to transit refers to the total level of transit service available to a particular area, taking into account the time it takes to walk to nearby transit stops and the frequency of transit

services available at each stop[1]. The closer that an area is to transit, and the more total transit services available (number of routes and frequency of service), the greater the area's access to transit is. This metric is an important indicator of how easy it is for someone living in an area to get around by transit generally, and how many options they are likely to have.

Access to destinations refers to the total number of destinations, such as jobs or schools, that a person living in an area can access, using transit, within a given time (e.g. 45 minutes). *Access to jobs* in particular is an important metric as it is an indicator of how many potential job opportunities are available to residents of an area. This is particularly important for people who are dependent on transit.

This paper discusses some of the factors that have an impact on transit access (section 2), outlines the approach to identifying low-income areas in need of improved access (section 3), and finally discusses opportunities to improve transit access for low-income groups across the region (section 4).

2 Factors affecting mobility and access to transit in the GTHA

There are a number of factors that influence people's mobility and access to transit, including:

- Income
- Location of home, work and other destinations
- Regional structure and urban form
- Transit network and service characteristics
- Affordability

The analysis described in section 3 considers location of home and work, regional structure and urban form, and transit network and service characteristics in identifying access to transit and mobility gaps for low income areas in the GTHA. Affordability is not explicitly considered in this study. Demographic indicators of transit use such as gender or age, or transit use by marginalized groups, are not discussed here. The focus of this work is on the opportunities to access transit that are available to all residents of a particular area, and on the impact of income on one's ability to access transportation. Other demographic indicators, with the possible exception of cultural norms, do not directly impact access to transportation options, and are often correlated with income. Further, this paper does not explicitly consider the limitations that the design of products, devices, services, stations, or other environments may impose on access to the transportation system for people with disabilities.

[1] In this paper, "access" refers to the role that transit plays in providing connectivity - connecting people to places they want to go - rather than *accessibility* which refers to the design of products, devices, services, stations, or other environments for people with disabilities.

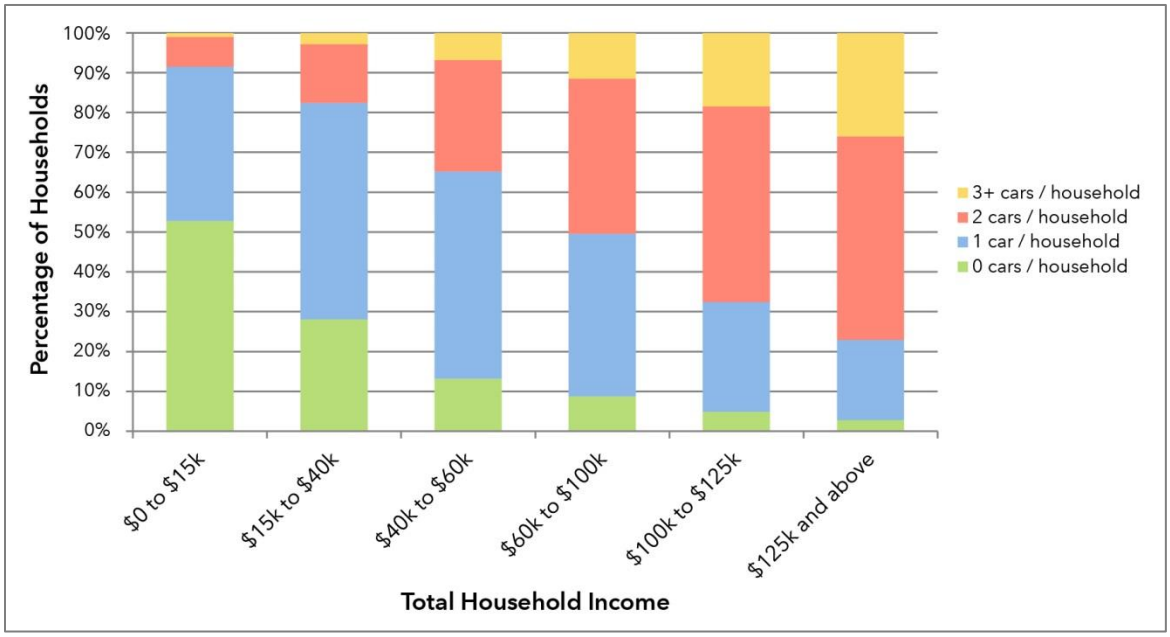
2.1 Income

Low-income households are often more dependent on transit than the general population because they have fewer transportation options, largely due to the high cost of car ownership. As shown in Figure 1, lower income households are less likely to own a vehicle, on average, across the region.

Figure 2 shows the mode share for all trips, on average, over an entire day, by total household income. Lower income households have higher the transit mode shares overall. Overall mode share by income is shown for Toronto, Hamilton and other municipalities in the GHTA in Figure 3. As expected, transit mode shares are significantly higher in Toronto than in the rest of the region across all income categories, due in part to the greater levels of transit service, population and employment density, and urban form. In municipalities other than Hamilton and Toronto, significant numbers of low-income residents are still driving for most of their trips, which may indicate that transit is not a viable option for them.

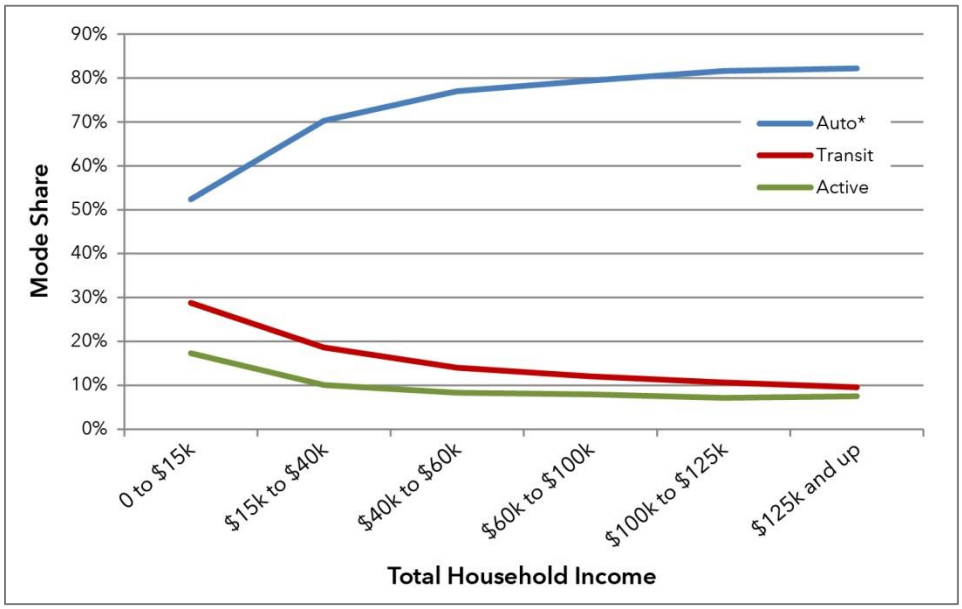
Figure 4 shows the transit mode share for all trips over a full day broken down by type of transit. Residents of lower income households are far more reliant on buses than residents of higher income households, which are typically the least reliable and slowest of transit modes, unless provided in dedicated or priority lanes. As discussed in the *Transit Needs and Opportunities* study, lower-income residents face travel time disadvantages when travelling by transit (IBI Group, 2016).

Figure 1: Average number of vehicles per household by total household income in the GTHA



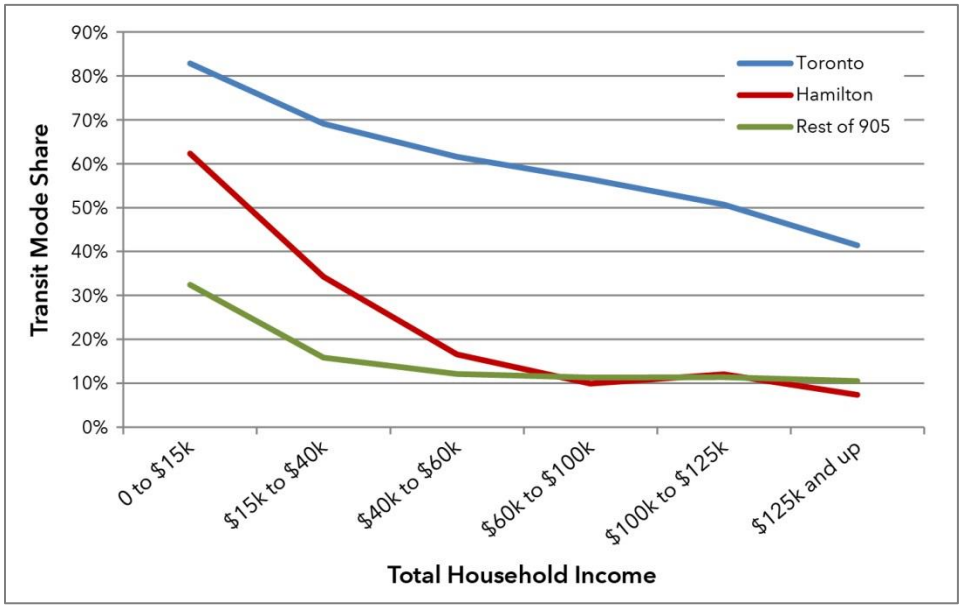
Source: University of Toronto Data Management Group, 2016 Transportation Tomorrow Survey.

Figure 2: Overall mode share by total household income in the GTHA



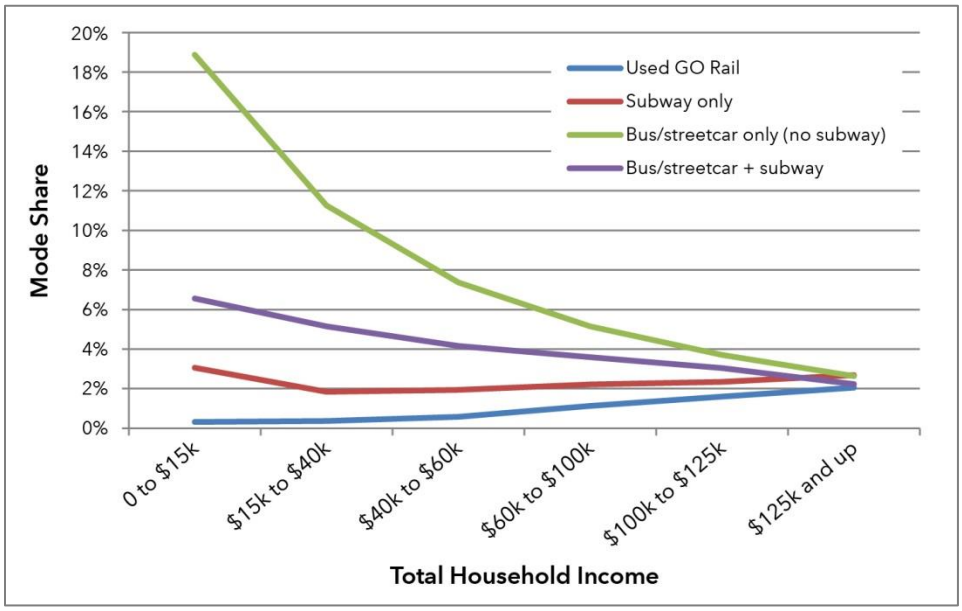
***Includes auto driver and auto passenger.**
Source: University of Toronto Data Management Group, 2016 Transportation Tomorrow Survey.

Figure 3: Transit mode share by total household income for different municipalities in the GTHA



Source: University of Toronto Data Management Group, 2016 Transportation Tomorrow Survey.

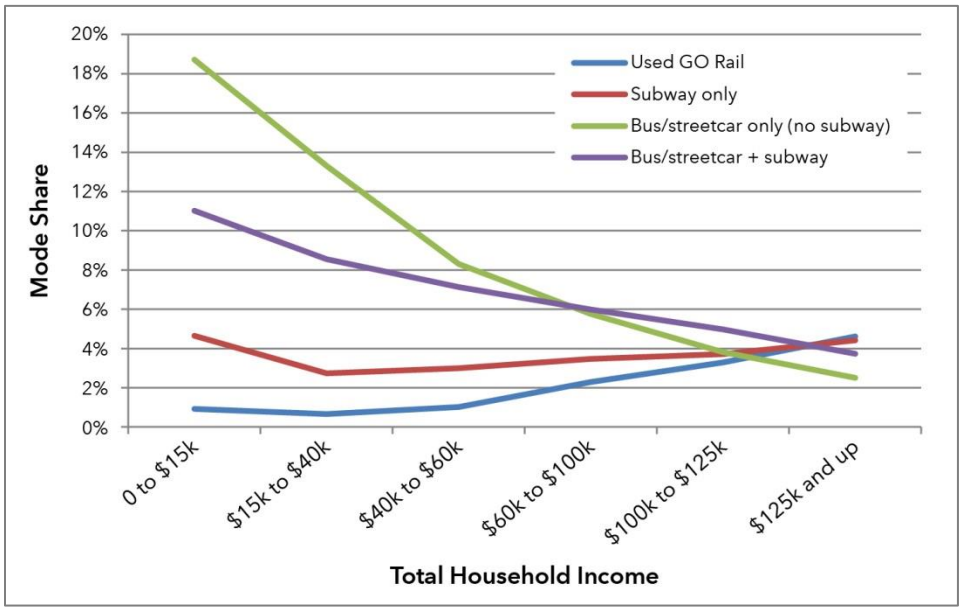
Figure 4: Transit mode share by total household income in the GTHA



Source: University of Toronto Data Management Group, 2016 Transportation Tomorrow Survey.

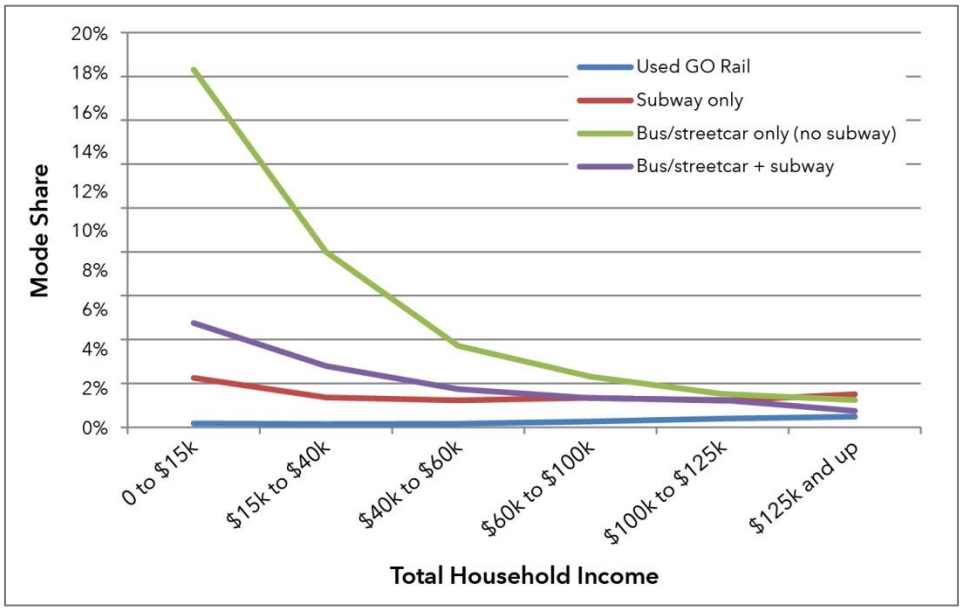
The transit mode share broken down by type of transit is shown for work trips in Figure 5, and for discretionary trips in Figure 6. Buses are used predominantly by lower income groups both to access the subway or for their entire journey to work, and commuter rail and subways are used more likely to be used by higher income groups. Across all income groups, discretionary trips are overwhelmingly made by car. However, people in lower-income households are still far more likely to take transit for these trips than those in higher-income households, and are far more likely to rely exclusively on busses and streetcars for their daily travel needs other than going to work, as shown in Figure 6.

Figure 5: Work trip transit mode share by total household income in the GTHA



Source: University of Toronto Data Management Group, 2016 Transportation Tomorrow Survey.

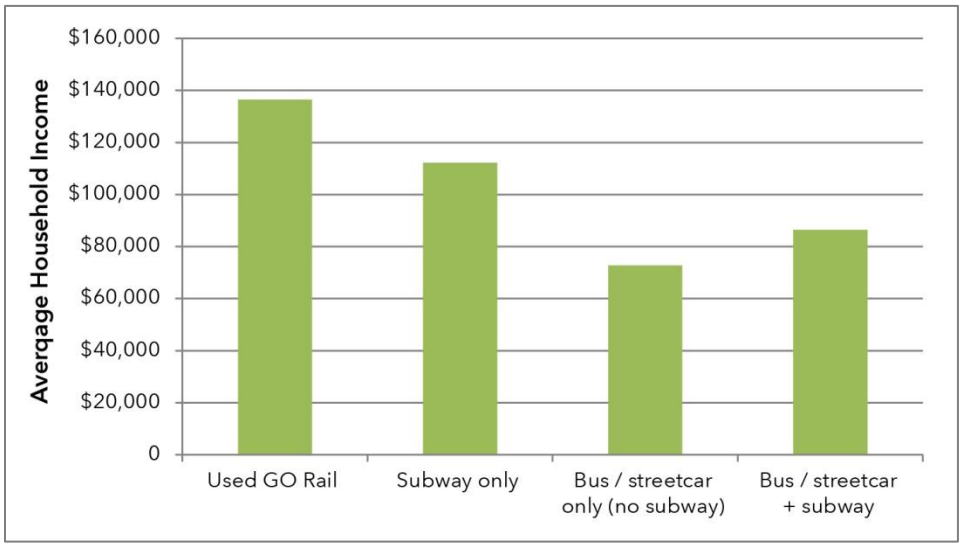
Figure 6: Discretionary trip transit mode share by total household income in the GTHA



Source: University of Toronto Data Management Group, 2016 Transportation Tomorrow Survey.

GO rail users have higher average household incomes than those using local transit systems (see Figure 7), but GO rail trips make up only a small fraction of all transit trips being made in the region each day. The GO commuter rail system is currently focused on serving predominately the 9-5 downtown office job market, which tends to consist of higher-wage jobs on average. Other factors that may deter low-income residents from using GO Rail include the higher cost of GO fares compared to local transit fares, the higher cost of housing near GO stations, and the use of the automobile as the predominant access mode to GO Rail. While the GO Rail system will still focus on the downtown office market, providing two-way all-day service and bringing fares in-line with local transit fares could help to make GO Rail more attractive for low-income users and for non-work trips.

Figure 7: Average household income by type of transit for all trips in the GTHA



Source: University of Toronto Data Management Group, 2016 Transportation Tomorrow Survey.

2.2 Location of home, work and other destinations

In the GTHA, population growth is mostly occurring in areas that are further away from the dense, transit-oriented urban areas of the region, a pattern that is expected to continue (IBI Group and Hemson Consulting Ltd., 2016). The high and rising cost of housing in the region has also contributed to the creation of an entrenched and deepening spatial pattern whereby lower-income groups, who face fewer choices in the housing market, are moving into areas that are less transit-accessible (Huchanski, 2007; Hertel, Keil, & Collens, 2016; Walks, 2013). Commute times in the GTHA are among the longest in Canada (Statistics Canada, 2016), and areas with good access to transit are becoming more desirable and thus less affordable for lower-income households. This study identifies areas on the region that are low income and have poor access to transit.

For the purposes of this study, areas with good access to transit are areas that have high levels of service (frequency), with stops that are close to home. Transit operating in mixed traffic is more likely to experience poor reliability, lower speeds and more passenger crowding than transit operating in its own exclusive right of way (e.g. subways, GO Rail, BRT and LRT). While this has an impact on all income groups, low-income groups are more reliant on bus service in mixed traffic conditions than are others in order to access the same opportunities.

Areas with new dedicated transit infrastructure typically see higher land values and housing costs than in areas without quality transit infrastructure (Kahn, 2007). Service improvements alone, such as increased frequency of bus service, are less likely to have an uplift effect. A recent Metrolinx study looked at land value impacts of different types of transit investments and found that bus and bus rapid transit improvements had the least impact on land prices, followed by increasing prices for light rail, subway, and GO rail (Metrolinx, 2013). The permanency of built infrastructure makes it important to understand the impacts of new transit infrastructure and services (Hertel, Keil, & Collens, 2016), especially on low income residents who may be forced out of neighbourhoods with new or improved rapid transit service due to gentrification effects.

Many major employment areas in the GTHA are difficult to reach by transit, having been built in suburban areas that are not transit-supportive. A recent study by the Neptis Foundation reveals a regional economic landscape characterized by concentrations of employment in downtown Toronto, plus three large suburban employment megazones and five Suburban Knowledge-Intensive Districts (Neptis Foundation, 2015). What sets downtown Toronto apart is the fact that it is well-served by transit. However, the employment areas, like downtown Toronto, contain a high proportion of "core" jobs that draw income into the region and foster innovation and competitiveness. Research by El-Geneidy indicates that transit use is lower among the lowest-wage workers (less than $16/hr) than among higher-wage workers, which may indicate that low-wage workers are travelling to and from areas that are not well served by transit, working multiple jobs, or travelling outside of peak hours (El-Geneidy, et al., 2014). While certainly there are low-wage jobs in downtown Toronto, on average people taking jobs in areas well served by transit are less likely to be low-income due to the nature of the jobs in those areas. Further, low-wage workers are more likely to travel during off-peak hours when transit service is generally not as frequent or reliable. A more in-depth study of the commuting patterns of low-income workers is the subject of future study.

2.3 Regional structure and urban form

Urban form has a large impact on access to transit. Denser urban areas typically have a more regular, grid-like street pattern, which makes it easier to walk or cycle to access transit. Lower-density suburban areas are typically designed with wider block spacing and poor pedestrian access to neighbourhoods and transit services. Wide streets, fast-moving traffic, lack of pedestrian amenities and other barriers (e.g. crossing major highways) decrease comfort and safety for pedestrians, further impeding pedestrian access to transit. Low density suburban areas are also more difficult to serve with transit, and service levels (e.g. coverage, frequency) are generally not as high as in dense urban areas.

In suburban areas, higher-income residents who use transit are more likely to drive to a rail station for the first leg of their journey. With the high cost of housing in the region forcing lower-income groups into suburban areas (Huchanski, 2007; Hertel, Keil, & Collens, 2016; Walks, 2013), low income residents, who are more likely to rely on walking to local transit for their entire journey or as a means of accessing subway or commuter rail services, face increasing barriers to mobility due to the difficulty they face in accessing the transit network. Poor transit accessibility may require low-income households in suburban areas to own a car, which consumes scarce resources that are needed for other essentials.

In recent years, GTHA transit agencies have expanded their service areas, increased service levels and most have adopted explicit service planning principles with the goals of expanding and improving service (IBI Group, 2016). Today, while 90% of the region's residents and jobs are within walking distance of some form of transit in the morning peak period, only 9% are within walking distance to rapid transit (IBI Group, 2016; Metrolinx, 2016).

Encouraging intensification of the built-up area and transit-oriented development that will increase housing density around transit stations and support public transit is a policy goal of the *Growth Plan for the Greater Golden Horseshoe*, *2017 (*The *Growth Plan)*, the 2041 RTP and of most local official plans and/or transportation plans across the region. While this has the potential to bring more people within walking distance of rapid transit, it may also exclude low income residents without affordable housing provisions. The *Growth Plan* includes policies to develop a housing strategy that include establishing targets for affordable ownership housing and rental housing.

2.4 Transit network and service characteristics

The actual service provided to different areas of the city has a large impact on the ability of residents to use transit reliably and easily to not only get to work but for all of their daily needs. Currently in the GTHA, the rapid transit network (including the subway and commuter rail) is largely radial, focussed on efficiently transporting people into and out of downtown Toronto. A grid of bus and streetcar routes, running primarily on arterial roadways, is focussed on connecting to subway and commuter rail stations. In Toronto, most local bus and streetcar routes operate frequently throughout the day to serve the needs of people travelling downtown and to other parts of the city. Other parts of the GTHA are moving towards creating a more frequent network of local and express bus routes to serve more local travel needs, and not just the needs of commuters travelling to downtown Toronto.

Transit that is oriented to downtown Toronto may serve the needs of commuters to high-paying office jobs, for example, but may not be as useful to someone working multiple

suburban jobs in different areas, at different times of the day. Such a system may make it more difficult to travel for other daily needs such as shopping, health care, or other community services. Low income residents in particular will benefit more from living near transit that is part of a strong network, providing connections to different parts of the city at all times of the day. The RTP recommends a Frequent Rapid Transit Network that would provide fast, reliable and frequent service for travel throughout the region, and not just to downtown Toronto.

We are also seeing the rapid introduction of new mobility service models, autonomous and connected vehicle technologies and mobile applications, which, as in other urban regions, will have implications for transit. As described in the *Transit Needs and Opportunities* paper (IBI Group, 2016), new mobility may complement traditional public transit by providing improved services for segments of the population and has the potential to address first-and last-mile gaps that transit has found challenging to meet (e.g. serving suburban office parks). However, there is a risk that the benefits of on-demand mobility may bypass low-income travellers (e.g. if they require mobile apps) and eclipse the potential societal benefits that could result from a more coordinated and balanced mobility system.

2.5 Affordability

While this study does not consider affordability of transit explicitly, it is certainly an important aspect of overall accessibility. Higher fares for express, regional or rapid transit services, or travel across municipal boundaries, may be a barrier for lower-income residents to access job opportunities in a reasonable travel time. For example, lower-income residents may be forced to use local transit even when a faster GO Rail option is available due to the higher cost of GO, even for local travel. Related background studies to support the update of the RTP examine this more closely (Hertel, Keil, & Collens, 2016).

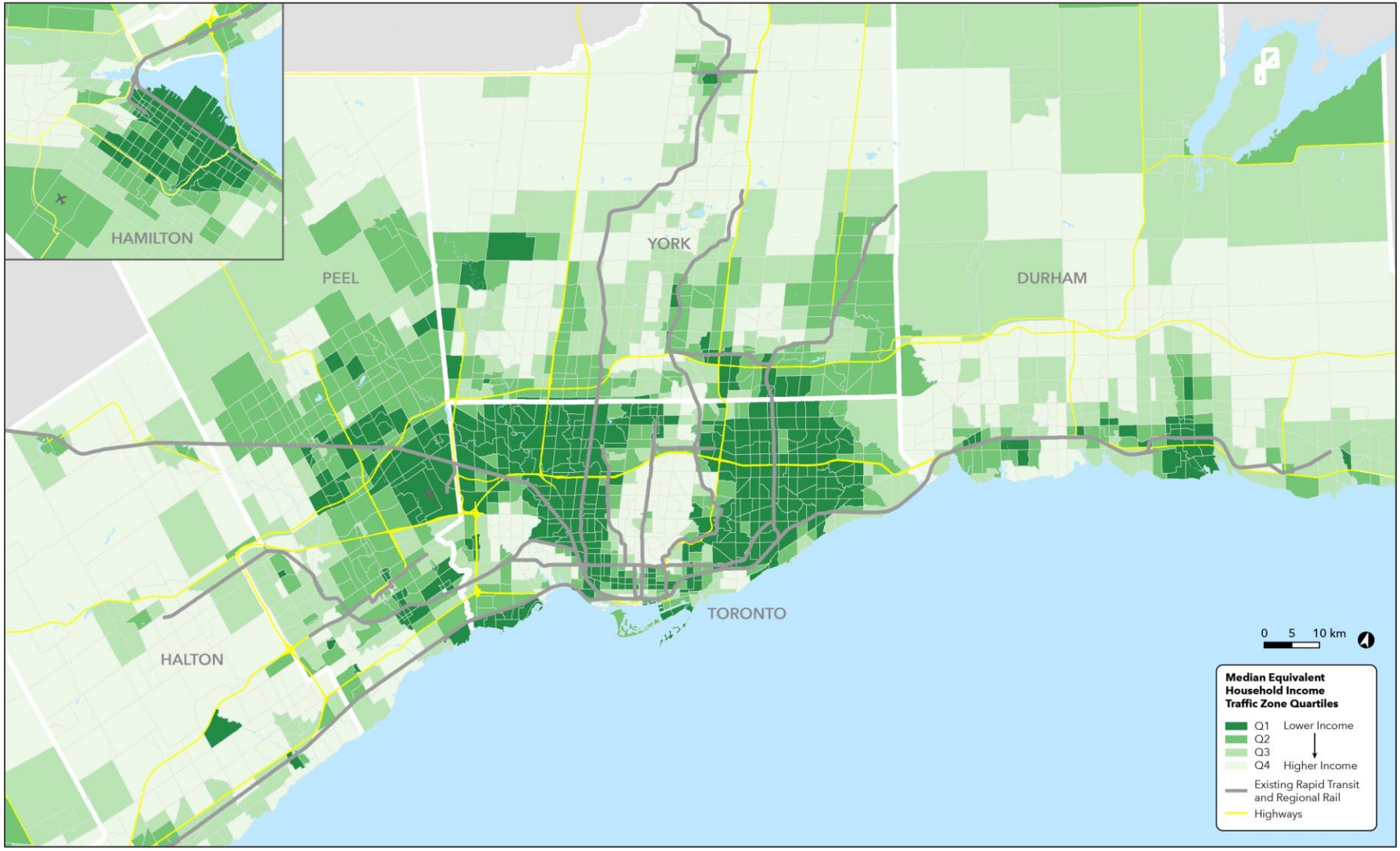
Metrolinx is currently considering regional fare integration as a means of enhancing connectivity in the region. The current regional fare structure poses several challenges to low-income groups, particularly the requirement that riders pay a double fare for cross-boundary trips on different transit systems. As the options for fare integration remain in discussion, the outcomes for low-income households have yet to be determined.

3 Identifying Gaps in Transit Access

This paper focuses on low-income areas across the GTHA that are underserved by transit. Low-income areas are defined in this study as areas having median equivalent household incomes within the lowest quartile of the median equivalent household incomes in the GTHA. At the Traffic Analysis Zone (TAZ) level, this corresponds to median equivalent household incomes below about $39,000. Areas that are underserved by transit are considered here to be areas that have poor *access to transit* or poor *access to destinations*.

Equivalent household income is a measure that takes into account the number of members in the household, which compensates for larger households having to spread the household's total income over more household members, but also accounting for efficiencies that come with multiple people living together. A map showing the median equivalent household income for GTHA traffic zones is shown in Figure 8. More details on the equivalent household income measure are provided in the Appendix.

Figure 8: Median equivalent household income in the GTHA



A tool was developed by Metrolinx with Arup Consulting (2015) that measures *access to transit* and *access to destinations* in the GTHA, using General Transit Feed Specification (GTFS) data[2]. Other factors that impact equity in transit, such as reliability, crowding, or affordability, were not considered in the analysis.

A gap analysis was conducted to identify areas in the GTHA that have both low median equivalent household incomes and poor access to transit, or poor access to jobs. More details on the tool, methodology and approach used to develop the metrics are provided in the Appendix.

3.1 Access to transit

Access to transit is a proxy for the total level of transit service available to a particular area, taking into account the time it takes to walk to nearby transit stations and bus stops and the average wait time for transit, which is related to the total frequency of services available at each stop[3]. The closer an area is to transit and the more total transit services available (number of routes and frequency of service), the greater the area's access to transit will be. This metric is an important indicator of how easy it is for someone living in an area to get around by transit generally, and how many options they are likely to have.

The average walk distance to transit stops and wait time for transit at the stop were combined to get an equivalent frequency measure which was used to generate an index of transit accessibility throughout the region (on a scale of 0 to 10)[4]. The street network and actual walk distance to transit is used in the analysis, which captures the added transit accessibility that walkable, dense urban areas provide. Other factors that impact the quality of transit service, such as reliability and speed, are not considered here.

The tool calculates access to transit for a grid of points spaced every 100 m throughout the entire GTHA; however, for analysis purposes the values were aggregated to the Traffic Analysis Zone (TAZ) level. Different time periods can also be analysed. The all-day network is important from an equity perspective as many non-work trips are made outside of the morning and afternoon peak periods. As discussed, low income households rely more on transit than higher income households for their daily travel needs, rather than just to get to and from work.

A map showing access to transit over a full day (from 6 a.m. to 7 p.m.) is shown in Figure 9. Access to transit scores are relative and what can be considered "good" is subjective, depending on factors such as local context and public expectation. For the purpose of this analysis, areas with "good" access to transit were considered to have a score of 6 or greater.

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[2] GTFS is a standardised way of making transit routes and schedules available to software developers. With the exception of Durham Region Transit, all transit agencies in the GTHA at the time that this analysis was conducted made their GTFS data available so that routes and scheduled headways could be used to calculate access to transit and access to destinations. Data used in this analysis are from 2015, the latest available at the time.

[3] In this paper, access to transit refers to the role that transit plays in providing connectivity – connecting people to places they want to go - rather than *accessibility* which refers to the design of products, devices, services, stations, or other environments for people with disabilities.

[4] A logarithmic scale is used to capture the intuitive idea that increases in transit service have a larger impact on one's access to transit when service is poor than when it is good (e.g. doubling a service from every 30 minutes to every 15 minutes has a larger impact than doubling a service from every 4 minutes to every 2 minutes).

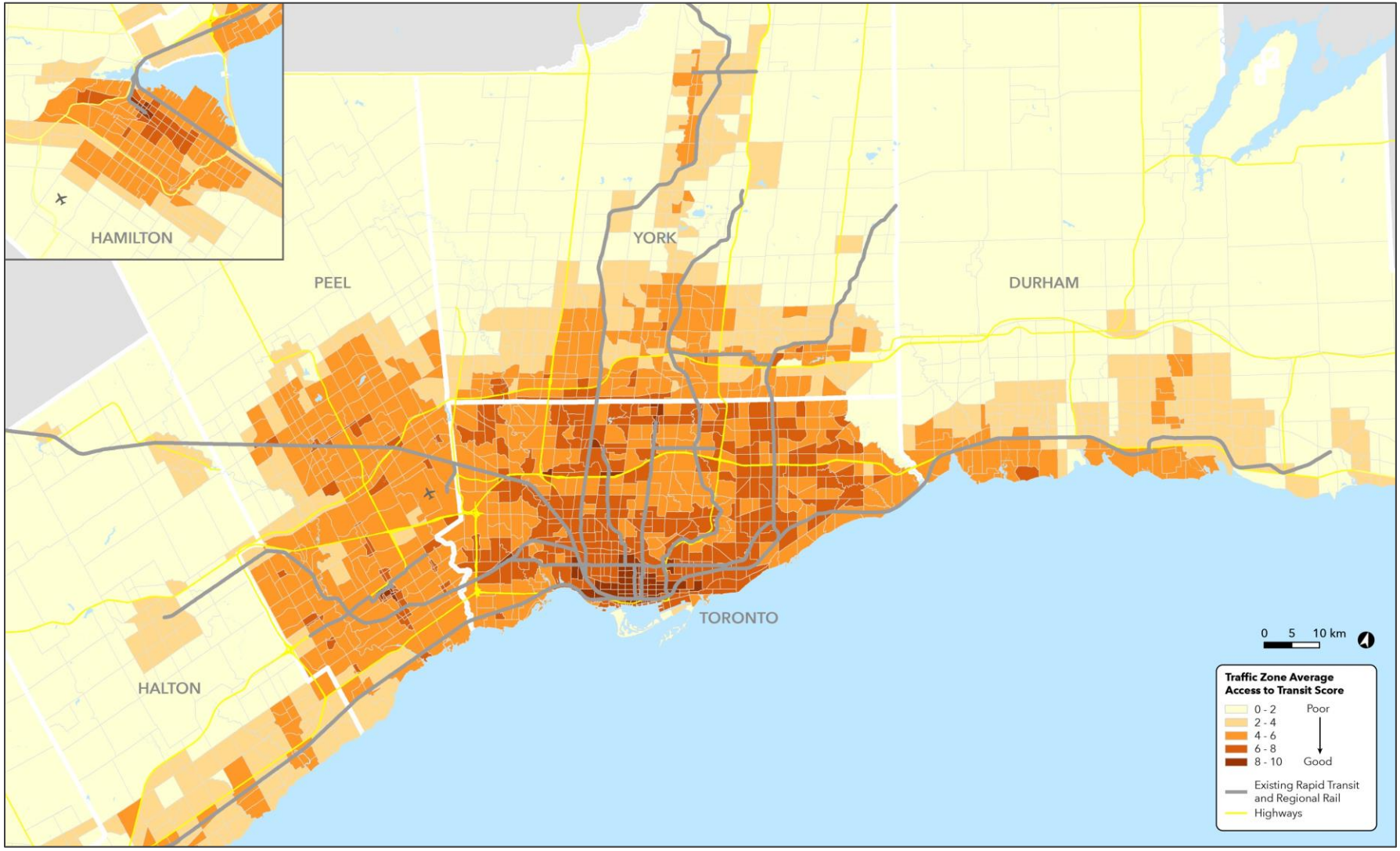
An access to transit score of 6 corresponds approximately to having access to one transit route with service every 5 minutes (10 minutes in each direction) with a stop right in front of your front door (no walk time), having two transit routes each with service every 10 minutes (20 minutes in each direction) both with stops located a 2.5 minute walk away, or having three transit routes each with service every 10 minutes (20 minutes in each direction) each with stops located a 5 minute walk away.

From Figure 9, it is evident that areas with poor access to transit can be found in every municipality across the GTHA. Most areas in the GTHA that have at least basic bus service achieve an average access to transit score of at least 2. This corresponds to being within a 5 minute walk of one transit route with service every 15 minutes (30 minutes in each direction). Areas of the region that are closer to a higher-density of route options, including all-day GO Rail, typically achieve a score of 4 or greater, which approximately corresponds to being a 7 minute walk from 2 transit routes each with service every 10 minutes (20 minutes in each direction). Areas in the GTHA that are closer to a high-density of frequent transit routes have scores that are greater than 6, typically in Toronto, downtown Hamilton and a few areas in Peel Region. Finally, areas in the GTHA with the best access to transit scores of 8 and above are found almost exclusively in downtown Toronto, downtown Hamilton and downtown Mississauga. These areas can access on average 3 transit routes each with service every 3-5 minutes or better (6-10 minutes in each direction) each within a 1-2 minute walk.

Figure 10 shows the access to transit score for low income traffic zones in the GTHA (traffic zones having the lowest quartile of median equivalent household income). Most of the lowest income areas in the GTHA are concentrated in north-west and north-east Toronto, as well as areas just east and west of downtown and south Etobicoke. There are also large low income areas in north-east Mississauga in around Pearson airport, in central Brampton and parts of south-central Mississauga, south Oshawa, and much of central Hamilton.

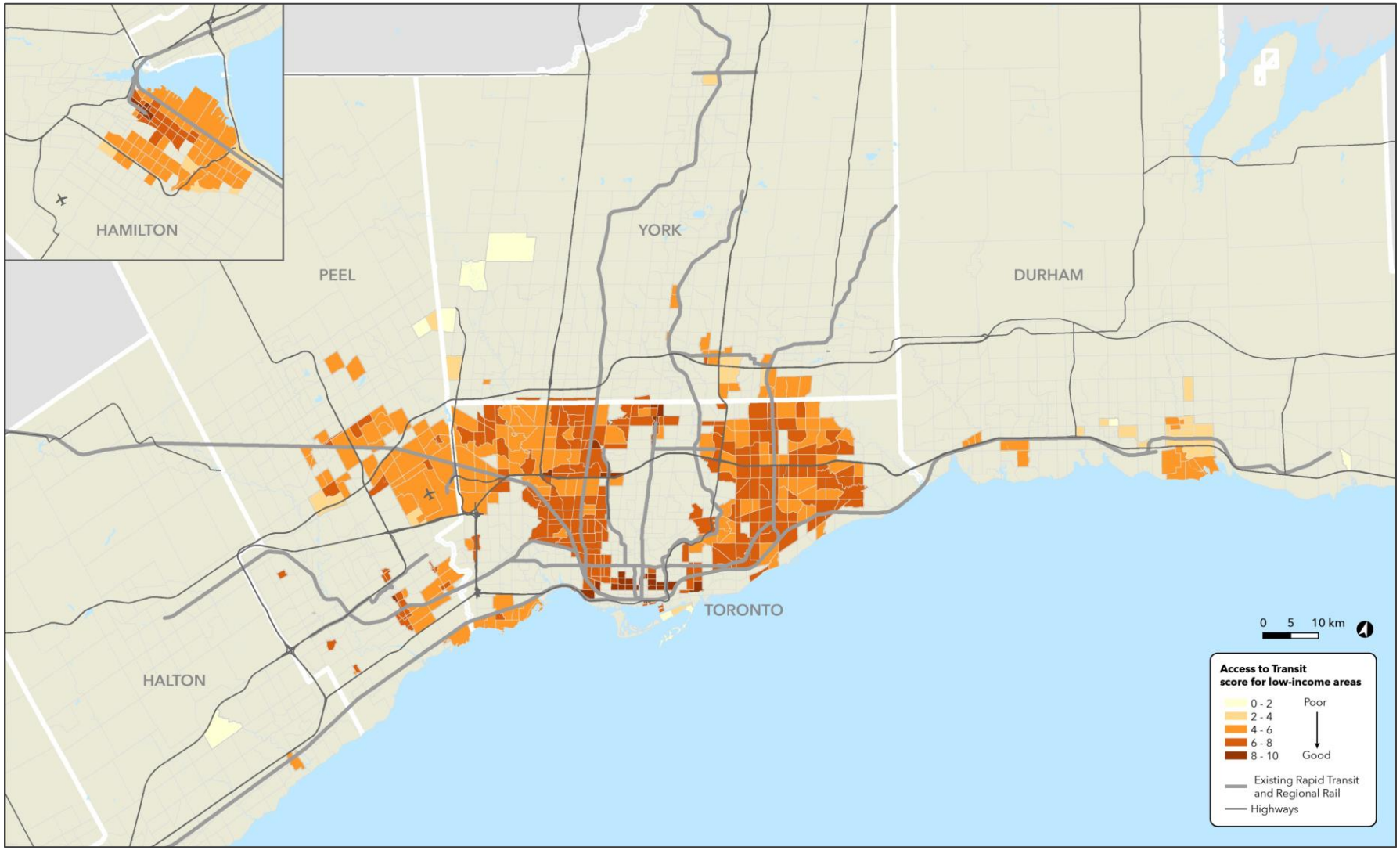
Not all low-income areas have poor access to transit. There are many parts of Toronto, Mississauga and Hamilton that have access to transit scores greater than 6 or even 8. Figure 11 shows low income traffic zones that also a low access to transit score (less than or equal to 6), revealing gaps in transit access from an equity perspective, or areas with poor transit that rely on transit most for their daily needs.

Figure 9: Access to transit score



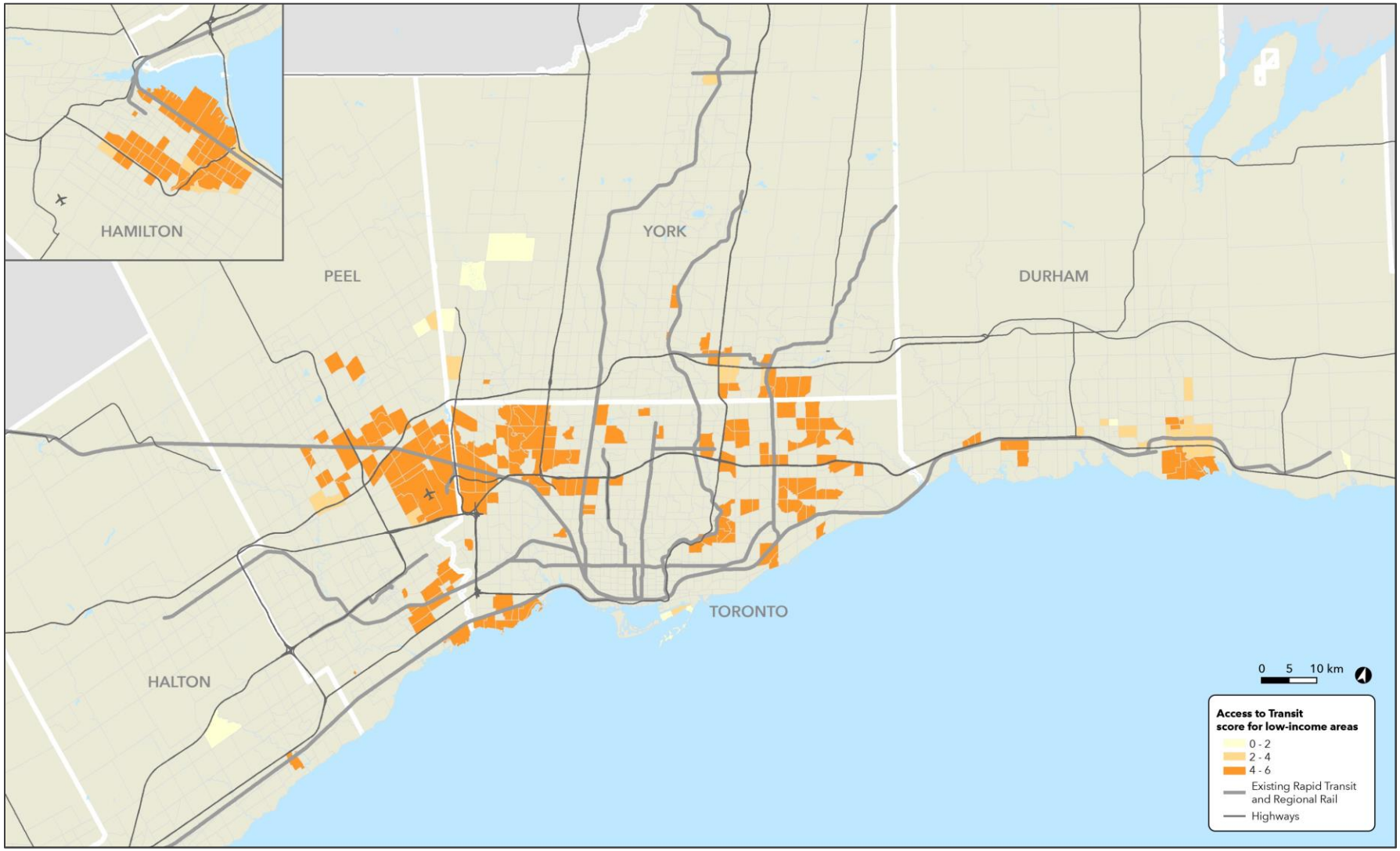
Note: Data for Durham Transit were not available and transit scores in Durham Region reflect access to GO bus and rail only.

Figure 10: Access to transit score for low income areas



Note: Data for Durham Transit were not available and transit scores in Durham Region reflect access to GO bus and rail only.

Figure 11: Low income areas with poor access to transit



Note: Data for Durham Transit were not available and transit scores in Durham Region reflect access to GO bus and rail only.

As seen in Figure 11, low income areas with poor access to transit are primarily located in the inner suburbs of Toronto, particularly in the northeast (Scarborough) and north-west (Etobicoke). Also notable are areas in Hamilton, and smaller clusters in Brampton, north-east and south-east Mississauga, Richmond Hill, Markham, south and central Oshawa, central Picking and Ajax, and south Etobicoke.

As noted above, this analysis only looks at total transit service in an area, regardless of the quality of the transit service (speed, reliability, comfort, etc.). While many of the low income areas in north east and north west Toronto have good access to frequent service, most of these areas are not close to reliable rapid transit. Bus service in these areas can be unreliable and slow, resulting in long travel times to many destinations. The next section looks at the number of jobs that residents in low income areas can access by transit within 45 minutes, which takes the travel time into account. Opportunities for future work include studying where residents of low income areas are actually travelling to and how long it takes them to get there by transit.

Although this work only considers existing transit service, it was used to inform the RTP by identifying where further improvements in transit are needed to address gaps. Many rapid transit projects are currently funded for construction across the GTHA, which will improve access to transit for many residents; however, many gaps will still remain. It is also worth noting that the access to transit scores shown here are independent of the population of an area. Improving transit in an area that has very poor access to transit with a large population could have more of an impact than improving transit in an area with poor access but a smaller population, for example.

3.2 Access to destinations

Access to destinations refers to the total number of destinations of interest, such as jobs, schools or other services, that a person living in a particular area can access using transit within a given time (e.g. 45 minutes or one hour), and as such it is a measure of both travel time and land-use. Access to jobs in particular is an important metric as it is an indicator of how many potential job opportunities are available to residents of an area, and is the focus of the analysis in this report. To estimate the number of jobs accessible from TAZ in the GTHA within a certain time, the number of jobs in each TAZ in the region that can be accessed within the designated time by transit was totalled, including the walk time to the transit stop, the average wait time, the transit travel time, and time for any transfers.

Figure 12 shows the number of jobs accessible within 45 minutes by transit[5] in the morning peak period (6:00 a.m. to 9:30 a.m.) from each traffic zone in the GTHA. This is a measure that takes into account both the access to transit from each zone as well as the location of employment relative to each zone. This metric can be considered a proxy for employment opportunities, which is particularly important for low income people who are dependent on transit.

The areas with the best access to jobs are found in downtown Toronto and in the areas around the subway lines. This reflects both the speed and frequency provided by the subway and the large concentration of jobs along these lines (primarily in downtown Toronto). This

[5] 45 minutes by transit includes walk time to the transit stop, the average wait time (dependent in the headway), travel time, and transfer time (if any).

analysis does not identify a threshold for "good" or "bad" access to jobs. It is useful from a regional perspective to look at access in this way as a relative measure of competitiveness across the GTHA; people living in areas that can access a greater number of jobs within a certain travel time by transit will simply have more employment opportunities. People who are dependent on transit to get to work will be particularly impacted by a lack of employment opportunities.

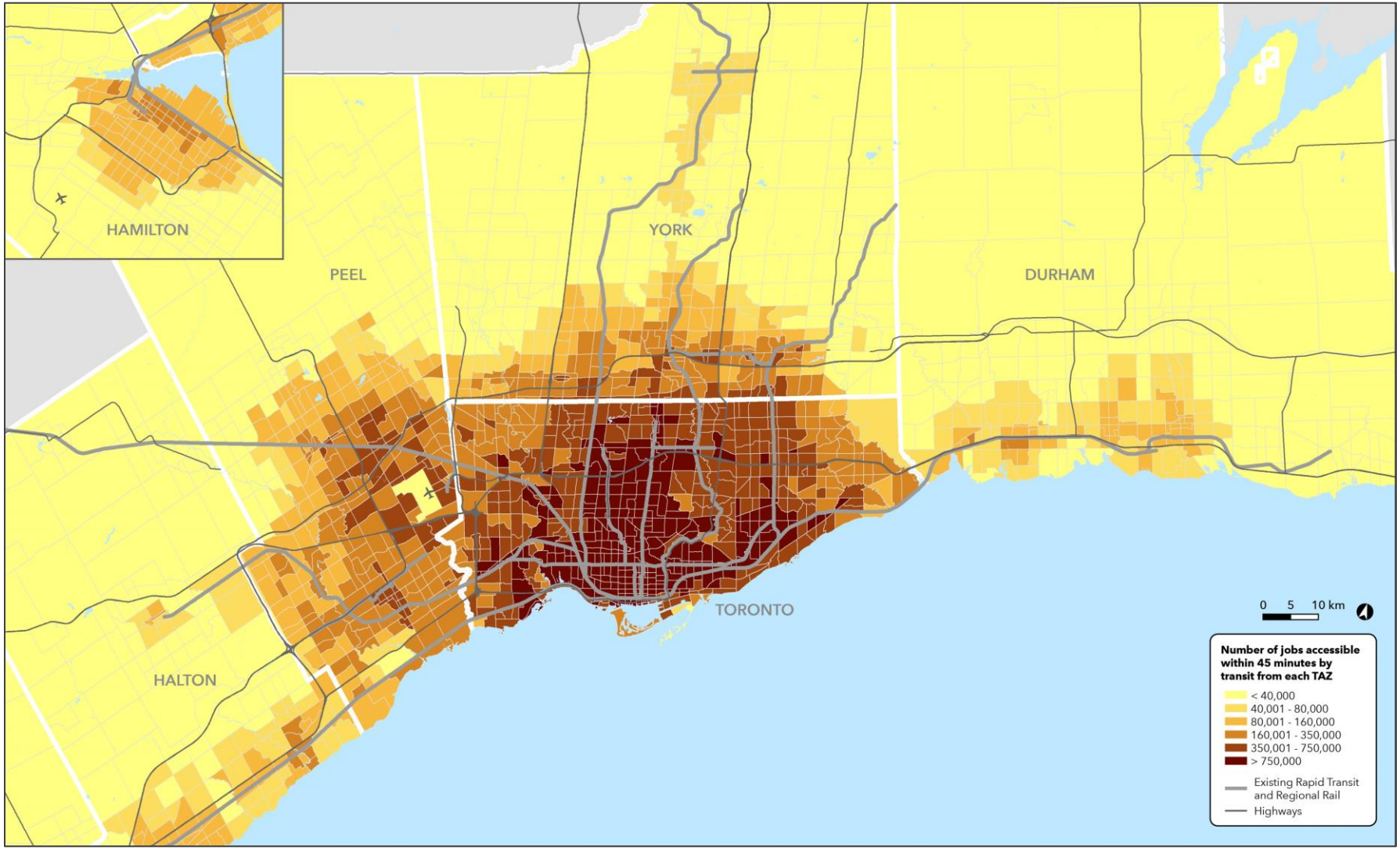
Most parts of the City of Toronto have good access to jobs within 45 minutes by transit (160,000 + jobs), with western Scarborough and much of North York having very good access (350,000 + jobs). This is in part due to the relative proximity to downtown Toronto as well as the strong network of frequent bus routes that exist in most of Toronto. Other areas of the GTHA with good access include central and western Mississauga and Brampton, central Hamilton, Brampton, south York Region. A few large suburban employment areas and city centres have very good access by transit, such as the intersection of Highway 404 and Highway 407, downtown Mississauga, Richmond Hill, and the Airport Corporate Centre.

It is important to note that the access to jobs by transit metric does not take into account the distribution of population - where people actually live. Further, it does not consider the actual distribution of trips that are made throughout the region by residents of different areas. Thus the access to jobs metric does not say anything about how many people will actually be able to get to those jobs using transit; a zone with high access to jobs might not provide people with opportunities if no one lives there, or might not be providing good transit service to places where people actually work. This is the subject of future analysis.

The number of jobs accessible within 45 minutes by transit for low income zones is shown in Figure 13. Most of the low income areas in Toronto have very good access to jobs by transit (350,000 + jobs). Parts of northern Etobicoke and central Scarborough do not have access to as many employment opportunities by transit. Low income areas with the fewest accessible jobs are in much of Hamilton outside of the downtown area, including Hamilton mountain, much of central and south Oshawa, as well as other low income areas scattered around the GTHA that are far from good transit service or employment opportunities.

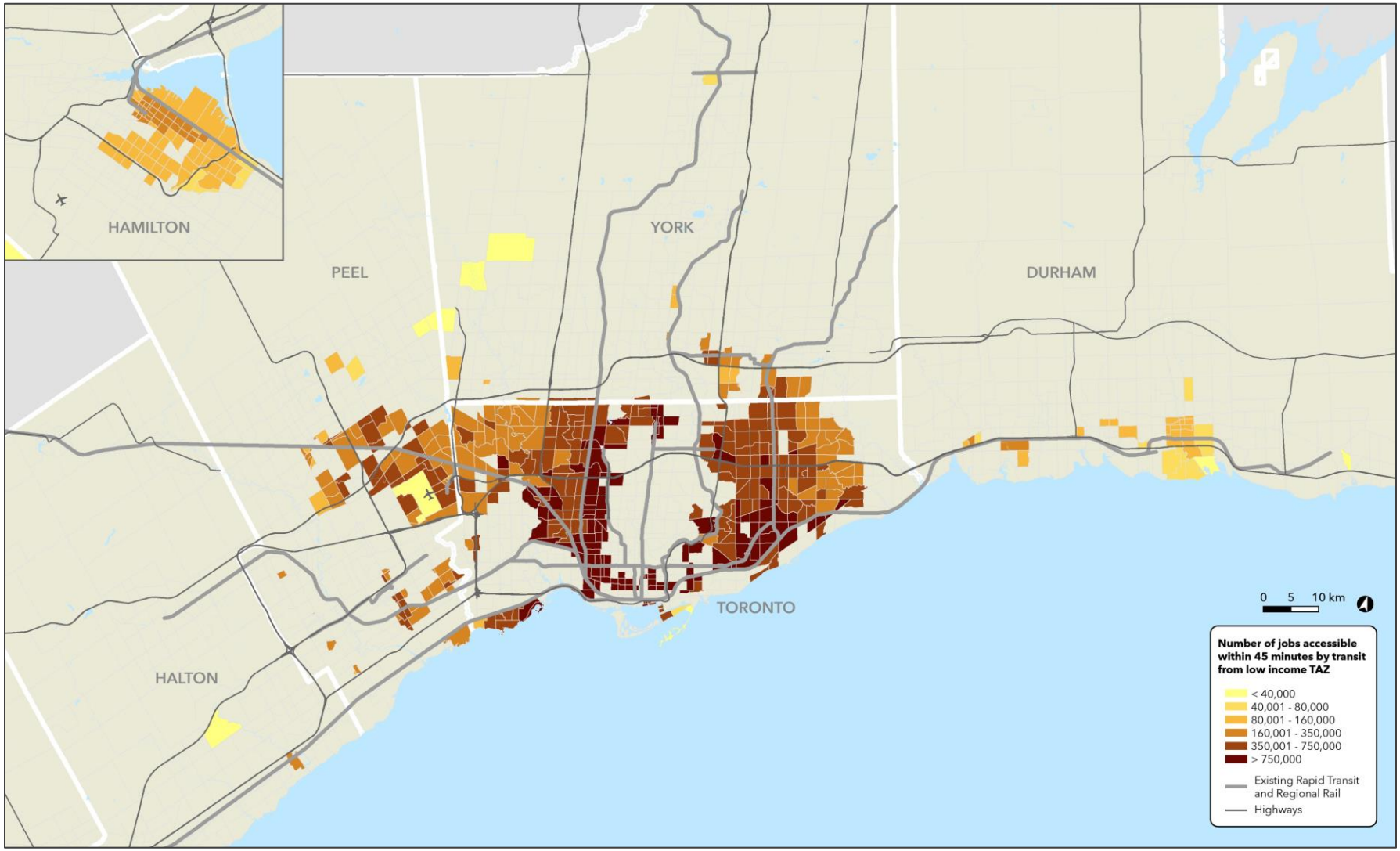
A more thorough analysis of accessibility to jobs in the GTHA can be found in academic research conducted for Metrolinx by El-Geneidy (El-Geneidy, et al., 2014).

Figure 12: Jobs accessible within 45 minutes by transit



Note: Data for Durham Transit were not available and transit scores in Durham Region reflect access to GO bus and rail only.

Figure 13: Jobs accessible within 45 minutes by transit from low income areas



Note: Data for Durham Transit were not available and transit scores in Durham Region reflect access to GO bus and rail only.

4 Discussion

This section identifies some opportunities that could improve transit access in geographies of need to enhance equity in the region. Most focus on transit service, rather than just the provision of new infrastructure, including measures such as improved access, frequency, reliability, speed, affordability, comfort and convenience. Several strategies are presented in the *Transit Needs and Opportunities* study undertaken for the legislated review of the RTP (IBI Group, 2016).

Low income households are disproportionally dependent on transit, and thus strategies to address equity in the region place a greater emphasis on improving conditions for existing users, rather than on attracting new users.

4.1 Transit service opportunities

The RTP emphasizes the importance of leveraging existing transit infrastructure and service to support growth in the region. From a regional transit network planning perspective, opportunities to address social equity with improved transit access include service improvements and targeted infrastructure improvements. More broadly, from an equity perspective, it is essential that land use policies encourage a greater integration of development and transportation decisions, encouraging high-density development near transit stations to create transit-supportive and pedestrian-friendly environments, while taking into account impacts of proximity to rapid transit and gentrification on housing prices.

Improving frequency and span of service. One of the most important factors influencing transit use is the frequency of service. Frequent transit service reduces wait time, which is a large deterrent to transit use for choice riders, and reduces the wait time disadvantage for those using transit. Providing frequent service all day, in the evening, at night and on weekends is essential for people who are dependent on transit, and especially for low income users who are more likely to work irregular hours, multiple jobs, and use transit for daily shopping and other needs. Areas in the GTHA with the best access to transit and to jobs are areas that are served by a network of frequent transit service, which is usually defined as bus, streetcar or subway service every 10-12 minutes or better. Most of the TTC network already operates frequent, all-day scheduled service on the arterial road grid in the inner suburbs of Toronto, and a more closely-spaced grid of frequent service covering central Toronto. There are core bus routes throughout the rest of the GTHA that provide frequent service, but other parts of the region could benefit from a stronger network of frequent services that run all day and on weekends.

Improving reliability. Reliability of service is a crucial part of any transit service, and networks of frequent transit service depend on headway reliability to realise their full benefits. One of the key advantages of frequent transit service is that riders can show up at the stop without having to consult a schedule, knowing that a bus or train will arrive within a few minutes most of the time, but if the service is unreliable, an average 10 minute service headway could easily turn into a 20-30 minute wait. For less frequent services where riders rely on a schedule, missing a bus because it arrived early could mean a very long wait for the next bus. Low income residents are particularly vulnerable to service irregularity, as they may not be able to afford alternatives, such as taking a taxi, or more reliable GO Rail service where duplication exists, and are more likely to work in jobs with less flexible start times. This is especially

important for bus service, as bus users are more likely to be from low-income households, and bus service is more vulnerable to service irregularity.

Riders can experience delays caused by operating in mixed traffic or on routes with very high ridership, causing buses to arrive early or later than scheduled. Gapping and bunching, where vehicles arrive two or three at a time with a large gap between this arrival and the arrival of the next vehicle(s), is a common frustration for transit users.

One way to improve reliability is to apply Transportation Systems Management (TSM), which seeks to improve the efficiency of the transportation network by employing a variety of operational and policy changes using technology or other relatively inexpensive improvements to prioritize the movement of transit vehicles in traffic, such as transit signal priority or HOV lanes. Buses and streetcars can utilise a variety of TSM measures, improving reliability without the need for significant infrastructure investments.

Creation of a regional Frequent Rapid Transit Network: A comprehensive network of fast, reliable, and frequent service could significantly improve transit for low income groups, connecting densely populated and underserved areas to employment areas, regional centres, and other services throughout the GTHA, and not just to downtown Toronto. A Frequent Rapid Transit Network (FRTN) would create an interconnected system that would allow people to travel efficiently and seamlessly across the GTHA by using a variety of transit priority measures to improve reliability and travel time and fare integration measures to eliminate fare barriers, which are crucial factors making transit a viable and competitive option to the automobile and improving equity in the region.

Transit service is often subject to changes driven by operational cost concerns, which can have a disproportionate impact on low-income transit users and transit dependents. It will be important to ensure that operational funding is provided along with capital funding for projects on the FRTN. Local transit service, including local frequent transit networks, play an important role in connecting people to the FRTN for longer trips, and operational funding must also be provided to maintain adequate service levels to support the FRTN.

Priority bus: Priority bus corridors are a practical and affordable way of providing fast, frequent and reliable transit service to people without the need for fully dedicated infrastructure. Priority bus corridors are part of the FRTN and will use TSM (e.g. transit signal priority) and other measures to reduce conflict with single occupant vehicles (e.g. HOV lanes) to prioritise transit and complement BRT, LRT, subway and frequent GO Rail services. The cost of housing tends to be higher near rapid transit stations, all else being equal, and housing prices often go up when a new rapid transit line is built. This contributes to inequity, making housing less affordable for those who would most benefit from living close to rapid transit. However, research has shown that housing prices are most impacted by proximity to rail transit, and less so by bus or local transit. Priority bus corridors are less likely to impact housing affordability in the same way that subway or heavy rail do, and can be a good solution to bring improved transit service to low income areas without adverse negative impacts for low-income residents.

Improving first- and last-mile connections. There is a connection between active mode share and income levels, with low-income households having higher active mode shares (see Figure 2). First- and last-mile (FMLM) refers to the part of a trip to and from transit stations and transit stops by foot, bicycle, passenger pick-up and drop-off, or shared mobility solutions. In recent years, FMLM has been recognized by transit providers as a crucial factor

in growing ridership. FMLM trips must be perceived to be safe, direct, easy to navigate, well-designed and have appropriate amenities, such as lighting.

4.2 Policy solutions

Transit fare policy. In the GTHA, residents of lower-income communities make more transit trips than higher income groups, and are more likely to use local transit, even for long trips, rather than using GO or a combination of local transit and GO for longer trips because of higher fares. A range of fare strategies and structures can be used to mediate the cost of using transit for low income residents, such as allowing transfers between transit systems without double-payment, time-based transfers, peak and off-peak pricing to allow for cheaper travel in the off-peak times, concession fares for low income residents, and a variety of fare-by-distance or mode options. These strategies could help low income users who are more likely to use transit for multiple trips at different times of the day. Metrolinx's initial work on fare integration found low-income people use transit during both peak and off-peak times, and so the base fare that riders pay for local transit services is important, as approximately half of all low-income transit trips are made exclusively using buses and streetcars.

Connecting mobility and affordability. Improving transit, especially rail and other dedicated rapid transit, has the potential to increase housing prices in surrounding communities (Kahn, 2007), making it less affordable and forcing low-income families to move father away from rapid transit. When improving transit for low-income communities, it is important to consider ways to mitigate the negative impacts of increasing housing prices on low-income residents.

Regional structure and urban form. Land use policies that encourage high-density, mixed-use development near transit stations and better integration of development and transportation decisions can create environments that better support walking, cycling and transit use. Pedestrian-friendly environments that bring more people and destinations closer to each other and to frequent, reliable transit, have the potential to most benefit low-income households who are more dependent on transit, as long as the potential negative impacts of increased housing prices are mitigated through affordable housing policies.

5 Conclusion

This background paper identified gaps in transit access in the region, as well as opportunities to improve social equity in the provision of public transit, toward the 2041 Regional Transportation Plan for the GTHA. Transit access was used to refer to the level of transit service that is available to low-income groups, taking into account both the walking distance to transit stops and the wait time for transit vehicles (an indicator of service frequency).

The analysis found several areas in the region where there are significant areas of need that are not well-served by transit; and many smaller pockets in particular parts of Toronto, Hamilton and the regional municipalities.

There is also an opportunity, as data become available and the regional rapid transit network is built out to 2025, to develop measures of transit access. Further work would also benefit from greater integration with a regional population and employment trends analysis. Similarly, the delivery of rapid transit infrastructure projects across the region, and any introduction of fare integration provide opportunities to implement and develop measures

that could advance transit's contribution to greater social equity in the region. Further work to understand the travel patterns of low-income residents would also inform how to better meet their needs.

Appendix

Income Data

Income and other socio-economic data from Statistics Canada are available at the Dissemination Area (DA) level. Dissemination Areas are composed of approximately 300-700 people (residential locations) in a census tract. Due to privacy protection, these data are not available in a more disaggregated form.

Many variables are available at the DA level, such as income; housing cost, type and tenure; ethnicity; gender; age; occupation, and household size and composition. This study used median household income data at the DA level and average household size in the DA to calculate the median equivalent household income for each DA.

The National Household Survey (NHS) replaced the Long Form Census in 2011, with the NHS being voluntary rather than mandatory. This resulted in a significant sampling bias, where households with low and high incomes especially were under-reported. Environics combined the NHS data with other datasets, including income tax records, to adjust the data for sampling bias. This adjusted data is offered in a product called DemoStats and was purchased by Metrolinx for 2011. DemoStats was used for income data for this analysis. The income metrics available from DemoStats are total before-tax income.

The metrics available in DemoStats at the DA level include:

- Median household income
- Aggregate household income (a sum of all household income in each area)
- Average household size
- Total population

None of these metrics are ideal for measuring income. Household income does not take household size into account. Looking at income per person in a household does not consider the economies of scale available as the household size increases, like sharing household expenses and the cost of rent or mortgage payments.

The Low Income Measure used internationally and by Statistics Canada recognizes these issues and developed the 'household equivalent size', which is the square root of the household size (Statistics Canada, 2015).

To calculate the equivalent income, the household income is divided by the equivalent size. This gives a metric of income that falls between the household income and the individual income. It adjusts for both household size and the economies of scale available to households with more than one person.

This 'equivalent income' was calculated for dissemination areas using the variables available in DemoStats. For each DA, the equivalent income is calculated as:

$$Equivalent\ income = \frac{Median\ household\ income}{\sqrt{Average\ household\ size}}$$

The median income is used rather than average income because average incomes can be overly influenced by outliers, whereas the median more accurately reflects the majority of the population in an area.

Since equivalent income is an adjusted metric that sits between individual income and household income, the values are often presented in quantiles (groups consisting of equal numbers of observations) from lowest to highest equivalent income.

Travel Data

Travel survey data come from the Transportation Tomorrow Survey (TTS), which provide details about individual trips such as mode, purpose, origin / destination, time of day, and routing information for transit trips, as well as information about the individual and the household they live in.

Income information is not available as part of the TTS. Ideally, cross-tabulated data would be available that would associate individual household incomes with travel data. In addition to income not being available as part of the TTS, for privacy reasons both DemoStats and location information for TTS data are only available at an aggregated level. Thus in order to link travel behaviour data to income, the Demostats and TTS data were combined spatially, which associates average travel behaviour patterns in an areas with median equivalent household incomes in the same area. The result is that average travel patterns can be calculated for all residents living in an area with a certain median equivalent household income only, and not the travel patterns of people who actually live in households with a certain median equivalent household income.

We can describe the average trip patterns of households located in a given area and then associate this area with a metric of income. This association is used to understand trip patterns by income. This approach will somewhat obscure low income travel behaviour though averaging effects with higher income residents who live in lower income areas, and will over-represent the impact of location on travel behaviour (e.g. high transit use in a low income neighbourhood could also be due to the location of that neighbourhood to quality transit, which could also impact the travel choices of higher-income residents).

Despite these limitations, this approach allows us to understand patterns of travel behaviour by income at a broad regional level and identify spatial relationships, as well as identify current and potential markets for transit.

TTS data are available by location only at the traffic zone (TAZ) level, which are typically slightly larger than Dissemination Areas. Equivalent household income data from Demostats were aggregated to the traffic zone level weighting by population.

Accessibility/Connectivity Metrics

There are two main metrics developed for this analysis: Access to Transit and Access to Destinations. The results can be compared across different networks and for different time periods (a.m. peak or all-day).

Access to Transit is an index of the level of transit service available at a given location. This is based on walking distance to transit stops as well as the wait time for transit vehicles (frequency of service).

The Access to Transit calculation estimates the 'Accessibility Index' (AI) of transit services stopping near each node in the input network. This is a level of service that takes walking distance and transit frequencies into account. An access to transit score from is then calculated based on the accessibility index for each node.

The accessibility index is calculated for a 100 m grid of points across the GTHA. A tool was developed for Metrolinx by Arup that calculates the accessibility index based on the road network, a transit network of routes and stops with headways (from GTFS data), and customizable parameters defining maximum walk distances to each type of transit.

The access to transit calculation first finds all transit stops within a defined walking distance for each node (default values are 5 minutes walking for surface routes and 10 minutes for separated rail). For each transit route with stops within walking distance of the node, the closest stop is selected.

The *Equivalent Doorstep Frequency* (EDF) is a measure that is calculated for the closest stop on each route within walking distance. As it builds walk time into the calculation, it can be considered a proxy for the service frequency a user would experience if there was no walk time to the stop. The *Equivalent Doorstep Frequency* is calculated as follows:

$$EDF = \frac{30}{\frac{headway}{2} + walktime}$$

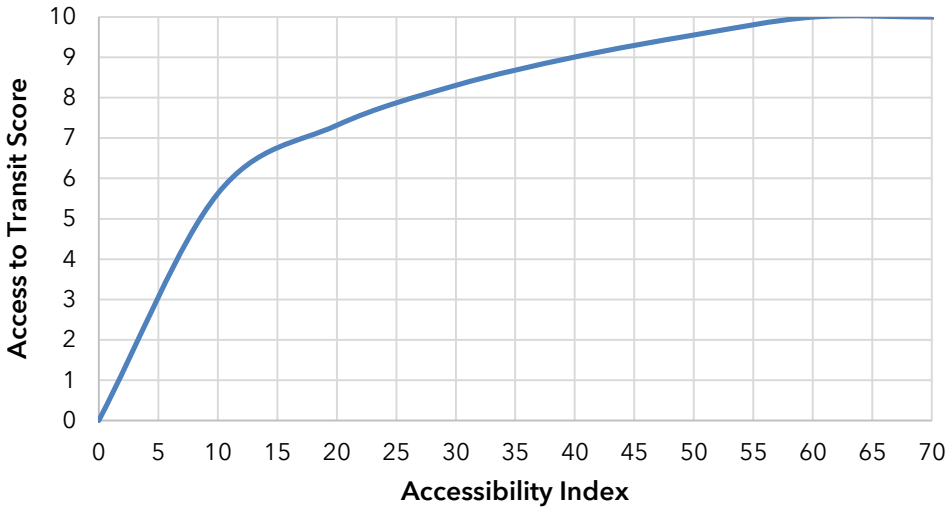
where the EDF is measured in vehicles per hour and headway and walk time are in minutes. Thus an EDF of 6 corresponds to a route with busses running with a 10 minute headway, stopping right in front of the user's home.

The *Accessibility Index* is the sum of *Equivalent Doorstep Frequency* values of all routes within walking distance from the node.

In the following example, the Yellow line has a frequency of 6 and a walk time of 7 min with an EDF of 2.5; the Green line has a frequency of 6 and a walk time of 2 min with an EDF of 4.3; and the Red line has a frequency of 12 and a walk time of 8 min with an EDF of 2.9. The AI is then EDF(yellow)+EDF(green)+EDF(red) = 2.5 + 4.3 + 2.9 = 9.7.

The *Access to Transit* score is simply the logarithm of the Accessibility Index, normalised to a maximum score of 10. This is to reflect the intuitive idea that doubling the frequency from a very infrequent service (e.g. from every 30 minutes to every 15 minutes) makes a larger difference to the level of service available than doubling the frequency of service on an already frequent route (e.g. from every 4 minutes to every 2 minutes). Figure 14 shows the relationship between AI and ATT scores.

Figure 14: Relationship Between Accessibility Index and Access to Transit Score



Access to Destinations is a metric that estimates the number of specific destination locations (e.g. jobs) that can be accessed from each origin location within a certain (user defined) travel

time using transit. The travel time includes walk time to the stop, wait time, and any transfer time. The destination locations are inputted by the user as point locations or as the number of destinations within a defined area (e.g. jobs in each traffic zone).

The access to destination calculation uses the Pathfinder tool in TransCAD. The tool allows for calculation of area-based destinations or point-based destinations. The tool evaluates all transit routes from each location and sums the jobs from each traffic zone that can be reached in a specified time using transit.

The tool also has the option of multiplying the number of destinations by a gravity function that weights closer destinations more heavily than farther destinations to account for the relative desirability of destinations (e.g. jobs) that are closer. This function was not used in the analysis presented in this paper.

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