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North Toronto rapid transit line feasibility study

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NORTH TORONTO RAPID TRANSIT LINE FEASIBILITY STUDY

by

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Abstract

Traffic congestion is an existing problem in North Toronto with Highway 401 and other area roads operating at capacity during peak hours. Future population and employment growth across north Toronto will increase traffic demands in the area. With many roads already operating at capacity, alternative non-auto modes of transportation will be required to accommodate future traffic demands and minimize future traffic congestion. Public transit is the best means of providing a non-auto transportation mode in north Toronto. Higher-order rapid transit can offer travel-time savings and many other benefits over auto-travel in congested conditions; however, no rapid transit service presently exists across north Toronto.

This paper provides the rationale for a north Toronto rapid transit line and confirms its feasibility for its implementation.

Acknowledgements

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1.0 INTRODUCTION

Traffic congestion is a problem for many urban centres of all sizes all over the world, and the Greater Toronto Area is no exception. Today, the City of Toronto is home to over 2.5 million people [1] while the Greater Toronto Area (GTA), which includes the Regional Municipalities of Durham, York, Peel and Halton are home to over 5.1 million people.[2]

Highway 401, a major east-west highway running across northern Toronto is now the busiest in North America carrying in excess of over 350,000 vehicles on an average day along its busiest segments. [3,4] Traffic demands are steadily increasing Highway 401 and along parallel arterial roads in north Toronto. Traffic congestion increases greenhouse gases by 1.2 to 1.4 mega tones every year and costs an average of $3 billion dollars annually due to lost time.[5] With an additional 3.7 million people expected to move into the GTA by 2031,[6] this will undoubtedly place more traffic demands on the City's already congested road network. Highway 401 is currently 14 lanes across (7 lanes per direction) along its widest segments and cannot be widened further. Increasing traffic demands with require the need for additional capacity. Public transit is the most efficient means of providing this additional capacity in a congested network as it can provide an alternative to automobile travel.

1.1 STUDY OBJECTIVE

The objective of this study is to determine the feasibility of implementing a higher-order, high-frequency, continuous, Regional Rapid Transit Line across northern Toronto, addressing the lack of such a route in the area and to accommodate future travel demands across north Toronto and the Highway 401 corridor.

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[1] Community Profiles 2006, City of Toronto, Retrieved January 21, 2008 from Statistics Canada website www.statcan.ca
[2] Ibid
[3] Ontario Highway 401 History, The History of Ontario's Kings Highways, Retrieved March 31, 2008 from Ontario Highways website www.thekingshighway.ca/Highway401.htm
[4] Toronto (Highway 401) COMPASS System, Retrieved 27 February 2008, from the Ministry of Transportation website www.mto.gov.on.ca/english/traveller/compass/systems/401main.htm
[5] The Cost of Urban Traffic Congestion in Canada, Retrieved 1 April 2008 from the Transport Canada website at http://www.tc.gc.ca/mediaroom/releases/nat/2006/06-h006e.htm#table
[6] Ministry of Public Infrastructure and Renewal, Places to Grow: A Guide to the Growth Plan for the Greater Golden Horseshoe, (Ministry of Ontario, 2006), p.3

1.2 SCOPE OF WORK

The study area for this project will be in the vicinity of the Highway 401 corridor across north Toronto between the City of Mississauga and City of Pickering borders. The scope of this project includes an overvi of the study area providing the background context for this project. This is followed by five main topic area a literature review, followed by a review of existing transit systems in the GTA, background transit studies and proposals, an analysis of current and future traffic data, followed by a summary, conclusion and recommendations.

The literature review includes a review of various types of transit technologies around the world that serve "regional" trips. Characteristics such as the service area, operational details such as frequency, speed, passenger capacity, ridership, cost and any other benefits and deficiencies with these transit modes are identified.

The review of existing transit services looks specifically at transit networks and route structures, identifyin any deficiencies related to serving regional trips across north Toronto.

The review of background studies examines past and present transit initiatives in the GTA and how they rel to the serving regional trips in north Toronto.

The data analysis for this project looks at existing and future traffic data and travel patterns to and from ma urban nodes in north Toronto. This review identifies existing and future transportation demands in the Highway 401 corridor and north Toronto, identifying the need for a rapid transit line in the area. An appropriate technology is selected for a north Toronto rapid transit line, along with a recommended alignm and cost estimate.

2.0 STUDY BACKGROUND

North Toronto includes portions of the former municipalities of North York, Etobicoke and Scarborough. These municipalities remained largely rural until after the 1940's when the growing population of the old City of Toronto grew into these largely undeveloped areas. The first segment of Highway 401 in north Toronto opened in the 1950's and was originally intended as a "Toronto by-pass". However, as the municipalities of North York, Scarborough and Etobicoke were incorporated into the Municipality of Metropolitan Toronto in 1954, rapid development occurred in these areas and around the Highway. Today, Highway 401 is surrounded by suburban car-oriented development which is typical throughout the entire north Toronto area. **Figure 1** illustrates the location of Highway 401 through the City of Toronto.

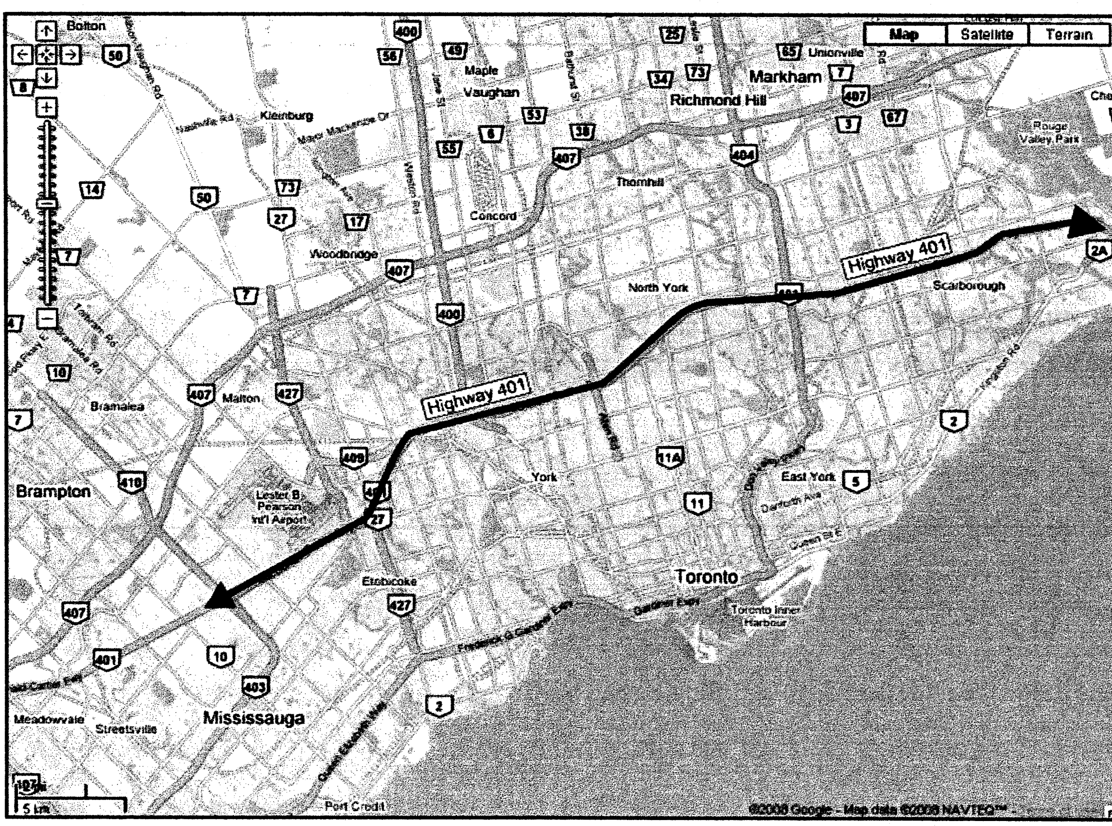

Figure 1: Highway 401 – Greater Toronto Area (GTA) Context

Development in north Toronto has cause a steady increase in traffic along Highway 401. The highway now has a cross-section of 14 lanes (7 lanes per direction) at its widest segments, and is still operating at capacity during peak periods. Development alongside the highway has limited the opportunities for additional road widenings.

In response to growing traffic congestion in the GTA and north Toronto, numerous studies and initiatives have been undertaken, proposing new regional transit lines throughout the GTA to encourage alternative non auto modes of travel, and limit future traffic congestion. However, as discussed in **Section 5.0** of this report, few studies recommended a rapid transit line across north Toronto.

3.0 LITERATURE REVIEW

A literature review was conducted to examine worldwide applications of regional rapid transit systems in operation. Regional transit modes are characterized by long transit lines operating within a 100 km radius of a central urban area, connecting central areas and suburbs (Vuchic, 2007, pg. 550). Regional transit modes include regional buses, commuter rail, regional rail and regional rapid transit (Vuchic, 2007, pg. 550).

Regional buses provide service at speeds comparable to the automobile, typically utilizing major arterials and highways. Regional express buses usually operate on local streets in the suburbs and then operate non-stop on a highway into a city centre. Express buses may operate in general purpose lanes on highways or may utilize designated facilities such as High Occupancy Vehicle (HOV) lanes. Buses operating in mixed traffic may be subjected to delays and poor operating speeds. Other high-performance measures include the use of exclusive busways for regional buses which are completely segregated from other forms of motor-vehicle traffic. Buses operating in busways typically provide the highest performance in terms of speed and reliability.

Commuter lines typically serve daily commuters taking them from the suburbs into the central area of a City during the AM peak, and back home to the suburbs in the PM peak, (Vuchic, 2007, pg. 551). Commuter lines are typically "radial" in nature, beginning from a central point or a number of centrally-located terminals on the fringes of a downtown area, radiating out in all directions to the surrounding suburbs. Commuter lines are efficient at bringing and returning peaked loads of daily commuters to and from the suburbs. They offer high speed, good comfort and reliability, and high capacities. Their disadvantages include long and or irregular headways, which make their use in off-peak hours difficult or impossible (Vuchic, 2007, pg. 551).

Regional lines are similar to commuter lines in that they serve a central area and the surrounding suburbs; however, they tend to provide better coverage than radial commuter lines, by providing a "denser" network of routes, serving more destinations. Regional lines also connect various urban and suburban centres in a built up area rather than just concentrating on one focal point such downtown. Furthermore, while commuter lines tend to operate several trips into the City in the AM and from the City in the PM, regional lines provide frequent service (5 – 20 minutes) throughout the day in both inbound and outbound directions (Vuchic, 2007, pg. 552).

Regional Rapid Transit (RRT) systems include long routes into suburbs with long station spacing's, high operating speeds, similar to those on regional lines, (Vuchic, 2007, pg. 552). However, RRT lines may also penetrate central areas with extensive transfers to other modes, short headways and high capacity, (Vuchic, 2007, pg. 552).

Since to focus of this project is a feasibility study for a regional rapid transit line connecting the urban centre in north Toronto, the literature review focuses on regional transit systems that provide regular, reliable, frequent and high-speed service between regional urban centres. Regional bus lines operating in mixed traffi such as general-purpose lanes and HOV facilities, as well as radial commuter lines were not reviewed.

3.1 REGIONAL RAPID TRANSIT TECHNOLOGIES

Regional rapid transit technologies reviewed in this study include the regional applications of heavy rail transit, light rail transit and bus rapid transit. A description and review of applications of each of these mode is provided in the following subsections.

3.1.1 Heavy Rail Transit

Heavy Rail Transit (HRT) is often referred to as a metro, subway or rapid transit. HRT represents the optim transit mode for a high-capacity route (Vuchic, 2007, p.g. 304). HRT systems typically operate along an exclusive grade-separated right-of-way with no conflicts with any other form of traffic. They typically utili electric traction, high platforms at stations and allow for simultaneous boarding and alighting from multiple doors. Operating speeds range between 25 and 60 km/h and peak hour frequencies range between 20 and 40 trains per hour (Vuchic, 2007, p.g. 305). HRT systems can typically transport between 20,000 and 40,000 passengers per hour per direction and track.[7] Some of the highest recorded capacities for HRT systems are i the range of 55,000 to 75,000 passengers per hour, which have been recorded New York City, USA, Tokyo, Japan and Moscow, Russia, for example (Vuchic, 2007, pg 191).

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[7] Parkinson, T. and Fisher, I, "Rail Transit Capacity," *TCRP Report 13* (1996): pg. xvii

HRT requires the most investment when compared to other rail modes as stations along HRT lines are typically very large in order to handle many people, while the rights-of-way are entirely grade-separated from other motor-vehicle traffic. This is achieved through the construction of tunnels, elevated structures, or grade-separated rights-of-way. Costs to construct HRT systems range between $60 and $100 million per km (Vuchic, 2007, pg 426). Regional applications of HRT systems are provided in the following **Section 3.2.**

3.1.2 Light Rail Transit

Light Rail Transit (LRT) is a transit mode that consists of electrically-powered, high capacity, high riding-quality vehicles operating in one to four car trains on a predominantly separated right-of-way (Vuchic, 2007, pg 302). Although LRT lines typically utilize separate rights-of-way, they are capable of operating in mixed traffic, exclusive transit lanes, elevated structures and tunnels. LRT systems also allow for simultaneous boarding and alighting from multiple doors along a train. Operating speeds for LRT systems vary depending on the right-of-way. LRT's operating in mixed traffic or reserved rights-of-way, such as designated lanes on a roadway, offer operating speeds ranging between 20 and 45 km/h (Vuchic, 2007, p.g. 303), transporting between 18,000 and 24,000 people per hour (Vuchic, 2007, pg. 191). LRT lines operating in segregated rights-of-way, such as a tunnel or elevated structure can provide operating speeds that are comparable to heavy rail transit, ranging between 45 and 55 km/h (Vuchic, 2007, pg. 304). LRT systems cost less to build than HRT systems, with costs ranging between $10 and $30 million per km (Vuchic, 2007, pg 426). Regional applications of LRT systems are provided in **Section 3.3**.

3.1.3 Bus Rapid Transit

Bus Rapid Transit (BRT) is a bus-based transit mode that includes many physical and operational elements that give them higher capacity, better performance and a stronger image than regular buses (Vuchic, 200, pg 69). Some of these features include:

- Reserved or segregated rights-of-way;
- Clearly designated stops, spaced 300 to 500 m apart;
- Regular or articulated buses with a distinct appearance;
- Good riding comfort and multiple-door boarding and alighting; and
- Frequent and regular service provided throughout the day

The performance of BRT operations depends mostly on the enforcement of bus priority along the right-of-wa (ROW) in which the buses operate. BRT has been used to classify limited-stop bus operations in mixed-traffic, to bus operations along segregated ROW's such as busways or bus tunnels. Operating speeds for BRT also vary depending on the ROW. BRT services in mixed traffic operations can be subjected to delays and offer speeds that are not much greater than regular bus services, in the range of 8 km/h in congested areas to 20 km/h, (Vuchic, 2007, pg 264, 286). However, BRT operations on exclusive ROW's can offer operating speeds similar to that of rail transit, ranging between 50 to 70 km/h, (Vuchic, 2007, pg 286).

BRT systems require less capital investment than rail transit, with construction costs ranging between $8 an $20 million per km along routes where reserved ROW's are considered, (Vuchic, 2007, pg 287). Constructi costs may be even lower if no segregation from other motor-vehicles is provided. This however, will reduce the performance of BRT operations. The introduction of grade-separated features on BRT lines can also increase BRT construction costs to prices that are comparable to rail transit.

Regional applications of BRT systems are provided in **Section 3.4**. Since the focus of this project is to examine high-performance, high-speed, rapid transit systems, the BRT systems reviewed in this study only include those with these characteristics. BRT systems with significant lengths of mixed-traffic operations were not included in the literature review.

3.2 APPLICATIONS OF REGIONAL HEAVY RAIL TRANSIT

3.2.1 Bay Area Rapid Transit – San Francisco Bay Area, USA

The Bay Area Rapid Transit (BART) system is a heavy-rail regional rapid transit network serving the City o San Francisco and the Bay Area in California, USA. The Bay Area comprises of 101 cities, has a land area o over 7,000 square miles (18,130 km2) and is home to 7.1 million people.[8]

The BART concept was formed to create a high-speed rapid rail network, linking major commercial centres and suburban sub-centres in the Bay Area. The intention was to reduce traffic congestion in the area and

[8] Bay Area Vision Project, Retrieved on 2 July, 2008 from the San Francisco Bay Area Vision Project website at www.bayareavision.org/bayarea/index.html

prevent total dependence on automobiles and freeways for transportation.[9] The BART system first opened in 1972 and today operates 5 lines for a total route length of (167.4 km), with service provided in most major cities in the Bay Area. BART's current system map (2008) is illustrated in **Figure 2.** An image of a typical BART train is illustrated in **Photograph 1.**

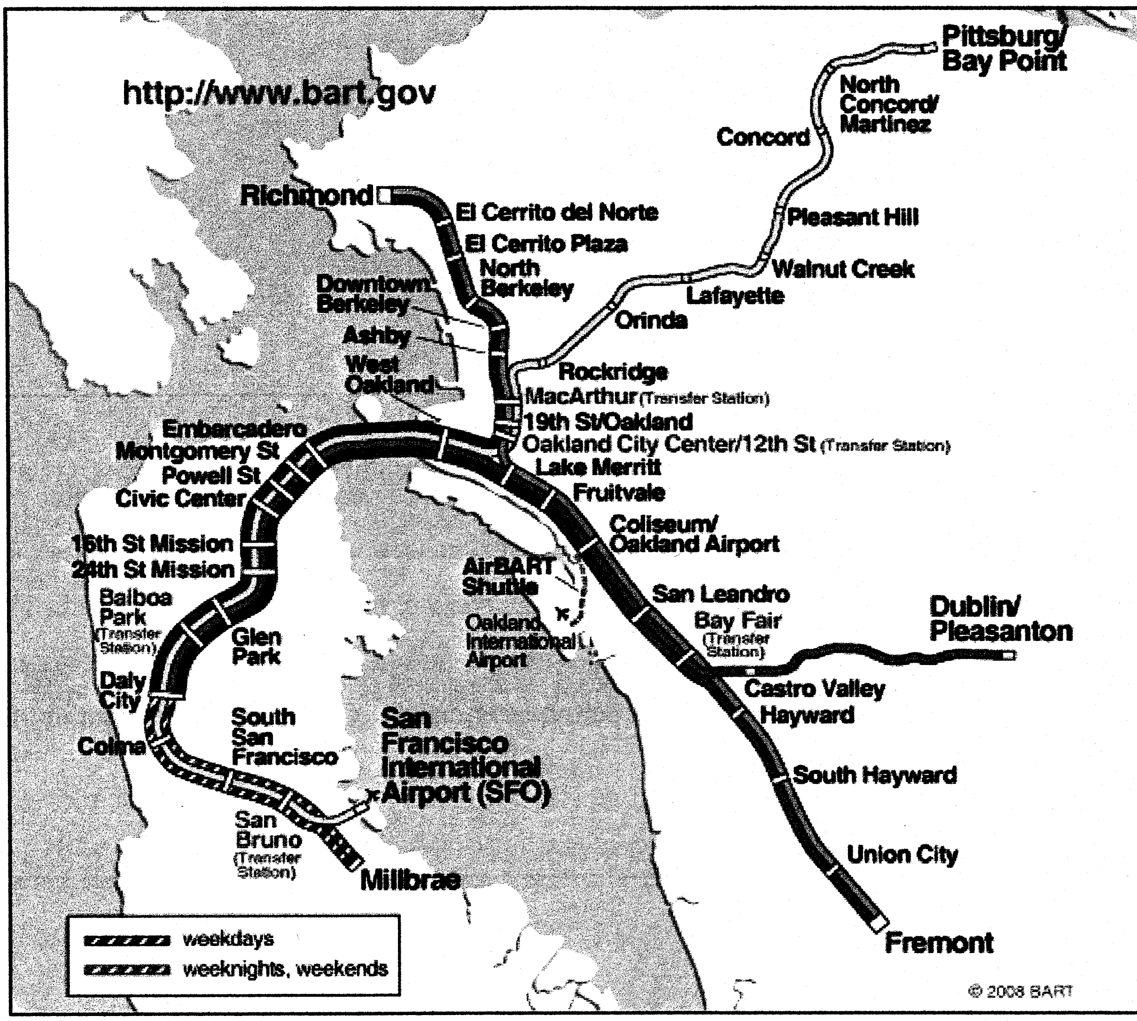

Figure 2: BART System Map

[9] BART A History of BART: The Concept, Retrieved on 2 July, 2008 from the Bay Area Rapid Transit website at www.bart.gov/about/history/index.aspx

Photograph 1: BART Train

The BART system is a mix between a suburban commuter rail network and an urban metro-type system. The trains used on the BART system can reach a maximum speed of nearly 130 km/h).[10] Trains on each of BART's 5 lines run a 15 to 20 minute intervals; however, in sections where different lines overlap, such as in San Francisco where 4 lines are interlined, train frequencies are between 2 – 3 minutes during peak hours. Because of this network configuration, BART can provide both high-frequency service in densely populated urban areas of the City, similar to that of an urban metro or subway line, and regular but not-as-frequent service suitable for the low-density suburbs, similar to that of a commuter rail line.

BART trains are automated, but drivers are still present aboard them. Train lengths vary between 3 and 10 cars. A 10 car train is capable of carrying up to 1,500 passengers at crush load.[11] BART has an average weekday ridership of approximately 355,000 people as of 2007.[12]

Due to a high average operating speed, the fact that the entire network is grade separated and the frequency of trains, the BART system can be classified as a regional rapid transit system.

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[10] BART System Facts, Retrieved on 2 July, 2008 from the Bay Area Rapid Transit website at www.bart.gov/about/history/facts.aspx

[11] Ibid

[12] BART quarterly weekday average exits, Retrieved on 2 July, 2008 from the Bay Area Rapid Transit website at www.bart.gov/docs/station_exits_quarterly.pdf

The initial cost to construct BART was $1.6 billion dollars in the late 1960's which would equate to over $15 billion dollars today.[13] With $275,124 in revenue received, to total annual operation loss was $298,063.[14] BART's farebox recovery ratio (which is the amount of revenue generated through fares) is 53% with the remainder of funding coming from other sources such as taxed, advertising, parking fees and government subsidies.[15]

Despite having the BART system, traffic congestion still exists in the Bay Area. However, a report completed by transportation researchers at the University of California, Berkeley indicated that if BART service were not available in, drivers would likely spend one to two hours on City streets just to get to the freeway, traveling at speed's as low as 2 mph, (3 km/h).[16] BART has helped to limit future traffic congestion in the Bay Area by providing a non-auto alternative to commuters.

The BART was a very expensive system to construct and is also very expensive to operate. Lost revenues due to the high operation costs of the system require the need for government subsidies to keep the system in operation. Although traffic congestion still exists in the Bay Area, it would be significantly worse if the BART system were not in operation.

3.2.2 Réseau Express Régional (RER) – Paris Métropolitain Area, France

The Réseau Express Régional (RER) is a heavy rail rapid transit system that serves the Paris metropolitan area, or Paris unité urbaine. The City of Paris has a population of approximately 2.2 million people, while the Paris metropolitan area has a population of approximately 10 million people.[17]

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[13] BART System Facts, Retrieved on 2 July, 2008 from the Bay Area Rapid Transit website at www.bart.gov/about/history/facts.aspx
[14] Financial Highlights: Statements of Revenues, Expenses and Changes in Net Assets
[15] BART 2005 Annual Report, Retrieved on 2 July, 2008 from the Bay Area Rapid Transit website at www.bart.gov/docs/AR2005.txt
[16] New Report finds "traffic nightmare" if BART service knocked out, Retrieved 2 July, 2008 from the UC Berkeley News (Oct 12, 2004) at www.berkeley.edu/news/media/releases/2004/10/13_BART.shtml
[17] Recensement de la Population Française Mars 1999, Aire Urbaine : Paris, Retreived on 10 July, 2008 from the Recensement de la Population Française website at www.insee.fr/fr/nom_def_met/definitions/html/aire-urbaine.htm

The RER is a combination of a modern city-centre subway and a regional commuter rail network in that it operates mainly underground within the city centre providing high-frequency service, but also connects directly to existing suburban regional lines. The RER network operates 5 lines and is currently over 587 km long with 257 stations. The current RER system map is illustrated in **Figure 3.** Underground and abovegrou illustrations of RER trains are shown in **Photograph 2** and **Photograph 3.**

Photograph 2: RER Train operating in Paris City Centre

Photograph 3: RER Train operating in Paris Suburbs

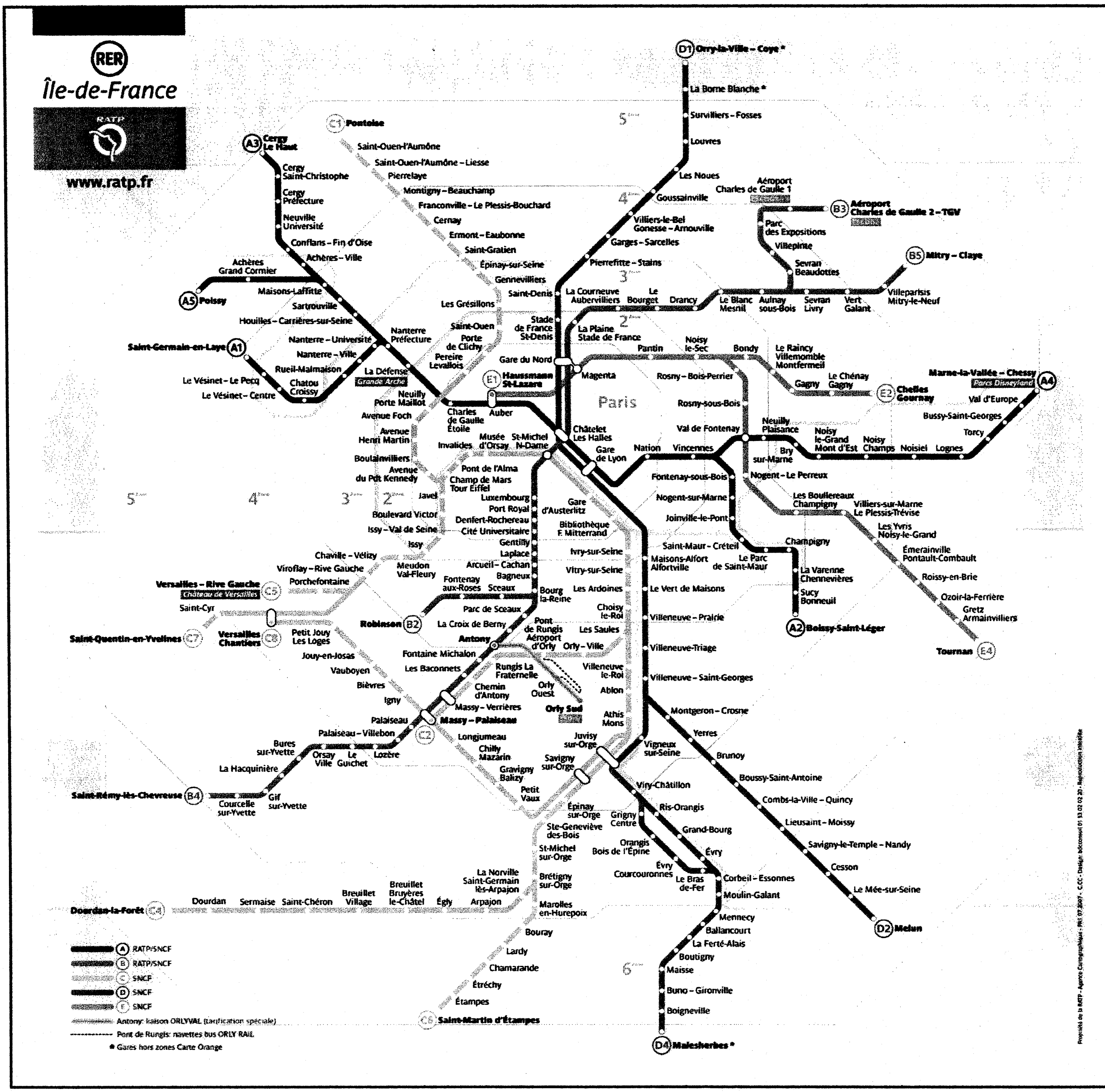

Figure 3: RER System Map

The entire RER network operates on its own right-of-way with some grade-level crossings outside of the City Centre. Within the City of Paris, most of the RER network is underground. RER uses high speed electric trains as some of its network is shared with France's Societe Nationale des Chemins de fer Francais (SNCF) rail network, which is a high-speed intercity rail network serving the entire country of France. Trains on the SNCF network are capable of speeds in excess of 560 km/h, although RER trains do not typically reach thos speeds.

The RER acts an "express" metro within the City of Paris. Because there are a limited number of stops withi the City Centre when compared to the Paris Metro, [18] passengers can travel across the City at much higher speeds than those offered by the Paris Metro or other surface transit.

Trains headways range between 10 and 20 minutes during peak hours, however, within the City Centre whe many of the lines converge, a train may arrive every 2 minutes.[19] Because of the high-speed and frequent service provided on many segments of the RER network, it can be classified as a rapid transit network.

The first segments of the RER opened between 1969 and 1977 at tremendous costs. In 1973, 2 billion franc were ($0.5 billion CAD) were allocated to the project alone.[20] This would equate to nearly 9 billion francs o $4.2 billion CAD in 2005. The high-cost can be attributed the deep tunnels and "grand" stations used to buil routes through the City Centre. Many stations within the City Centre were built entirely underground, and were built to much-higher standards in terms of "spaciousness" than typical underground railways. For example, three stations on the system, Etoile, Auber and Nation cost over 8 billion francs to construct, ($3.7 billion CAD).[21] Nation station is illustrated in **Photograph 4.**

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[18] Paris Metro is an urban subway network that provides local service within the City of Paris.
[19] Based on RER train schedules effective July 14, 2008 retrieved from the RER website www.metro.ratp.fr
[20] RER (Réseau Express Régional) – Retrieved July 14, 2008 from www.en.wikipedia.org/wiki/RER#cite_note-0)
[21] Ibid

Photograph 4: Nation RER Station

As shown in *Photograph 4,* underground stations are very spacious thus resulting in very high excavation costs.

Despite the high cost of construction, the RER is considered a success by many because of the high ridership on the system. Lines A for example, the busiest line in the network, exceeded ridership expectations and during peak hours carry up to 55,000 passengers per hour.[22] Double-decker trains have been used on some routes in the system since 1998, and today are at crush capacity during peak hours. High ridership can also be attributed to the fact that RER offers direct, fast and frequent service from some of Paris's furthest suburbs, directly in to the City Centre. Therefore, many passengers use the system for commuting and leisure trips. The annual ridership on RER's A and B lines was 452 million in 2006, and 657 million for joint RER and SCNF routes.[23]

Significant capital costs were involved in constructing the RER network. However, the system can be viewed as a success due to the high ridership levels on the system. It can be assumed that so many people use the

[22] RATP figures for 1992, cited in Gerondeau C, 2003, p61
[23] Les Transports en commun, edition 2005-2006, Retrieved 26 August, 2008 from the City of Paris website at www.paris.fr/portail/viewmultimediadocument?multimediadocument-id=31277

RER system because of the convenient, direct service it provides to destinations within the Paris City Centre and surrounding suburbs.

3.2.3 CityRail – Sydney and New South Wales, Australia

The City Rail network is a suburban rail network serving the City of Sydney and the New South Wales regio in Australia. The population of New South Wales, including the City of Sydney was 6.9 million people in 2007.[24] Today, City Rail operates approximately 2,300 services each weekday, carrying around 900,000 passengers daily.[25] The network consists of 11 suburban lines, 4 Intercity lines and 1 regional line,[26] serving 302 stations and consisting of 2,060 km of track.[27]

The first segments of the City Rail network were constructed in the 1850's and quickly expanded thereafter. Today, City Rail provides frequent service between Sydney and Newcastle to numerous suburban areas throughout New South Wales, with less frequent service provided to rural and intercity destinations.

The City Rail network is a combination of an intercity railway, a suburban commuter railway and an urban metro-style underground railway. Service is provided on some routes to urban areas over 160 km from Sydney. Suburban rail lines converge closer to the Sydney City Centre providing more frequent service with the City. In the City Centre, nearly all routes converge and operate in underground tunnels, providing high-frequency metro-like service in the downtown core. The City Rail network map is illustrated in **Figure 4.** Photographs of City Rail trains in the suburban areas of Sydney and in the underground sections in the City Centre are illustrated in **Photograph 5** and **Photograph 6** respectively.

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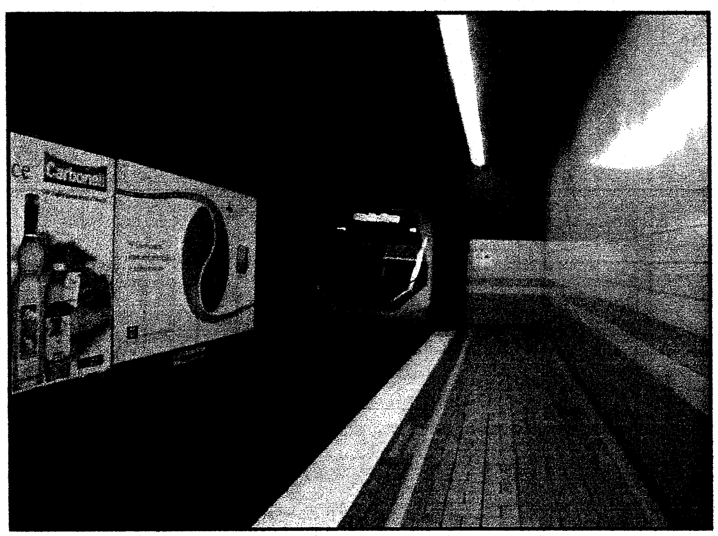
[24] 3101.0 – Australian Demographic Statistics, Dec 2008, Retrieved 14 July, 2008 from the Australian Bureau of Statistics websit at www.abs.gov.au/ausstats/abs@.nsf/mf/3101.0
[25] We help People and Organisations to Grow": State Rail Authority of N.S.W., Australia, Retrieved on 10 July, 2008 from The Growth Connection website at www.growconnect.com.au/programs/intro.html
[26] City Rail Timetables, Retrieved on 10 July, 2008 from the CityRail website at www.cityrail.nsw.gov.au/timetable/index.jsp
[27] We help People and Organisations to Grow": State Rail Authority of N.S.W., Australia, Retrieved on 10 July, 2008 from The Growth Connection website at www.growconnect.com.au/programs/intro.html

Photograph 5: CityRail Train in the Suburbs



Photograph 6: CityRail Train in the Sydney City Centre

In the City Centre and inner suburban areas of Sydney where multiple routes overlap, high-frequency service is available, especially during peak periods where train headways average every 2 – 3 minutes. City Rail operates 11 different types of rolling stock its fleet. All trains in City Rail's fleet are high-capacity vehicles with seating capacity of 77 to 115 seats per car. [28] Therefore a 10 car train can carry over 1,000 passengers. City Rail trains are capable of reaching speeds over 100 km/h. Trains operate on their own private right-of-way, with some passenger rail services shared with freight lines. Although the network completely segregated from other modes of transport, grade-level crossings do exist along some routes.

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[28] CityRail's fleet, Retrieved on 14 July, 2008 from the CityRail website at www.cityrail.nsw.gov.au/aboutus/trains/index.jsp

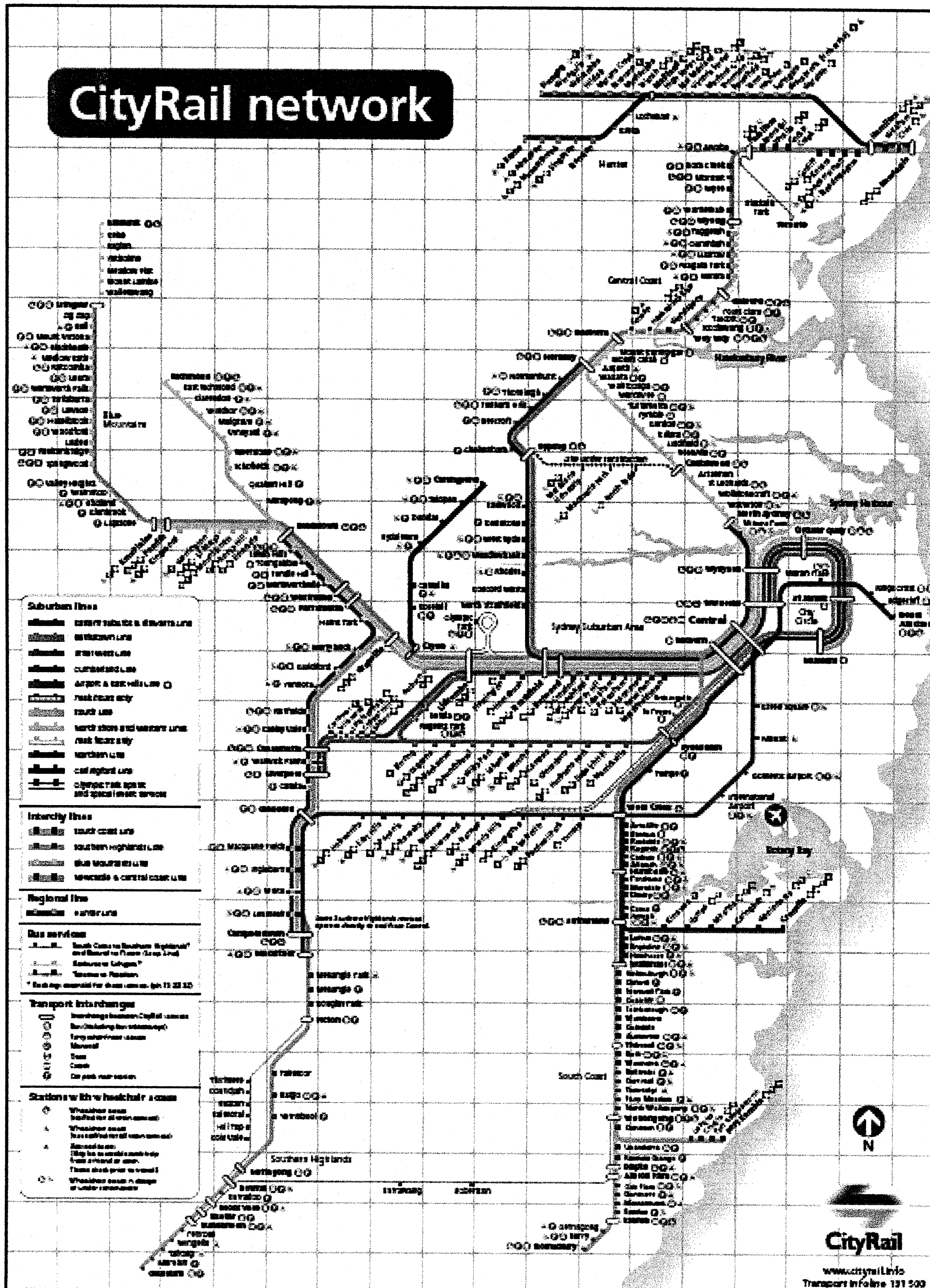

Figure 4: City Rail Network Map

Although City Rail carries close to 1 million passengers on a typical weekday, there have been some noted problems with the system. Because of City Rail's numerous overlapping services including a combination of regional, suburban and metropolitan (inner city) services, and the fact that these services are mixed with freight operations, the result is a very complex and "tangled" rail network.

Schedule-adherence is an ongoing problem for City Rail. A study conducted by Rail experts from Hong Kong in 2007 compared the efficiency, cost-effectiveness, reliability and maintenance of City Rail to other metro systems around the world. The results showed that City Rail was behind every other city compared. [29] Key findings from the study were:

- Trains travelled on average 32 km before getting delayed more than five minutes;
- Operating costs were \$6.70 per passenger, compared to \$0.98 and \$0.69 per passenger in Europe and Asia, respectively; and
- The cost of running a Sydney train station was four times the international average.

A large amount of funding for City Rail comes from taxpayer money. According to a report released by the New South Wales Government Ministry of Transport in 2003, the funding for City Rail from taxpayers is equivalent to one-fifth of the New South Wales government annual health budget.[30] Over \$2 billion per annum would be required to maintain and improve the current network, while even more would be required to extend the network to any significant degree. [31] The current arrangements are not delivering the most appropriate transport solutions to best meet the needs of the broad community and taxpayers are not getting the best possible value from the large amounts of money being spent annually on public transport. [32]

A report completed by RailCorp in 2007, the company that owns and operates City Rail, came up with the following findings:

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[29] "Aussie train services 'among world's worst'", Retrieved on 14, July, 2008 from the News from Australia website at www.news.com.au/story/0,23599,21418282-2,00.html

[30] Ministerial Inquiry into Sustainable Transport in New South Wales – Final Report Overview and Recommendations, Retrieved on 14 July, 2008 from the New South Wales Government – Ministry of Transport website at www.transport.nsw.gov.au/inquiries/parry-final-report.html

[31] Ibid

[32] Ibid

- On-time running increased from 57% in 2005 to 92% in 2006, following the introduction of a new timetable;
- $825.5 million in income from operating activities was received during the 2006-2007 year, an increase of $54 million or 7% on the prior year;
- Government contributions to the operation of the network totaled $1.48 billion. The proportion of the operating cost of the railway met by the traveling public has continued to decline; and
- Customer satisfaction has increased by 26% in 2006 when compared to a 2005 study.[33]

The results of the RailCorp study indicate that some measures have been taken to improve the on-time performance of the system, such as the introduction of a new timetable, and customer satisfaction has increased. However, a more detailed analysis of the methodology used to determine customer satisfaction would be recommended to see how the results from both studies were actually determined.

In summary, CityRail is a very extensive regional rail network serving the Sydney Area and New South Wales. Rail lines extend to many populated areas throughout the entire region. However, the complexity and high operational-costs of the network have contributed to low service-quality, below standards of other metro systems throughout the world.

3.3 REGIONAL APPLICATIONS LIGHT RAIL TRANSIT SYSTEMS

3.3.1 C-Train – Calgary, Canada

The "C-Train" is an LRT network serving the City of Calgary located in Alberta, Canada. The City of Calgary is 726.5 km^2, [34] while the metropolitan area of Calgary has a population of 1.1 million people.[35]

The concept for the C-Train was developed in the late 1960's (McKendrick et al, page 10) as part of a balanced plan for freeways and heavy-rail transit corridors for the City of Calgary to accommodate future

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[33] Rail Corporation New South Wales, Annual Report 2006-2007, "Our Operational Performance", pg-12
[34] 2006 Community Profile: Calgary, Alberta Metropolitan Area, Retrieved 14 July, 2008 from the Statistics Canada website at www.statcan.ca
[35] Ibid

growth in the City (Hubbel, J. and Colquhoun, D, page 3). However, at the time, Calgary had a population under 500,000 people and it was determined that the City could not support a heavy rail system. Therefore a more intermediate-capacity, surface-running mode was explored and LRT was selected as it offered the most advantages over bus-based transit.

The first segment opened in 1981. Today, the C-Train is 44.9 km in length with 2 routes and 37 stations.[36] Routes and stations are strategically located to connect major suburban residential and business districts with the downtown core. Trains operate in either the median of major arterial roads or on segregated ROW's and short tunnels outside of the City Centre. Trains along a 2 km stretch within the City Centre operate in a "transit-mall" sharing the road with buses and emergency vehicles.[37] The C-Train system map is illustrated in **Figure 5.** Photographs of the C-Train operations in the City Centre and along a separated ROW outside of the City Centre are provided in **Photograph 7** and **Photograph 8** respectively.

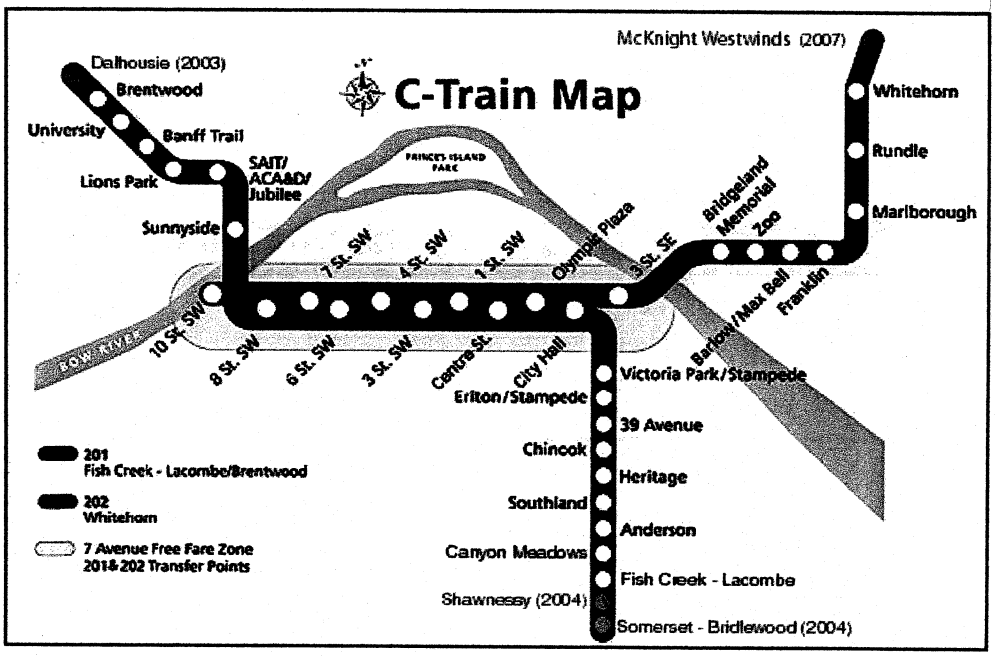
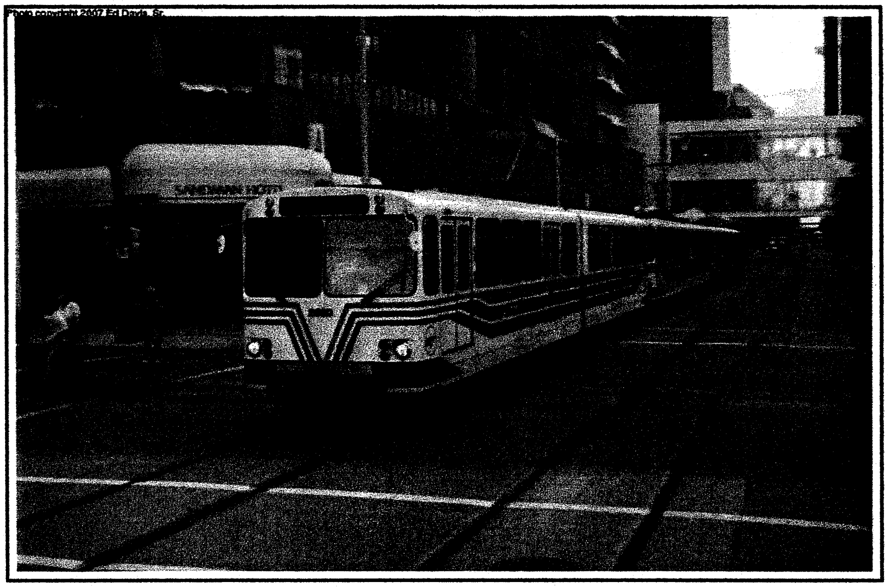
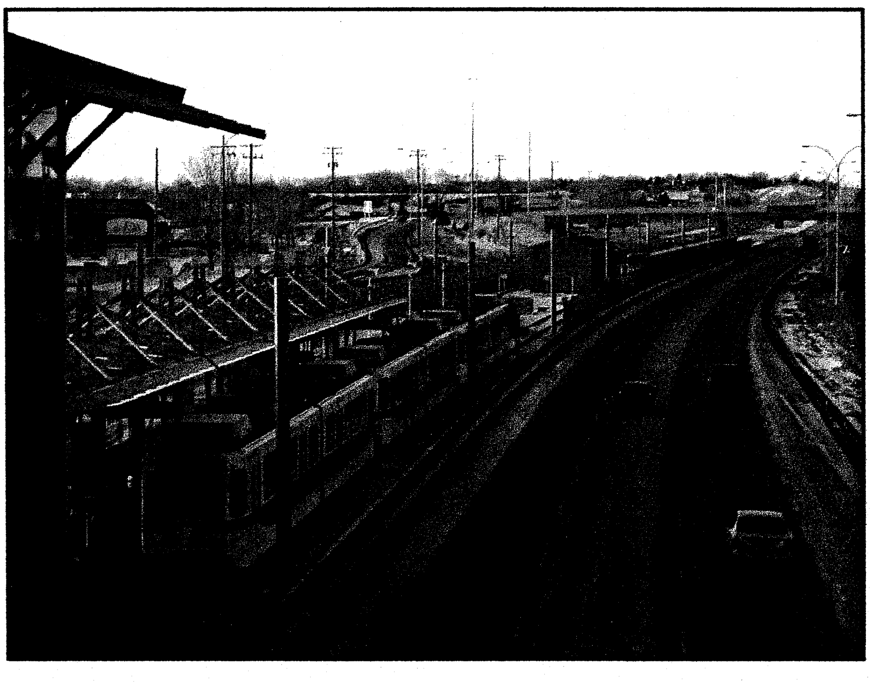


Figure 5: C-Train System Map

[36] LRT Technical Data, Retrieved 14 July, 2008 from the Calgary Transit website at www.calgarytransit.com/html/technical_information.html
[37] Ibid



Photograph 7: C-Train Operating in City Centre Transit Mall



Photograph 8: C-Train Operating in Segregated ROW in suburban Calgary

The C-Train network cost approximately $446.2 million dollars (in year 2000 US dollars) to construct or $15.2 million per kilometer, and ranks in the top third of LRT systems on the basis of lowest capital cost p mile, (McKendrick et al, Table 1: Capital Cost Comparison of Light Rail Systems, page 8).

C-Trains are typically 2 to 3 cars in length. Each car is designed to carry up to 200 people; therefore a 3 car train can carry 600 passengers. Trains typically run every 2 to 4 minutes during peak hours and every 10 to 15 minutes during off-peak hours.[38] The system is currently designed to carry 14,650 passengers per hour.[39] In the future, it is proposed that 4 car trains will be used which will increase the passenger carrying capacity to over 19,000 passengers per hour. The average operating speed throughout the network is 30 km/h. Because of the high-frequency service, fast operating speeds and high capacity provided, the C-Train network can be classified as a rapid transit system. C-Train carries 248,200 passengers on a typical weekday;[40] making it the most used LRT system in North America (McKendrick et al, page 15).

The high ridership on the C-Train shows that the LRT has had significant impacts on travel throughout the City of Calgary. The LRT system has contributed to significant benefits to the city's urban form and reduced the need for additional roads. The C-Train carries 42 percent of Calgary's 112,000 downtown workers, (McKendrick et al, page 7).

3.3.2 MTS Trolley "San Diego Trolley" – San Diego Metropolitan Transit System (MTS)

The MTS San Diego Trolley is an LRT network serving the City of San Diego and San Diego County located in California, USA. The City of San Diego has a population of approximately 1.3 million people while the San Diego County has a population of nearly 3 million people.[41] San Diego County has an area of over 10,000 km^2. The concept for a regional transit system began in 1966 to address long-term transportation issues in the county. Many options were considered, such as building a heavy rail transit system, similar to the BART, or an express bus system on freeways. Little progress was made until 1976 when the MTS was created. They developed criteria for any rapid transit line, indicating that:

- a corridor should offer high-speed service;
- Should have low capital costs;
- Should be at-grade with mostly exclusive and existing rights-of-way; and

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[38] Calgary Transit C-Train schedule, Retrieved 14 July, 2008 from the Calgary Transit Website at www.calgarytransit.com
[39] LRT Technical Data, Retrieved 14 July, 2008 from the Calgary Transit website at www.calgarytransit.com/html/technical_information.html
[40] Ibid
[41] San Diego (city) Quick Facts from the US Census Bureau, Retrieved 20 July, 2008 from the US Census Bureau State & County Quick Facts website at www.quickfacts.census.gov/qfd/states/06/0666000.html

- Operating deficits should be minimized.

An existing freight line between San Diego and the US/Mexican border was selected as the first route for th system. Since it was an existing rail corridor, construction costs for a new rapid line along the same route would be minimal. LRT technology was selected as it could operate shared services with freight trains alon the same route. Other alternatives, such as a heavy rail transit system were deemed as too expensive, while other modes would not meet the needs of the region.

The first segment opened in 1981 between San Diego and the US/Mexican border at a cost of $86 million U Today, the San Diego Trolley network is 86 km in length with 3 routes and 53 stations.[42] The system links residential areas east and south of the city with offices in the downtown core. Service is also provided to major universities and stadiums in the region. However, outside of the downtown core, trolley stations are n located near expanding office centres. Most suburban office developments to the north of the City are out o the trolley's reach.[43] Trains operate mostly on exclusive rights-of-way at grade, with some segments operat in reserved lanes in the median of major arterial roads, with a few elevated and tunneled sections. The San Diego Trolley system map is illustrated in **Figure 6.** Photographs of San Diego Trolley trains in operation o various rights-of-way found throughout the system are illustrated in **Photograph 9, Photograph 10 and Photograph 11.**

[42] San Diego Trolley Fact Sheet, Retrieved 20 July, 2008 from the San Diego Metropolitan Transit System website at http://www.sdmts.com/Trolley/TrolleyFactSheet.asp

[43] [43] San Diego Trolley "Overview: Transit System Characteristics", Retrieved 20 July, 2008 from www.ci.seattle.wa.us/transportation/SAP/TOD_Case_Studies/SanDiego_Trolley.pdf

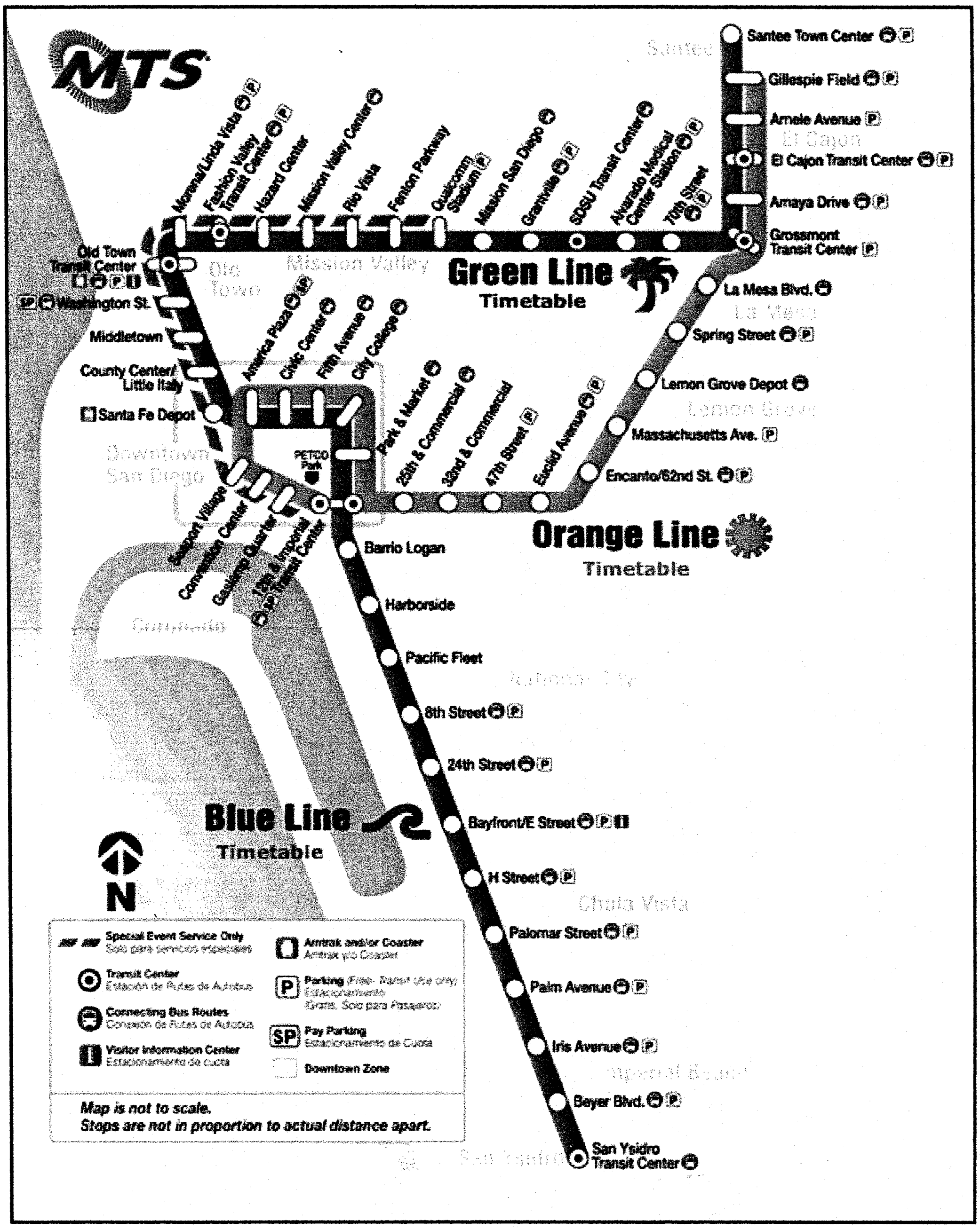
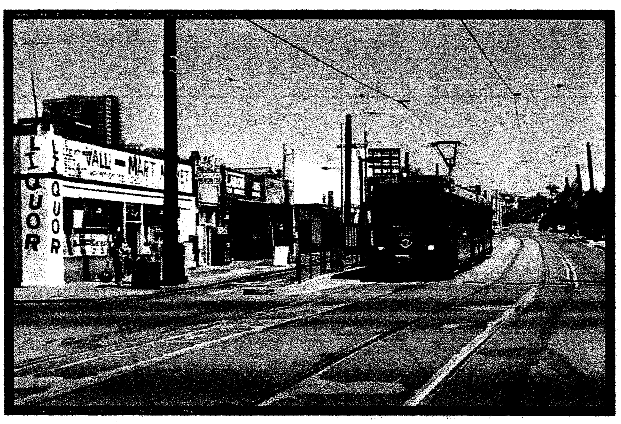


Figure 6: San Diego Trolley System Map

Photograph 9: San Diego Trolley in Operation along a Freight Line



Photograph 10: San Diego Trolley in Operation in a Reserved Lane

Photograph 11: San Diego Trolley in Operation at an Underground Station

The total capital cost for the San Diego Trolley network was approximately $776.4 million dollars (in year 2000 US dollars), (McKendrick et al, Table 1: Capital Cost Comparison of Light Rail Systems, page 8). San Diego Trolley trains are 1 to 4 cars in length. Each car can carry between 100 – 120 passengers.[44] Crush load capacity is 150-163 passengers.[45] Trains operate every 7.5 to 15 minutes during peak period, with 15 minute service provided throughout the rest of the day and 30 minute service in the late nights.[46] The system carries between 100,000 to 110,000 average weekday riders, with 35.1 million riders carried in the 2007 fiscal year.[47] Trains can reach a maximum speed of 90km/h. Average operating speeds throughout the network are 30 km/h. Because of the high-frequency service, fast operating speeds and high capacity provided, the San Diego Trolley network can be classified as a rapid transit system.

Construction of the trolley lines have resulted in additional development and the resurgence of communities served along LRT routes,[48] although most major redevelopment has occurred in the downtown core, (Dyett, M, and Bhatia, R. et. Al, page 81). It is currently the sixth most ridden LRT network in the United States.[49] Although ridership is respectable when compared to other light rail systems in the USA, some flaws with the network include the lack of direct connections to office, employment centres and central business districts outside of the downtown core. Providing these connections would most likely attract more riders. However, direct connections to such areas is difficult since San Diego trolley routes typically utilize existing private rights-of-way such as freight rail corridors and greenspaces which are typically not directly adjacent to built-up areas. The reason for this is constructing LRT lines along existing rights-of-way is relatively cheap. More expensive construction methods such as tunneling would be required to provide direct access to other urban centres.

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[44] San Diego Trolley Fact Sheet, Retrieved 20 July, 2008 from the San Diego Metropolitan Transit System website at http://www.sdmts.com/Trolley/TrolleyFactSheet.asp
[45] Ibid
[46] Ibid
[46] San Diego Trolley Schedules, Retrieved 20 July, 2008 from the Transit 511 San Diego website at www.transit.511sd.com
[47] San Diego Trolley Fact Sheet, Retrieved 20 July, 2008 from the San Diego Metropolitan Transit System website at http://www.sdmts.com/Trolley/TrolleyFactSheet.asp
[48] "After 25 years, the trolley keeps on moving", Retrieved 20 July, 2008 from the San Diego Union Tribune website at www.signonsandiego.com/uniontrib/20060723/news_1m23trolley.html#
[49] San Diego Trolley Fact Sheet, Retrieved 20 July, 2008 from the San Diego Metropolitan Transit System website at http://www.sdmts.com/Trolley/TrolleyFactSheet.asp

3.3.3 Tyne and Wear Metro – Tyne and Wear, United Kingdom

The Tyne and Wear Metro or "Metro" as it is simply called, is a modern light-rail system serving the Tyne and Wear region, a former metropolitan county in north east England with a population of approximately 1. million people, (Schwandl, R., page 136). Although technically a light rail system, the metro exhibits characteristics of a heavy rail underground urban metro and of high-speed suburban railroads. The entire network operates on its own exclusive right-of-way, separate from all other road traffic, although some lev crossings of roadways do exist. The majority of the network utilizes existing rights-of-way, many being former suburban railroad lines, with tunneled sections in major urban centres such as Newcastle and Gateshead.

The concept for the Metro system was conceived in the late 1960's when the existing suburban railway network serving the area had reached a desolate state (with some routes dating back to the 1850's). A stud team selected to devise a balanced program for investment in roads and public transport. It was decided to upgrade the suburban rail network into a rapid transit system with direct access into central areas. Direct access to major urban centre's such as Newcastle and Gateshead would be provided through tunnels. The b network was converted to serve the rapid transit network and car commuters were encouraged to use rapid transit to access the city centre. The rapid transit network was to also limit the growth in peak traffic flows across highly congested routes. [50] A LRT-type mode was selected as it met the two main objectives for the network (I) achieving the minimum cost consistent with safety and performance criteria; and (II) allowing system to be inserted easily in localities where rail rights of way were not readily available.[51] The vehicles used on the Metro are two-car articulated vehicles that are electrically-powered by overhead. Each articula car can seat 68 persons with standing room for 232 persons.

The first segment of the Metro network opened in 1980. By 1984, the system was carrying over 60 million passengers per year, which confirmed Metro's potential as the mainstay of a fully integrated public transpo system.[52] A social and economic impact report developed in 1985 showed that the system was succeeding i meeting the critical travel needs of the population more efficiently and attractively, offering improved level

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[50] "Nexus – History of Public Transport", Retrieved 26 July, 2008 from the Nexus website at www.nexus.org.uk/wps/wcm/connect/Nexus/Nexus/Press+office/Transport+history
[51] Ibid
[52] Ibid

of transport service and mobility.[53] The network was subsequently expanded and today it is 74.5 km long, comprising of two routes and 54 stations.[54] The network map is illustrated in **Figure 7** and Metro trains illustrated in **Photograph 12 and Photograph 13.**

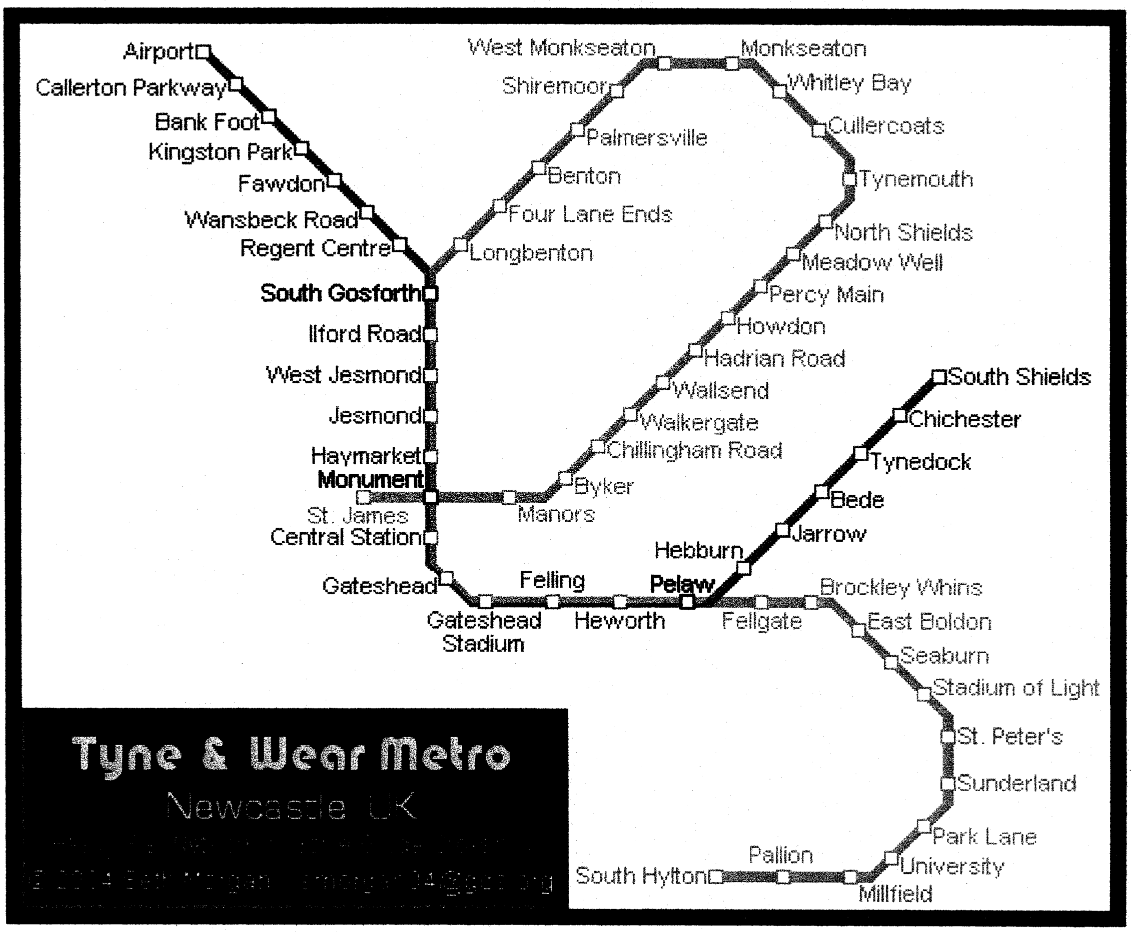
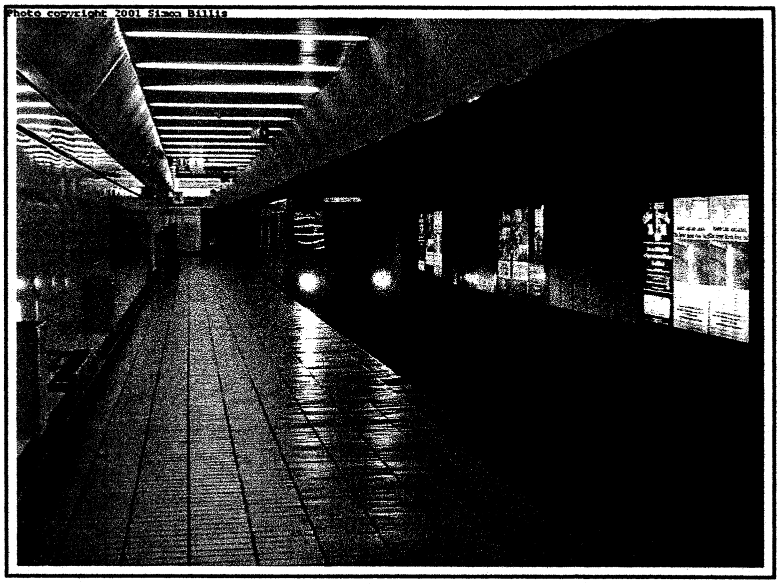
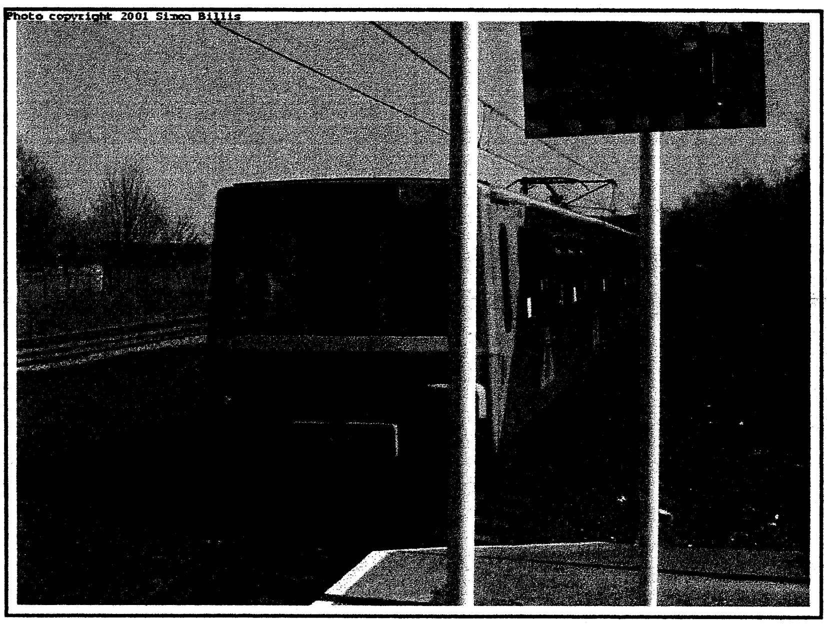


Figure 7: Tyne and Wear "Metro" Network

[53] "Nexus – History of Public Transport", Retrieved 26 July, 2008 from the Nexus website at www.nexus.org.uk/wps/wcm/connect/Nexus/Nexus/Press+office/Transport+history
[54] Ibid



Photograph 12: Tyne and Wear "Metro" train operating in an underground segment of the network



Photograph 13: Tyne and Wear "Metro" train Operating along a suburban section of track

Metro vehicles are capable of speeds of 80 km/h which are typically achieved on rural segments of the network. A base service of trains operates every 12 minutes during the day and every 15 minutes during th evenings and on Sundays on both routes. In sections where the two lines overlap, train frequency is double with service provided every 6 minutes during the day and 7 ½ minutes on evenings and Sundays, (Schwan

R., page 136). Additional service is provided during peak periods along the busiest segments of the network with trains operating every 3 minutes.[55] The average weekday ridership is 123,000 persons, with 36.6 million people using the system in 2006.[56]

Ridership is respectable throughout the system with the except for section between Park Lane and South Hylton on the Sunderland Route. This segment opened in 2002 and ridership has not met its expected targets. As a result, in 2005 train frequency along this segment was reduced to every 24 minutes as opposed to every 12 to 15 minutes, (Schwandl, R., page 149). One of the possible reasons for low ridership along this route is the alignment selected. The line utilizes a private right-of-way close to the banks of a local river and does not serve major population centres which are located further south of the transit line, by-passing the major catchment areas. Passengers bound for the City Centre for example, would have to take a local bus that goes in the opposite direction of the City Centre destination to access a Metro Station, then "back-track" on the Metro towards the City Centre. This is an awkward and inconvenient travel pattern, which may contribute to the poor ridership along this segment of the Metro.

3.4 REGIONAL APPLICATIONS OF BUS RAPID TRANSIT SYSTEMS

3.4.1 OC Transpo "Transitway" – Ottawa, Canada

OC Transpo is the public transit operator for the City of Ottawa in Ontario, Canada. The City of Ottawa metropolitan area has a population of 1.1 million people.[57] OC Transpo operates a "transitway" which is a BRT network over 60 km in length that connects Ottawa's suburban areas to its downtown core. The concept for the transitway arose in the 1970's when the city's future transportation needs were being determined. A bus-based system was selected because it was determined that the region's population, of roughly 500,000 people at the time, could not support a rail-based system.[58] The first segment of the transitway opened in 1983. Today, the transitway includes over 25 km of bus-only, two-lane, grade separated roadway, constructed

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[55] "More people choose Metro, latest figures show", Retrieved 26 July, 2008 from the Nexus website at www.nexus.org.uk/wps/wcm/connect/Nexus/Nexus/News/News+archive/2006/Nexus+news+-+More+people+choose+Metro%2C+latest+figures+show
[56] Ibid
[57] 2006 Community Profile: Ottawa-Gatineau Metropolitan Area, Retrieved 25 July, 2008 from the Statistics Canada website at www.statscan.ca
[58] Ottawa's BRT "Transitway": Modern Miracle or Mega Mirage, Retrieved 25 July, 2008 from the Light Rail Now website at http://www.lightrailnow.org/myths/m_otw001.htm

primarily on a former railroad right-of-way. At stations, the transitway widens to 4 lanes to allow for expre buses to pass local buses stopped at stations. The transitway network also includes over 35 km of reserved lanes on freeways, arterial roads and streets in the downtown core.[59] The network map is provided in **Figur 8**. The capital cost of the total transitway was approximately $435 million.[60]

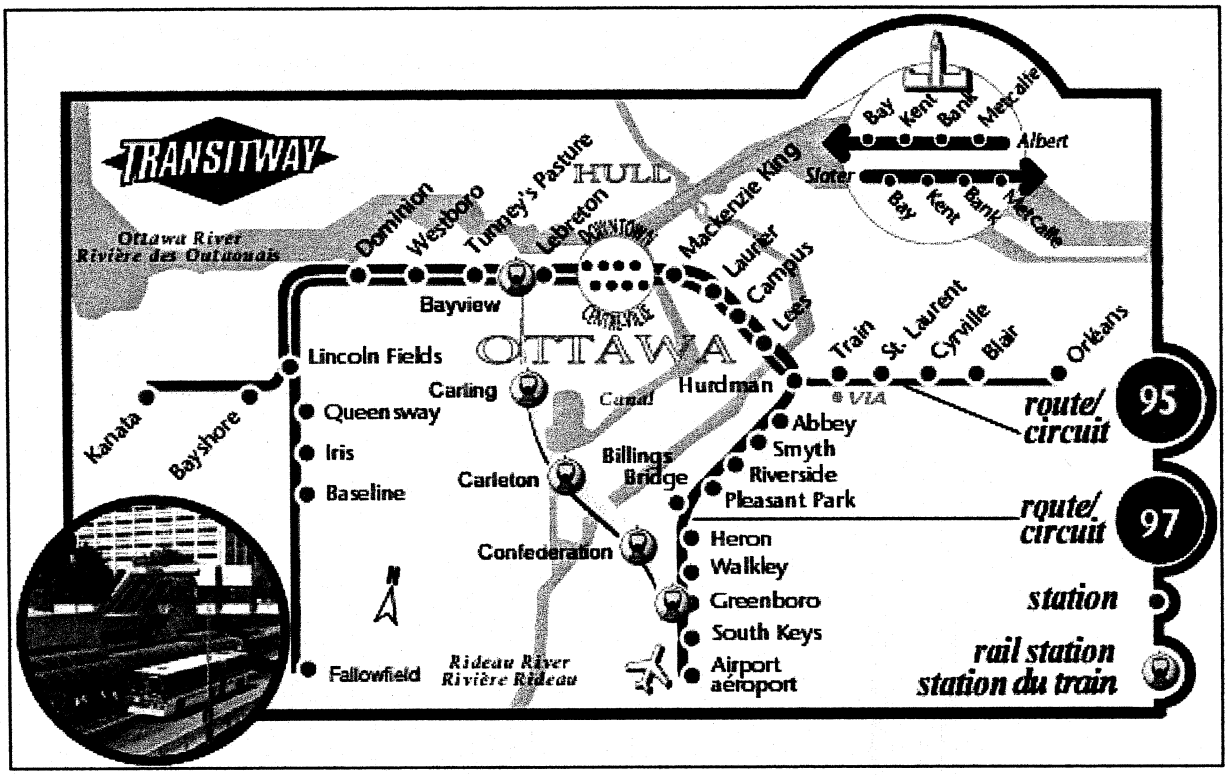

Figure 8: OC Transpo Transitway Network Map

Vehicles used on the transitway are the same as standard buses that operate on city streets, including 40 ft buses and 60ft articulated buses. An illustration of OC Transpo transitway is provided in **Photograph 14.** Most sections of the transitway have posted speed limits of 70 to 90 km/h between stations and 50 km/h in station areas. Base service on the transitway is provided by 6 major bus routes that each operate every 4 to minutes depending on the time of day. Several other city bus routes use portions of the transitway as well a peak hour express buses that operate from the suburban areas of the city with limited-stop service to the

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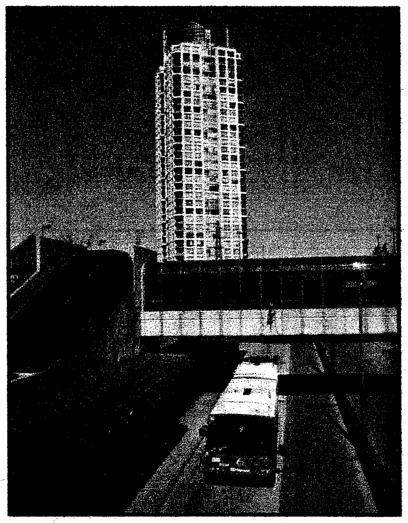
[59] Transitway (Ottawa) Description, Retrieved 25 July, 2008 from the Bus Rapid Transit Policy Center Project Database at www.gobrt.org

[60] Transitway (Ottawa) Cost, Retrieved 25 July, 2008 from the Bus Rapid Transit Policy Center Project Database at www.gobrt.

downtown core. Many of the routes that use the transitway operate on city streets in areas outside of the city centre, accessing the transitway at a suburban location, and then continuing along the transitway into the City Centre. This eliminates the need for transfers between local bus routes and transitway rapid transit lines. Over 85 different bus routes and 180 buses per hour per direction pass through the busiest segment of the transitway in the central area.[61] Combined service provides about one bus every minute, although they are all not headed to the same destinations.[62] The Transitway serves 240,000 weekday daily riders, including 10,500 peak hour, peak direction riders.[63]



Photograph 14: OC Transpo Transitway

The high ridership on the transitway would suggest that it has definitely impacted travel patterns in the city, especially into the downtown core. Over 50% of all persons who enter Ottawa's downtown core do so by the transitway.[64] Ridership levels on the transitway are higher than some LRT systems, such as the San Diego Trolley and the Tyne and Wear Metro, despite the fact that LRT is a higher-capacity mode. High ridership and high bus volumes have created problems for the system in the downtown core, since only a single reserved

[61] Facts – Transitway, Retrieved 25 July, 2008 from the OC Transpo website at http://www.octranspo.com/admin/Facts_Figures/Facts_Transitway.htm
[62] Transitway (Ottawa) Performance, Retrieved 25 July, 2008 from the Bus Rapid Transit Policy Center Project Database at www.gobrt.org
[63] Facts – Transitway, Retrieved 25 July, 2008 from the OC Transpo website at http://www.octranspo.com/admin/Facts_Figures/Facts_Transitway.htm
[64] Transitway (Ottawa) Performance, Retrieved 25 July, 2008 from the Bus Rapid Transit Policy Center Project Database at www.gobrt.org

bus lane per direction is available within the City Centre. This creates "bottlenecks" resulting in congestion related delays, scheduling problems and low travel speeds downtown.

Operating costs for this system can also be quite high when compared to other rail-based systems due to the number of buses and the number of drivers required to transport the high number of passengers using the system. Rail based systems can typically carry the same amount, or more passengers with less vehicles.

The structure of the system is also not the most user-friendly either since over 80 different bus routes can be operating on the transitway at any given time, all bound for different destinations. This can be confusing to users who may not know exact which bus to take. This also leads to increased pedestrian congestion in the downtown core as not all passengers will be boarding the next bus that arrives.

Because of the high ridership on the transitway and increased traffic congestion in the downtown core, there are now plans to eventually replace many segments of the transitway with LRT, and to construct an LRT tunnel through the downtown. [65]

3.4.2 Port Authority of Allegheny County - Busways – Pittsburg, USA

The Port Authority of Allegheny County is the public transit provider to the City of Pittsburg and surrounding area. Pittsburg and Allegheny County are located in Pennsylvania, USA. The City of Pittsburg has a population of over 312,000 while the surrounding metropolitan area has a population of 2.4 million people. [67] The Port Authority operates 3 busways in the Pittsburg area, the South Busway, the Martin Luther King Jr. East busway and the West Busway. All of the busways are served by standard buses which are capable of operating on local streets. An illustration of the Pittsburg busway is provided in **Photograph 15.**

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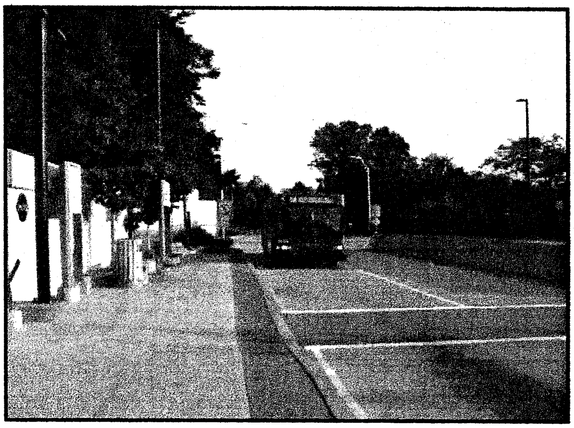
[65] City of Ottawa (2008), Transit – Rapid Transit Network Approved, Retrieved 23 August, 2008, from www.ottawa.ca/residents/public_consult/beyond_2020/tmp/transit/index_en.html

[66] U.S.Census Bureau, State & County QuickFacts – Pittsburg (city), Pennsylvania, Retrieved 16 July, 2006 from the U.S. Census Bureau website at www.quickfacts.census.gov/qfd/states/42/4261000.html

[67] Busways(Pittsburg),Performance, Retrieved 26 July, 2008 from the Bus Rapid Transit Policy Center Project Database at www.gobrt.org



Photograph 15: Pittsburg Busway

The South Busway was the first busway constructed in Pittsburg and opened in 1977 at a cost of $27 million. The busway links downtown Pittsburg to suburban neighbourhoods to the south and was constructed to bypass traffic congestion in nearby bridges and tunnels leading to the downtown core. The busway is two-lanes and is built parallel to a railroad line, utilizing a tunnel that is shared by light-rail vehicles. The busway is 4.3 miles long and has 8 stations. The busway carries 2,000 peak hour/peak direction passengers on 50 buses. Nearly 400 bus trips are made per direction per day with daily ridership at 13,000 passengers. Annual ridership is approximately 4 million riders. Express and all-stop service is provided along the busway with the average speed of express and all-stop services around 65 km/h 50 km/h, respectively. Bus trips into the downtown core are 6-11 minutes shorter than bus trips into the city before the busway was constructed.[68] The operating cost of the busway is approximately $475,000 per year. [69]

The Martin Luther King Jr. - East busway opened in 1983 at a cost of $115 million. It links downtown Pittsburg to suburban neighbourhoods east of the City. It was constructed to help alleviate traffic congestion on nearby highways where traffic would back up nearly 7 miles during peak commuting hours.[70] On its opening date, the busway was 11 km long. Before the busway opened, a trip from downtown to the area

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[68] South Busway (Pittsburg),Description, Retrieved 26 July, 2008 from the Bus Rapid Transit Policy Center Project Database at www.gobrt.org

[69] Ibid

[70] Martin Luther King, Jr. East Busway (Pittsburg),Description, Retrieved 26 July, 2008 from the Bus Rapid Transit Policy Center Project Database at www.gobrt.org

where the busway terminates would take 45 minutes. The same trip on the busway takes 15 minutes today. The East busway has since been extended and today is 15 km long with 10 stations.

The busway is two-lanes and was constructed adjacent to an active railroad line. Headways along the busw are every 12 minutes during peak periods and 12-20 minutes during off-peak periods. Both local "all-stop' and express "limited-stop" service provided. About 36 local and express bus routes operate on the East busway. Express buses travel at an average speed of 40 mph while local all-stop buses travel at 30 mph. Nearly 30,000 weekday riders use the East Busway, with 5,400 morning peak hour/peak direction riders carried by 110 buses. Pre-busway and post-busway travel times have reduced by 41 to 44% or an average t savings of 3.1 to 3.5 minutes per mile. [72] Annual operating costs for the East Busway are approximately $724,000, or $107,000 per mile.

The third busway constructed in Pittsburg was the West Busway which connects downtown Pittsburg to th western Allegheny County neighbourhoods and the Pittsburg International Airport. The West Busway is a exclusive bus-only roadway constructed along an abandoned railroad right-of-way. The busway has both t lane and four-lane cross-sections along its route to permit the passing of buses stopped at stations. The busway also utilizes a former 148 year old rail tunnel that was rehabilitated and refurbished to accommoda buses. [73] The west busway opened in 2000 at a cost of $275 million, with much of the cost attributed to the rehabilitation and reconfiguration of the rail tunnel.

14 bus routes operate along the West Busway, providing all-stop and express service. Approximately 45 b are in service during peak periods, carrying 1,700 morning peak hour/peak direction riders.[74] Weekday ridership is about 9,000 riders with 40,000 riders carried each week. The average travel speeds along the

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[71] Martin Luther King Jr. East Busway, Retrieved 26 July 2008, from the Pittsburgh Highways website at www.pittsburgh.pahighways.com/busways/ebusway.html

[72] Ibid

[73] West Busway, Retrieved 26 July 2008, from the Pittsburgh Highways website at www.pittsburgh.pahighways.com/busways/ebusway.html

[74] West Busway Busway (Pittsburg),Details, Retrieved 26 July, 2008 from the Bus Rapid Transit Policy Center Project Databas www.gobrt.org/db/project.php?id=109

busway are 48 km/h. Travel time savings for buses before the busway was constructed are approximately 3 minutes per kilometre.[75]

The construction of the busways have impacted the Pittsburg region by encouraging development along some of its routes. As of 1996, there were 57 developments along or near the East busway, ranging from retail office, medical and residential land uses, estimated at a total value of $302 million. Development that clustered around Busway stations accounted for nearly 58% of the total investment. [76] Ridership levels on the Pittsburg busways are within typical design thresholds for BRT systems.

3.4.3 Adelaide Metro "O-Bahn"– Adelaide, Australia

Adelaide Metro is the public transit provider for the City of Adelaide. The city and metropolitan area of Adelaide has a population of approximately 1.1 million people.[77] Adelaide metro operates the world's longest and fastest guided busway called the "O-Bahn". Buses on typical busways, such as those in Ottawa and Pittsburg, travel along dedicated travel lanes or separate roadways. The O-Bahn however, is constructed on a specially-built 20-foot wide concrete track using both elements of bus and rail systems. The route has also been designed to allow for future electrification. **Photograph 16** provides an illustration of the Adelaide O-Bahn.

The concept for the O-Bahn emerged as part of a transport blueprint developed by the Metropolitan Adelaide Transport Study in 1968.[78] The blueprint called for a network of freeways throughout the metropolitan area including one running to the northeast suburbs. However, there was much public opposition to this plan as many built-up areas would be demolished to make way for freeway interchanges and people did not want to see widespread "gridlock" observed in other cities with extensive freeway networks.

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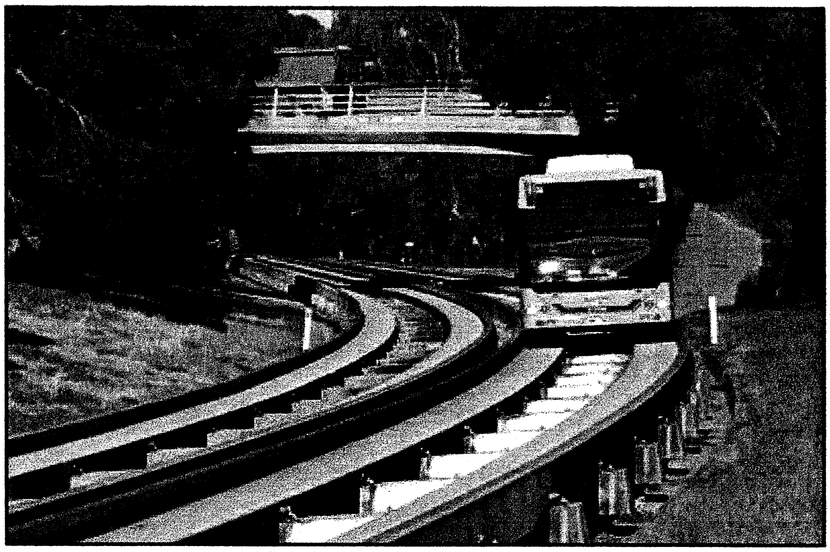
[75] West Busway Busway (Pittsburg),Details, Retrieved 26 July, 2008 from the Bus Rapid Transit Policy Center Project Database at www.gobrt.org/db/project.php?id=109

[76] Martin Luther King Jr. East Busway, Retrieved 26 July 2008, from the Pittsburgh Highways website at www.pittsburgh.pahighways.com/busways/ebusway.html

[77] Adelaide O-Bahn, Performance, Retrieved 27 July 2008 from the Bus Rapid Transit Policy Center Project Database at www.gobrt.org/db/project.php?id=54

[78] Adelaide's Freeways – A History from MATS to the Port River Expressway, Retrieved 27 July, 2008 from the Australian Roads Website at www.ozroads.com.au/SA/freeways.htm



Photograph 16: Adelaide O-Bahn

The freeway plan was subsequently abandoned and the government looked at way of improving public tra to minimize freeway construction.[79] A light-rail line was selected for the corridor connecting the northeast suburbs to the city centre and construction began in 1978. However, there was more public opposition to t light rail proposal as residents had concerns over the noise that would be generated by the vehicles. The lig rail line would also have to be tunneled beneath the city centre, increasing the capital cost of the project. Construction of the light rail line was halted, and it was decided to construct the O-Bahn. The O-Bahn was cheaper than the light rail alternative and was perceived as less noisy due to the use of rubber-wheeled vehicles on the trackway. A bus-based option also allowed for buses on suburban streets to enter the busw providing direct non-transfer service from the suburbs into the City Centre. Buses in the City Centre woul also operate on local streets, eliminating the need for the tunnel.[80]

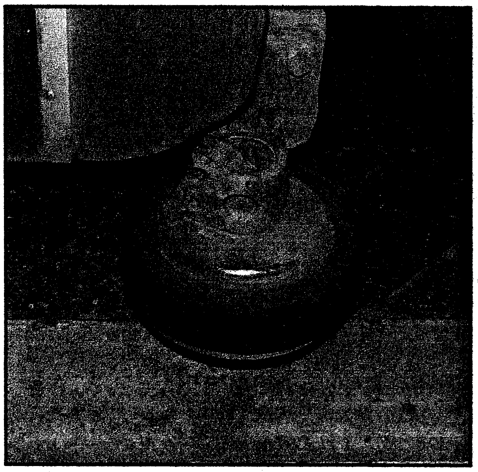
The first segment of the O-Bahn was completed in 1983, with the most recent extension being completed i 1989. The O-Bahn is 12 km long, running through parks and greenspace adjacent to a local river. It has 3 stations and connects Adelaide's central business district with the northeast suburbs. The O-Bahn cost $97

[79] Adelaide's Freeways – A History from MATS to the Port River Expressway, Retrieved 27 July, 2008 from the Australian Ro Website at www.ozroads.com.au/SA/freeways.htm

[80] Adelaide's Freeways – A History from MATS to the Port River Expressway, Retrieved 27 July, 2008 from the Australian Ro Website at www.ozroads.com.au/SA/freeways.htm

million (AU) to construct, with an additional $86.4 million (AU) required for river landscaping, which is approximately $8.2 million and $0.7 million (AU) per kilometer, respectively.[81]

Buses using the O-Bahn are fitted with special guide wheels that allow the bus to travel from a local road onto the track along the O-Bahn. The guided track allows buses to travel at speeds of up to 100 km/h.[82] The guided wheel is illustrated in **Photograph 17.**



Photograph 17: Adelaide O-Bahn Bus Guided Wheel

Eighteen bus routes use the busway, providing average headways of 50 seconds during peak hours and every 5 minutes during off-peak hours.[83] Express (non-stop), limited-stop and all-stop service is provided along the O-Bahn. Approximately 4,000 peak hour, peak direction riders are carried on the busway, with approximately 30,000 passengers carried per weekday. Ridership has increased by 75% between 1986 and 1996 with 7 million passengers carried annually.[84] The system is designed to carry 18,000 people an hour per direction.[85] Increasing ridership on the system shows that the O-Bahn is being used effectively and ridership levels are consistent with BRT thresholds. The fact that buses operate on local city streets in mixed traffic the downtown

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[81] Adelaide O-Bahn, Cost, Retrieved 27 July 2008 from the Bus Rapid Transit Policy Center Project Database at www.gobrt.org/db/project.php?id=54

[82] Adelaide O-Bahn, Performance, Retrieved 27 July 2008 from the Bus Rapid Transit Policy Center Project Database at www.gobrt.org/db/project.php?id=54

[83] Adelaide O-Bahn, Performance, Retrieved 27 July 2008 from the Bus Rapid Transit Policy Center Project Database at www.gobrt.org/db/project.php?id=54

[84] Ibid

[85] Ibid

core can cause some delays. In addition, the multiple bus routes that use to O-Bahn can lead to confusion a which bus to take, especially when heading out of the city centre as "outbound" buses serve various destinations in the north-east suburbs. However, the situation is not as complicated as Ottawa's transitway example since only 18 routes use the O-Bahn. Furthermore, during off-peak hours, many suburban bus rou terminate at stations along the O-Bahn, requiring a transfer onto "O-Bahn-only" bus routes to access the downtown core. Although the capital cost of the busway was determined was cheaper than the light rail alternative, this was mainly due to the elimination of the tunnel through the downtown core. Operating cos for the busway may also be higher than the light rail alternative due to the number of buses required to transport riders, which could be accommodated by a fewer number of higher-capacity light rail vehicles. However, fewer vehicles would lengthen headways, providing less-frequent service.

3.5 FINDINGS OF ALL TRANSIT SYSTEMS

Heavy Rail Transit can yield the highest ridership levels provided that a significant population base is pres and a network is well designed in that it directly-connects major origins and destinations in an urban area. Heavy rail systems also provide the highest quality of service when compared to LRT and BRT systems in terms of passenger comfort, speed, reliability. However, they also require the highest capital cost, typically the billion dollar range. The BART and RER systems were very expensive to construct due to the cost of tunnels and exclusive running-ways. From a regional perspective, many regional heavy rail networks cons of "bundles" of routes that diverge further away from central areas. This network structure is effective in t it can provide high-frequency service in central areas and less-frequent which is suitable in less-populated suburban areas. However, a delay to one train along a section of overlapping routes can impact the entire network. Scheduling difficulties may also arise due to the complexity of overlapping services. However, heavy rail systems are the most effective at transporting large volumes of passengers, in excess of 20,000 people per hour, per direction, quickly and efficiently.

LRT is suitable for transporting 15,000 to 25,000 persons per hour/per direction and is usually less costly t HRT systems, due to the use of smaller vehicles and its ability to share rights-of-way with other vehicles, eliminating the need for complete segregation from all other traffic. BRT systems are usually less costly th LRT systems, however when constructed along exclusive rights-of-way, the costs can be similar to LRT systems. Likewise, LRT systems constructed on existing railroad rights-of-way, such as those in San Dieg can be less costly than a BRT route. BRT systems however are typically designed to transport less than 10,000 persons per hour/per direction. Some BRT systems do have ridership levels that are consistent with LRT systems, such as Ottawa's transitway, which is now being considered for LRT conversion. Operating costs for LRT systems are typically lower than BRT systems when ridership levels are similar, since an LRT vehicle can carry more passengers than a standard or articulated bus. The trade-off however is, BRT systems can usually provide more frequent headways, such as a bus every minute, whereas LRT systems typically provide service every 5 to 15 minutes during peak periods.

For all transit modes, the most utilized transit systems, relative to the metropolitan area they served, were those that provided the most direct connections to between major residential and employment areas. Private rights-of-way are typically utilized for LRT and BRT systems operating on exclusive rights-of-way as they are less costly and less disruptive to construct. However, if stations are not strategically located in easily-accessible areas, providing convenient access to major destinations, ridership may not reach its full potential. The most utilized systems were those that penetrated directly into major urban and suburban centres.

4.0 REVIEW OF EXISTING TRANSIT SYSTEMS

Existing transit services in the GTA were reviewed to identify cross-town services that are currently provided. Route structures were reviewed to identify any deficiencies in the existing transit network in serving cross-town trips across north Toronto. System maps for all of the existing transit systems in the GTA that were reviewed can be found in **Appendix A.**

4.1 TORONTO TRANSIT COMMISSION

The Toronto Transit Commission (TTC) is the primary public transportation service provider for the City of Toronto. With nearly 1.5 million passengers carried on a typical weekday, it is the largest transit system in Canada and the third largest in North America. [86] [87] The TTC currently (as of 2007) operates 148 surface routes including 7,129.7 km of bus routes, 304.3 km streetcar lines, 61.9 km of subway lines and an Intermediate Capacity Transit System (ICTS) line known as the Scarborough Rapid Transit (SRT) which is 6.4 km long.[88]

TTC operates the following four rapid transit lines:

- The Yonge-University-Spadina Subway line;
- The Bloor-Danforth Subway line;
- The Sheppard Subway line; and
- The Scarborough RT.

The three subway routes are heavy rail transit lines while the SRT is an ICTS line. ICTS technology is similar to subway technology in that is powered by third rail, it is completely grade separates and provides speeds comparable to a subway line; however, it uses smaller vehicles and has a maximum carrying capacity of

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[86] Toronto Transit Commission Operating Statistics 2007, Retrieved on 25 May, 2008 from the TTC website at www.toronto.ca/ttc/pdf/operatingstatistics2007.pdf
[87] "Toronto transit chief says searches unlikely" Retrieved on 25 May, 2008 from the Canadian Television CTV news website at www.ctv.ca/servlet/ArticleNews/story/CTVNews/1122072619227_40/?hub=CTVNewsAt11
[88] Toronto Transit Commission Operating Statistics 2007, Retrieved on 25 May, 2008 from the TTC website at www.toronto.ca/ttc/pdf/operatingstatistics2007.pdf

approximately 20,000 passengers per hour. Subway lines typically handle approximately between 20,000 a 40,000 passengers per hour. [89]

TTC's rapid transit network radiates out of the downtown core with the Bloor-Danforth subway providing service east and west of the downtown in the southern regions of the City. The Yonge-University-Spadina subway line provides service north of the downtown core in the central area of the City. The SRT acts as a easterly extension of the Bloor-Danforth subway. The Sheppard Subway is the only subway line in Toront that does not serve the downtown core. It runs beneath Sheppard Avenue between Yonge Street and Don Mills Road in north Toronto. This line runs in close proximity and parallel to Highway 401. However, it cannot be considered a true cross-town rapid transit line as it is only 5.4 km long, while the approximate distance across northern Toronto is approximately 42 km between the Mississauga and Pickering borders.

Construction is expected to being in September 2008 for Construction on a northwesterly extension of the Spadina subway to York University and into the City of Vaughan is expected to commence in September 2008. This extension however, does not provide rapid transit service across north Toronto.

There are numerous high-frequency, local cross-town bus routes serving the north Toronto. However, these bus routes are to provide local service and cater mainly to short-distance trips along the corridor they serve and do not serve long-haul commuters traveling across the City well. Due to the frequent bus stop spacing congestion-related delays experienced on these routes, travel time across north Toronto can take up to 2 hours.[90]

Therefore, no rapid transit lines are present, or proposed by the TTC across north Toronto, and cross-town service cannot be classified as rapid transit routes since they have low operating speeds, operate in mixed traffic and are subjected to the same congestion-related delays experienced by other road users.

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[89] Parkinson, T. and Fisher, I, "Rail Transit Capacity," *TCRP Report 13* (1996): pg. xvii

[90] Based on a review of TTC's current bus schedules, Retrieved 23 July, 2008 from the Toronto Transit Commission's website a www.ttc.ca

4.2 YORK REGION TRANSIT / VIVA

York Region Transit (YRT) is a transit system servicing York Region, north of the City of Toronto. YRT operates 65 regular bus routes and 5 bus rapid transit (BRT) routes under the brand name "VIVA".[91] YRT bus routes provide local service to various destinations within the City while VIVA routes provide limited-stop service, connecting major nodes and urban centres in York Region. YRT does provide service into the City of Toronto while TTC extends some of its bus routes into York Region; however, since YRT is based in York Region, no cross-town service is provided within the City of Toronto city limits.[92]

4.3 BRAMPTON TRANSIT

Brampton Transit (BT) is a transit system serving the City of Brampton located north-west of Toronto. BT currently operates over 35 bus routes within Brampton with some services extending into the City of Mississauga, York Region and Toronto. BT's Route 77 (operated in conjunction with York Region Transit), provides cross-town service between Brampton and the TTC's Finch Subway station located in North York via Highway 7 in York Region. Although this can be considered a cross-town route, is does not operate in the vicinity of the Highway 401 corridor. It is also a local bus route with frequent stops and low operating speeds. Therefore, BT does not currently operate any rapid transit services.

4.4 MISSISSAUGA TRANSIT

Mississauga Transit is a transit system serving the City of Mississauga, located west of the City of Toronto. It currently operates 109 bus routes and is based in the City of Mississauga with some routes operating into the City of Toronto. However, Mississauga provides some regular local bus service into the Rexdale area of north Toronto; however no regional cross-town regional service provided.[93]

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[91] Based on York Region Transit's Summer 2008 system map, Retrieved 30 June, 2008 from the York Region Transit website at www.yrt.ca

[92] Based on York Region Transit's Summer 2008 system map, Retrieved 30 June, 2008 from the York Region Transit website at www.yrt.ca

[93] Based on Mississauga Transit's Summer 2008 system map, Retrieved 30 June, 2008 from the Mississauga Transit website at www.mississauga.ca/file/COM/WeekdayMap_Aug2008.pdf

4.5 DURHAM REGION TRANSIT

Durham Region Transit (DRT) operates over 50 local bus routes in the Region of Durham, located east of City of Toronto.[94] Transit operations are based in Durham Region. Only one route operates within Toronto city limits, providing rush hour service between the City of Pickering and the Rouge Hill GO Station, local near the Toronto-Pickering boundary. DRT does not operate any cross-town services in the City of Toront

4.6 GO TRANSIT

GO Transit is the operated by the Greater Toronto Transit Authority (GTTA) and is the City of Toronto's regional transit operator. GO Transit provides regular train and bus service throughout the GTA. Seven rai commuter rail lines are operated out of Union Station in downtown Toronto and provide service to suburb regions north, east and west of Toronto. GO Transit also operates several bus routes throughout the GTA which connect various urban, suburban and rural centres throughout the GTA. Regular cross-town bus services are provided by GO Transit along the Highway 401 corridor connecting to major urban centres in north Toronto such as North York, Pearson International Airport, Scarborough City Centre and York University. No cross-town rail service is provided.[96]

Bus routes on Highway 401 have operating characteristics that are typical of regional bus services *(see Section 3.0)* with buses typically operating on local arterial roads outside of the City, then utilizing general purpose lanes on highways, operating non-stop between specific urban centres within the City.

Buses on Highway 401 operate as frequently as every 10 minutes during peak hours, but, due to traffic congestion; buses are often subjected to delays and low operating speeds. No HOV lanes are present along Highway 401. The Ministry of Transportation's HOV Plan for 400 series highways in the GTA also show that no HOV facilities or bus lanes are planned for Highway 401 beyond 2017.[97] Therefore, GO Transit's operations along Highway 401 cannot be considered rapid transit despite the fact that buses operate on ma

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[94] Based on Durham Region Transit's 2008 system map, Retrieved 30 June, 2008 from the Durham Region Transit website at www.durhamregiontransit.com

[95] Ibid

[96] Based on GO Transit's 2008 system map, Retrieved 30 June, 2008 form the GO Transit website at www.gotransit.ca

[97] Figure 3 of Ontario's High Occupancy Vehicle Lane Network; Summary of the Plan for the 400-Series Highways in the Gre Golden Horseshoe, 2007, Retrieved June 30, 2008 from the Ontario Ministry of Transportation Website at www.mto.gov.on.ca/english/traveller/hov/summary2007.htm

expressways. Since there are no designated lanes for buses or HOV's, buses operate in general purpose lanes and are subjected to same delays experienced by other road users.

4.7 SUMMARY OF EXISTING TRANSIT SERVICES IN THE GREATER TORONTO AREA

A review of the existing transit systems in the GTA show that there is no cross-town rapid transit services in north Toronto in the vicinity of Highway 401. GO transit is the only regional transit operator in the GTA. Although it does provide cross-town express bus service through North Toronto, it cannot be considered rapid transit since buses do not any type of priority-treatments and buses operate in general purpose lanes, thus being subjected to the same congestion-related delays experienced by other road users.

The TTC operates many high frequency bus routes across north Toronto; however these are local bus routes primarily serving short-distance trips through the corridor. Due to the frequent stop-spacing along these routes, and the lack of designated transit lanes, operating speeds are lower than those of rapid transit services and travel times to cross the 42 km length of the City can be in excess of 2 hours.

Transit operators in suburban regions immediately adjacent to the City of Toronto do not provide cross-town rapid transit services in north Toronto. These operators are based in the cities and regions that they serve, providing a few connections to TTC services.

5.0 REVIEW OF BACKGROUND STUDIES

5.1 GO ALRT PROGRAM

Go Transit's Advanced Light Rail Transit program (GO-ALRT) was initiated by GO Transit in the early 1980's and included feasibility studies and environmental assessments for a "Northern" rapid transit line across Toronto. The Northern route was proposed in 1984 with feasibility and operational studies commencing at this time. Although never finalized, the conceptual route connected Pearson International Airport, North York Centre and Scarborough Centre with other major urban centres in throughout the GTA such as Mississauga, Brampton and Pickering. The proposed GO ALRT network, including the Northern Line is illustrated in **Figure 9.**

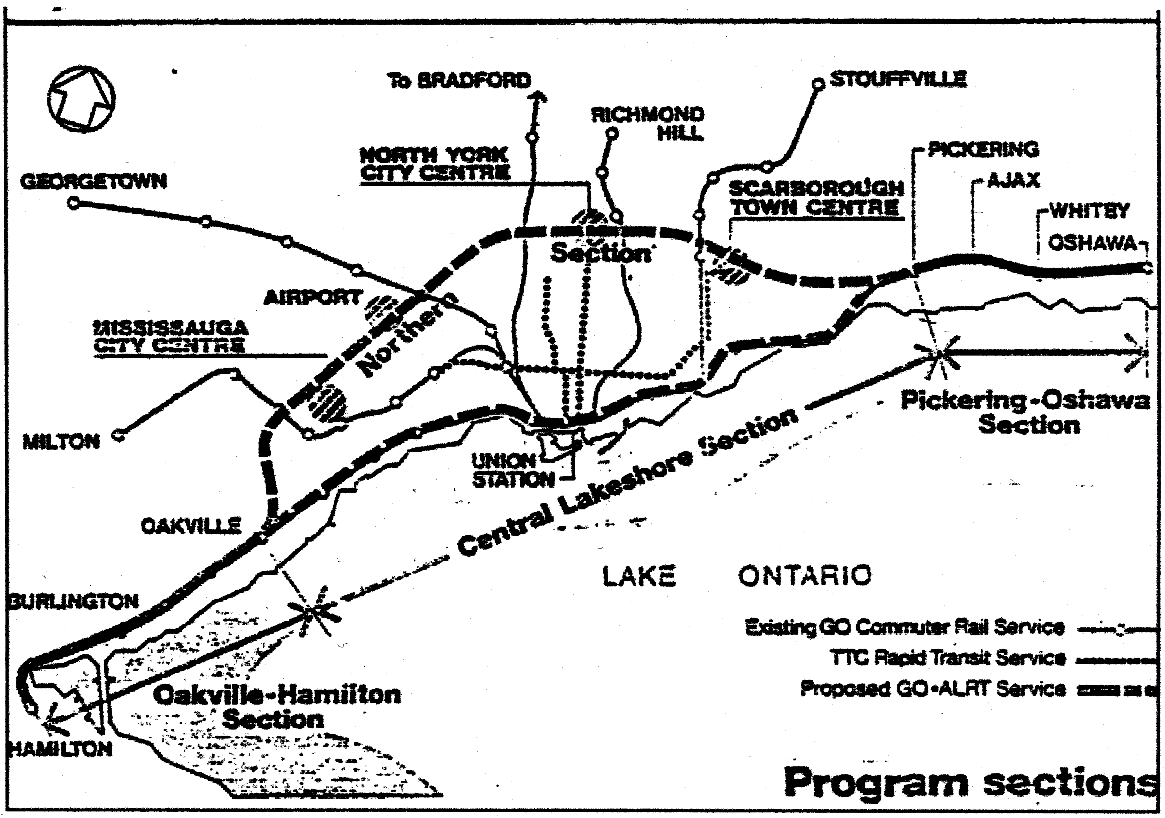

Figure 9: Proposed GO ALRT Network [98]

[98] The GO-ALRT Program, Retrieved 17 July, 2008 from the Transit Toronto website at www.transit.toronto.on.ca/gotransit/2107.shtml

The network was to comprise of a fully grade-separated rapid transit line primarily on elevated guideways because of the lower costs when compared to depressed or underground alignments.[99] The vehicle proposed for the GO-ALRT network was an automated, electrically powered intermediate-capacity (ICTS) vehicle, similar to those used on the SRT *(Refer to Section 4.1)* capable of seating 124 passengers per car.[100] The maximum design train length was for five cars, allowing for a train to carry 620 seated passengers. A maximum speed of 120 km/h was to be achieved with an average speed of 70 km/h with stations spaced on average every 3 km[101]. Trains were to ultimately operate anywhere between 2 and 10 minutes during peak periods. Travel demand estimates for the Northern Line were in the range of 15,000 to 20,000 people per ho[ur] per direction by 2021, with system designed for an ultimate capacity of 25,000 passengers per hour. [102] The proposed vehicle concept is illustrated in **Figure 10.**

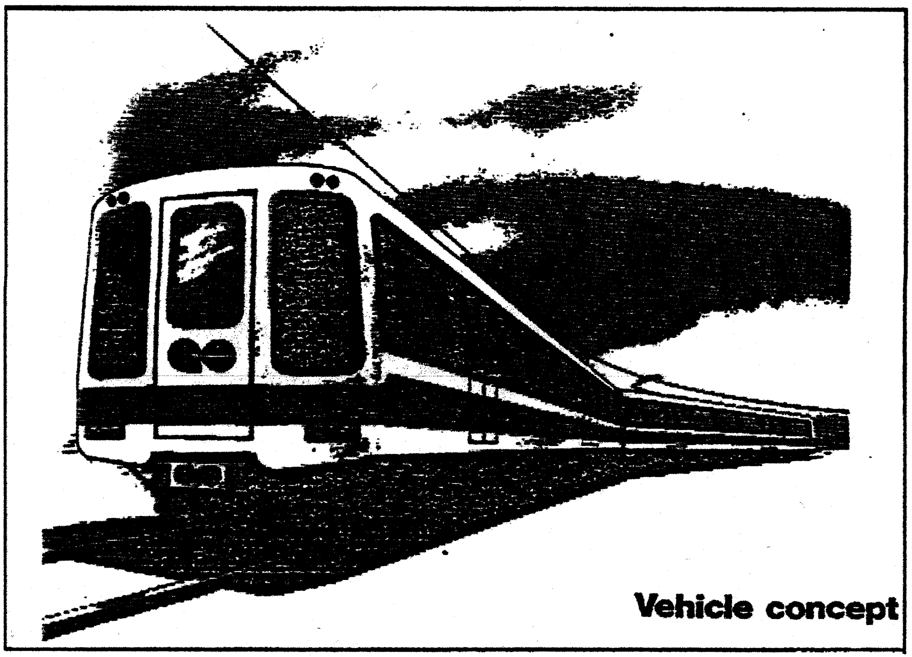

Figure 10: Proposed GO-ALRT Vehicle

[99] Marshall Macklin Monaghan Ltd, GO ALRT: Northern Section Joint Use Study Draft Report, System Description (March 15, 1984), p.3-1
[100] The GO-ALRT Program, Retrieved 17 July, 2008 from the Transit Toronto website at www.transit.toronto.on.ca/gotransit/2107.shtml
[101] Ibid
[102] Marshall Macklin Monaghan Ltd, GO ALRT: Northern Section Joint Use Study Draft Report, Travel Demand Estimates (Ma 15, 1984), p.8-1

A draft route concept was completed by Marshall Macklin Monaghan Limited (a consulting engineering firm) in 1984 utilizing hydro and freeway corridors through northern Toronto. Initial cost estimates for a 52 km, 26-station, double-tracked route across north Toronto were in the range of $1.5 to $3.0 billion dollars in 1984 dollars, excluding the cost of vehicles, maintenance facilities and ancillary facilities at stations.[103]

No finalized route concept was ever developed for the Northern Line as the GO-ALRT program was ultimately cancelled in 1986. One of the main reasons for cancelling the project was a change in federal legislation which gave higher priority to passenger trains operating on freight lines, rather than vice-versa. Since existing GO commuter trains operated on freight lines, it was cheaper to expand the existing GO Rail network using the conventional commuter rail technology already in service, rather than developing a new technology and creating new routes segregated from freight traffic.[104] Other hypothesized reasons for cancelling the project include a change in political power and hesitancy in using ICTS technology, which was unproven and untested at the time. Regardless, given the traffic congestion present today throughout northern Toronto along the Highway 401 corridor, it is expected that this route would have been very useful to many people traveling throughout north Toronto.

5.2 PLACES TO GROW

The "Places to Grow" study is an initiative undertaken by the government of Ontario to manage regional growth and development in the Ontario and the GTA to the year 2031. Part of this initiative includes the creation of "urban centres" that will serve as major destinations in the GTA with an emphasis on transit access. Urban growth centres are planned:

- as focal points for investment in institutional and region-wide public services, as well as commercial, recreational, cultural and entertainment uses;
- to accommodate and support major transit infrastructure;
- to serve as high density major employment centres that will attract provincially, nationally or internationally significant employment uses; and

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[103] Marshall Macklin Monaghan Ltd, GO ALRT: Northern Section Joint Use Study Draft Report, Cost (March 15, 1984), p.9-1
[104] The GO-ALRT Program, Retrieved 17 July, 2008 from the Transit Toronto website at www.transit.toronto.on.ca/gotransit/2107.shtml

- to accommodate a significant share of population and employment growth[105]

The Places to Grow study recommends a 40% intensification target for urban centres in the GTA, meaning that at least 40% of all future growth in the GTA should occur within urban centres. Proposed urban Centre in the GTA are illustrated in **Figure 11.** Major urban centres in the north Toronto include Scarborough Cen North York Centre and Yonge and Eglinton Centre. Other major centres in north Toronto include Pearson International Airport and York University. Highway 401 provides direct access into north Toronto from Durham and Halton Region's and runs in close proximity to these many of these urban centres. However, given the capacity constraints and existing traffic congestion along Highway 401 and other parallel arterial roads in north Toronto, the existing road network will not be able to handle the increased traffic demand generated by these destinations. There will be a need to connect these centres with a higher-order transit system, which they will be designed to accommodate.

5.3 MOVE ONTARIO 2020

The MoveOntario2020 study is a proposal released by the provincial government in 2007 for the constructi of 52 separate transit projects throughout the Greater Toronto Area, including 902 km of new or improved rapid transit lines.[106] This plan was created in response to increasing traffic congestion and population gro in the GTA. The plan states that effective and expanded public transit will:

- Reduce traffic congestion and make it easier and faster to get people and goods where they need to
- Cut smog and provide cleaner air to breathe;
- Help Ontario reduce greenhouse gas emissions; and
- Support sustainable urban development that leads to stronger communities and a higher quality of life.[107]

A map of the proposed MoveOntario 2020 plan is illustrated in **Figure 12.**

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[105] Ministry of Public Infrastructure and Renewal, Places to Grow: A Guide to the Growth Plan for the Greater Golden Horsesho (Ministry of Ontario, 2006), p.16

[106] MoveOntario 2020, Retrieved 17 July, 2008 from the Premier of Ontario – Backgrounders website at www.premier.gov.on.ca/news/Product.asp?ProductID=1384

[107] MoveOntario 2020, Retrieved 17 July, 2008 from the Premier of Ontario – Backgrounders website at www.premier.gov.on.ca/news/Product.asp?ProductID=1384

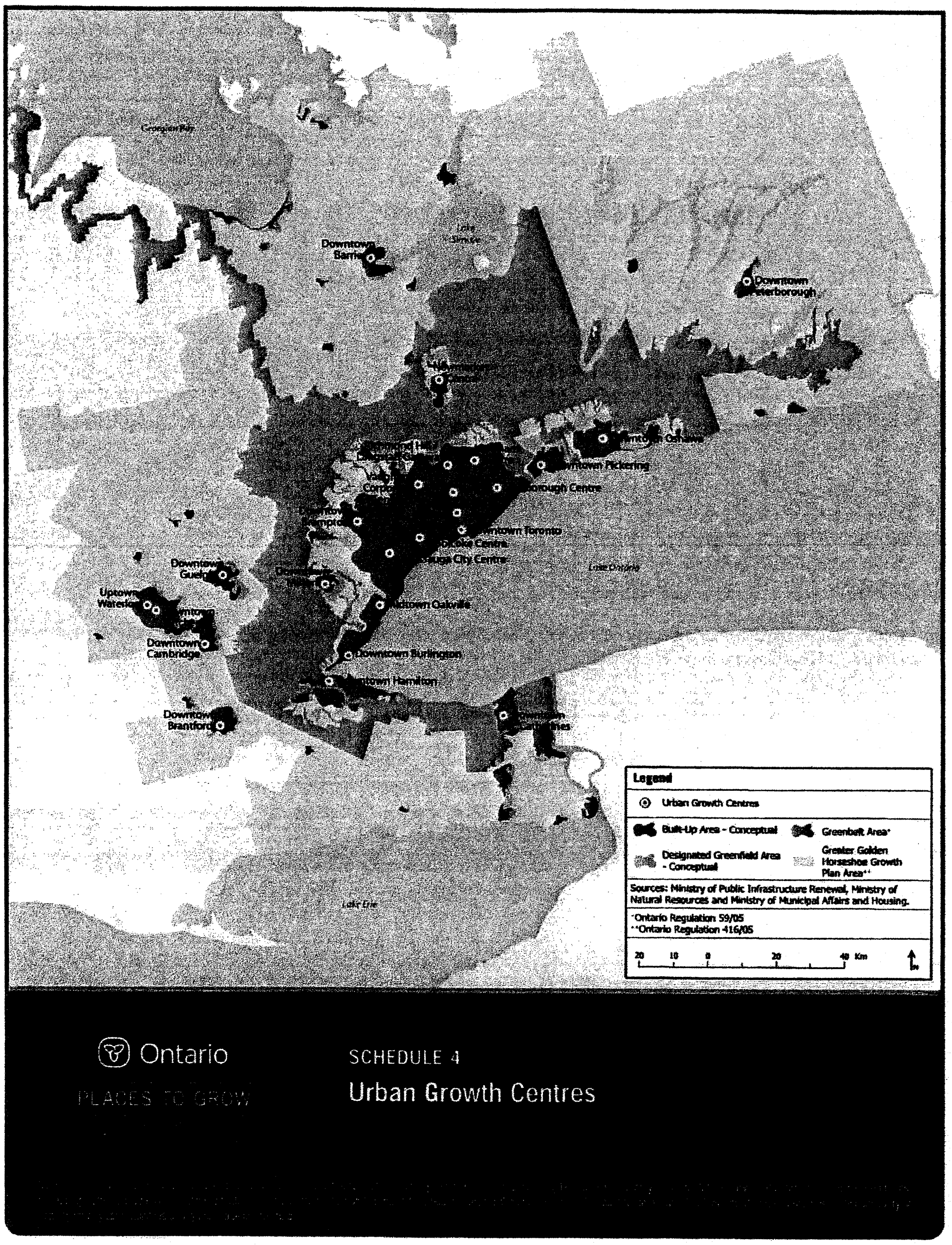

Figure 11: Greater Toronto Area Urban Centres

Figure 12: MoveOntario 2020 Plan

Despite the 52 recommended new or improved transit projects, no rapid transit line across north Toronto is proposed.

5.4 METROLINX REGIONAL TRANSPORTATION PLAN

Metrolinx is the name of the former Greater Toronto Transportation Authority. Metrolinx is a crown agenc of the Province of Ontario whose mandate is to improve the coordination and integration of all modes of transportation in the region, which stretches from Oshawa to Hamilton.[108]

Metrolinx has developed a series of draft Regional Transportation Plan reports, currently available for publi review and comment. These reports provide the strategic framework for managing future growth in the GT Metrolinx's Green Paper #2 report completed in February 2008, titled "Mobility Hubs" recommends the creation of mobility hubs throughout the GTA which are similar to the urban growth centres proposed in th Ministry of Ontario's Places to Grow strategy *(see Section 5.3).*

Mobility Hubs are areas of medium to high density development, high population and employment and are classified into three categories, as listed in **Table 1.**

[108] Metrolinx Frequently Asked Questions "What is Metrolinx", Retrieved 17 July, 2008 from the Metrolinx website at www.metrolinx.com/NonTabPages/1/Faq.aspx

Table 1: Mobility Hub Types [109]

Mobility Hub Type	Characteristics
Primary Hubs	Significant regional city centres with potential for the highest levels of population and employment densities Highest levels of travel demand Includes subway stations and some urban growth centres depending on scale, character, transit service and function
Secondary Hubs	Major regional destinations and/or functionally important gateways that have inter-regional connections Includes airports, universities/colleges, major parks and stadiums, and regional shopping centres
Tertiary Hubs	All stations located on a higher-order transit line not included in the previous definitions.

Primary Mobility Hubs in Northern Toronto within close proximity to Highway 401 include North York Centre and Scarborough Centre. Secondary Hubs include Pearson International Airport, Humber College, Woodbine Centre (Shopping Mall), Downsview Park, York University, Yorkdale Mall, Seneca College (Newham Campus), Fairview Mall, Centennial College (Progress Campus), and University of Toronto (Scarborough Campus).

Metrolinx's Green Paper #7 completed in February 2008, titled "Transit" recommends the development of full hierarchy of transit services, including a regional express service in the GTA. This report identifies the need to integrate transit and land use, specifically integrating mobility hubs with higher-order transit lines.[110] A transit modal-split, which is the percentage of total trips generated by an area that are made by transit, of 30% is desired at mobility hubs.

Conceptual rapid transit networks are illustrated in Green Paper #7, with the alternative requiring the most capital investment, the "bold alternative" recommending a Regional Express Rapid transit line across northern

[109] Metrolinx, Green Paper #2: Mobility Hubs, (Metrolinx, 2008), p.4
[110] Metrolinx, Green Paper #7: Transit, (Metrolinx, 2008), p.15

Toronto, connecting Pearson International Airport with the North York Centre and Scarborough Centre and other centres throughout the GTA. Metrolinx's "bold alternative" rapid transit network is illustrated in **Figu** **13.**

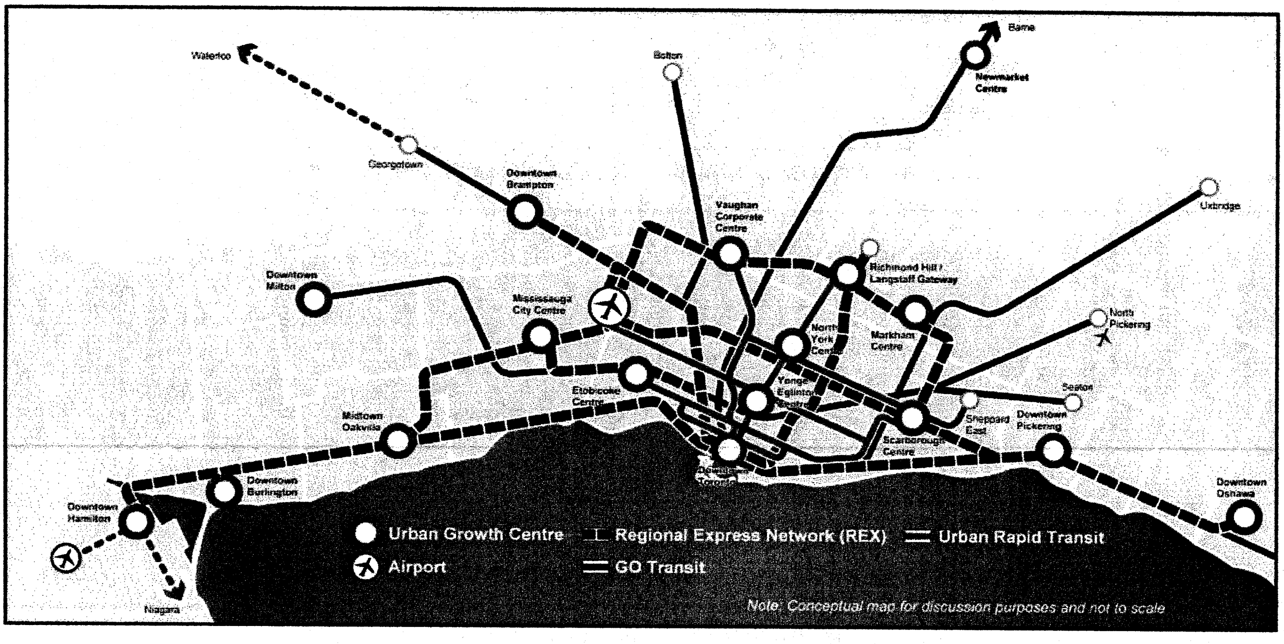

Figure 13: Metrolinx "Bold Alternative" Rapid Transit Network for the Greater Toronto Area

Given the number of mobility hubs located in northern Toronto and the fact the population and employment growth expected at these locations, it is expected that transportation demands across Northern Toronto will increase significantly in the future, further illustrating the need for a higher-order rapid transit line in the are

5.5 TRANSIT CITY

The "Transit City" project (which is also included in the MoveOntario 2020 plan) is a program being undertaken by the Toronto Transit Commission (TTC) to create a network of LRT lines across the City of Toronto. The proposed network of LRT routes are to provide fast travel between major areas of Toronto, offering people a truly travel-time competitive and less-stressful alternative to private cars. Service along the proposed routes are to be highly-reliable, frequent and in road space designated for transit customers, eliminating delays caused by operation in mixed traffic.[111] The conceptual Transit City network is illustrated in **Figure 14.**

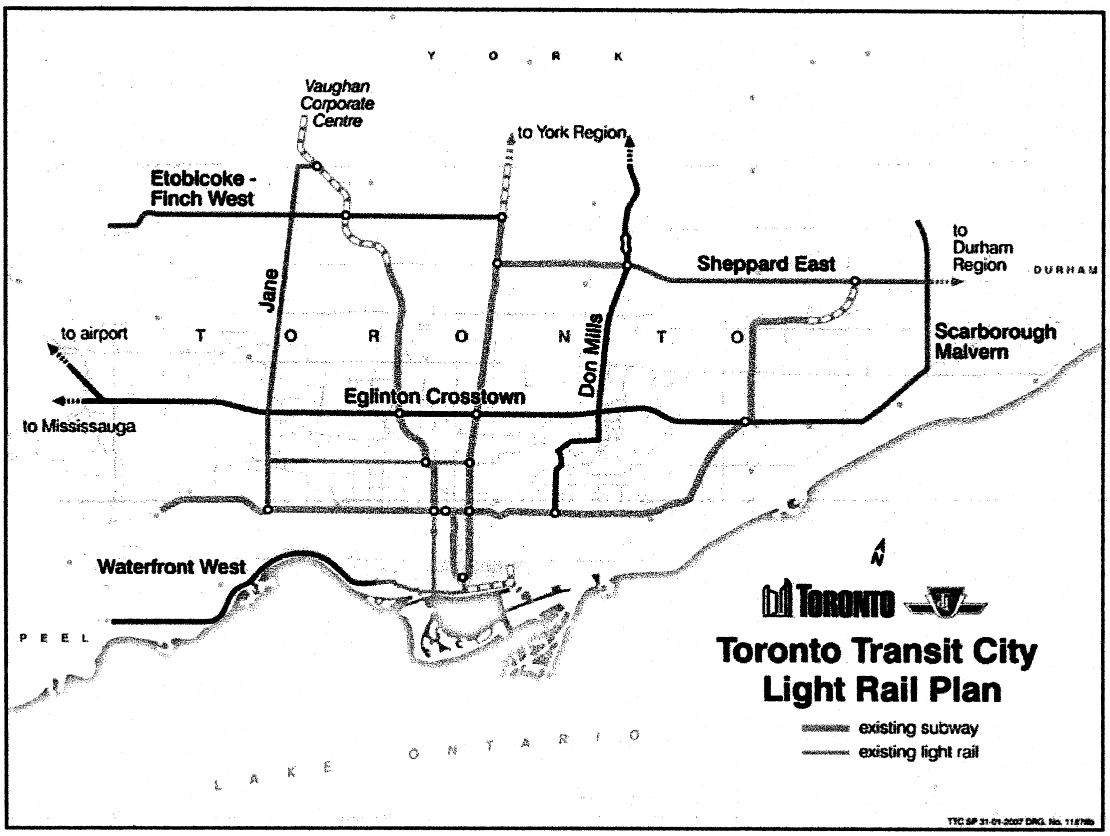

Figure 14: Conceptual Transit City Network

Assuming funding is received for the project, the network would be completed by 2021. This plan however is a City-based plan and not a regional plan. Although routes are proposed in north Toronto along Finch Avenue West and Sheppard Avenue East, these routes are not connected. Direct travel across north Toronto between Scarborough Centre and Pearson International Airport for example, would require 4 transfers and 5 different routes. Furthermore, Transit City routes are catered to persons making local trips along Transit City corridors. Transit stops on the proposed Sheppard LRT line for example, will be spaced at 400 to 500 m intervals, translating to an average speed of 22 to 23 km/h.[112] For comparison, the Bloor-Danforth Subway line operates

[111] Toronto Transit Commission, Transit City Report – Light Rail Plan, (TTC, 2007), p.1
[112] City of Toronto Public Open House Display Panels, Sheppard East LRT: Municipal Class Environmental Assessment Study, Impacts of LRT Stop Spacing on LRT Route Speeds, (City of Toronto / URS, 2008)

at an average speed of 32 km/h. [113] The short station spacing is so passengers would have a shorter walk to access stations. The proposed Sheppard LRT route will have nearly 30 stops along its 13.6 km length. Othe Transit City lines will have similar characteristics.

For comparison purposes, the distance along Highway 401 across north Toronto is approximately 40 km. Translating the average stop spacing proposed on the Sheppard East LRT line along the length of Highway 401 across Toronto would equate to nearly 95 stops.

Although the proposed Transit City network connects major areas in Toronto and is suitable for local, short distance trips, it does not act as a regional express service through north Toronto due to the relatively low travel speed of its vehicles and the frequent stop spacing.

5.6 GO TRANSIT INTER-REGIONAL BRT INITIATIVE

GO Transit's Inter-Regional BRT Initiative was a study completed in 2002 for a cross-regional bus rapid transit line for the GTA. The study was completed in response to the increasing number of trips made throughout the GTA that are not destined to downtown Toronto, which is already well-served by GO Trans rail services. Specifically, it was developed to serve suburb-to-suburb commuters, which have been steadily increasing in number over the past decade. The study indicated that 58% of peak period travel in the GTA i destined to areas outside of downtown Toronto.[114] The proposed BRT line would run between Oakville and Pickering through the cities of Mississauga, Toronto, Vaughan and Markham. The line would connect majo urban centres such as Mississauga City Centre, the Airport Corporate Centre in Mississauga, York Universi Markham Centre, Scarborough Centre and central Pickering. The proposed BRT line is illustrated in **Figur 15.**

[113] City of Toronto Public Open House Display Panels, Sheppard East LRT: Municipal Class Environmental Assessment Study, Impacts of LRT Stop Spacing on LRT Route Speeds, (City of Toronto / URS, 2008)
[114] Mc Cormick Rankin Corporation "GO Transit Inter-Regional BRT Service" Report, Introduction p.1

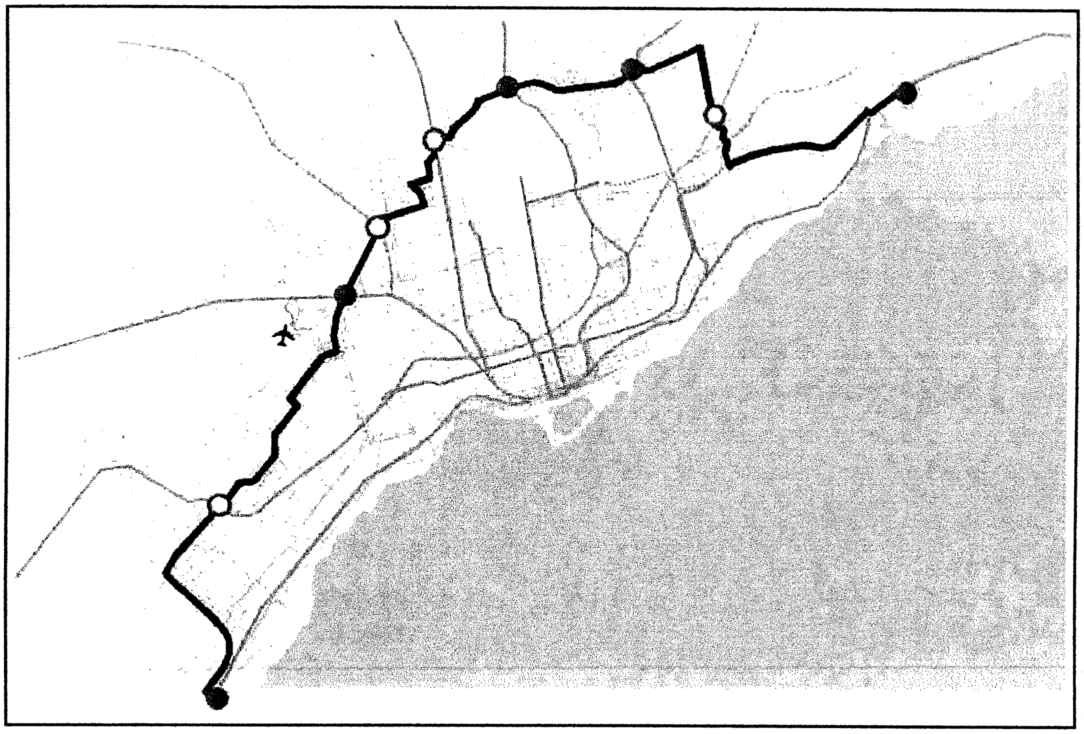

Figure 15: Proposed GO Transit BRT Spine Line

Source: Exhibit 1.1, GO Transit Inter-Regional Bus Rapid Transit: A BRT Vision for the GTA

Ridership projections estimated that the line could carry anywhere between 2,000 to 15,000 riders per hour per direction. [115] Based on these ridership estimates, a bus-based system was recommended. Local all-stop, limited-stop and express services would be offered along various segments of the route. Construction of the Mississauga segment of the BRT line is expected to commence in late 2008 with a scheduled opening date in 2012.[116]

This proposed BRT line does address the lack of a cross-town rapid transit service through north Toronto as no route is proposed between York University and Centennial College within Toronto's city limits. Between these points, the proposed route travels north of Toronto through the cities of Markham and Vaughan.

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[115] Mc Cormick Rankin Corporation "GO Transit Inter-Regional BRT Service" Report, Operating Plan – Ridership, p.23

[116] Mississauga BRT Basics, Retrieved 27 July, 2008 from the Mississauga Transit website at www.mississauga.ca/portal/residents/brt

5.7 SUMMARY OF BACKGROUND STUDIES AND PROPOSALS

Based on the review of the background studies and proposals, the GO ALRT program (which was cancelled in the 1980's) and the Metrolinx Regional Transportation Plans, which are still pending approval, were the only studies that recommended a regional rapid transit line across north Toronto. No such line was proposed in the other studies. With more development expected around north Toronto urban centres, traffic demands along Highway 401 and across northern Toronto are expected to increase. Since many roads are already operating at congested levels, alternative non-auto modes of transport are required to transport people across northern Toronto. This is why an emphasis on higher-order transit access is stressed at urban centres throughout the GTA.

6.0 DATA ANALYSIS

6.1 EXISTING TRAVEL DATA

Existing travel patterns in the study area were determined based on the Transportation Tomorrow Survey (TTS) completed in 2001for the GTA. The TTS survey is a comprehensive travel survey conducted in the GTA once every five years to collect information on urban travel. [117,118] The results from the 2006 TTS have not yet been released therefore the most recent 2001 data set was be used. The TTS was be used to estimate the total number of trips to and from urban centres in north Toronto study area to establish "desire lines" that identify the origins and destinations of these trips. Trips were classified by automobile and transit trips.

6.1.1 Existing Data Retrieval Methodology

The AM peak hour (8:00 to 9:00 a.m.) was selected as the time period for analysis. TTS classifies trip patterns by planning districts and traffic zones. Existing travel patterns were determined by using TTS to find the number of peak hour auto and transit trips destined to and originating from planning districts in north Toronto adjacent to the Highway 401 corridor, including where in the GTA those trips originated from or were destined to. The north Toronto planning districts (PD's) selected for trip generation purposes were PD 4, PD9, PD10, PD 11, PD12, PD 13 and PD 16. These PD's were selected because the north Toronto urban centres were located in these areas. A map of the Toronto Planning Districts can be found in **Appendix B.**

This exercise gave an overview of the number of trips generated by the north Toronto planning districts. However, planning districts in north Toronto typically cover a large area, ranging in size from 5 to 10 km^2. TTS traffic zones further break down planning district areas into smaller components. Therefore, to get a better idea of trips destined to or originating from a specific urban centre within a planning district, TTS was again used to further refine trips within the north Toronto by examining trips destined to or originating from the traffic zones where urban centre's are located. The planning districts and traffic zones selected for trip generation purposes are summarized in **Table 2.** A map of the Toronto traffic zones selected for the north Toronto urban centre's can also be found in **Appendix B.**

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[117] Data Management Group, University of Toronto, Retrieved 31 March 2008 from the Data Management Group Transportation Tomorrow Survey website at www.jpint.utoronto.ca/dmg/tts.html

[118] Transportation Tomorrow Survey, Retrieved 31 March 2008 from the Transportation Tomorrow Survey website at www.jpint.utoronto.ca/ttshome

Table 2: North Toronto Urban Centre Traffic Zones

Urban Centre	Planning District Number (Location)	Traffic Zones
Pearson International Airport & Airport Corporate Centre	36 (Mississauga)	1524, 1525, 1608, 1610, 1604, 1609, 1505, 1602
Humber College	9 (Toronto)	53
York University	10 (Toronto)	95
North York Centre	11 (Toronto)	309, 311, 317, 319, 320, 323
Yonge & Eglinton Centre	4 (Toronto)	284, 285, 286, 287
Scarborough Centre	13 and 16 (Toronto)	417, 425, 426, 450, 440
U of T Scarborough Campus	15 (Toronto)	460

Existing travel patterns were determined based on the origins and destinations of existing trips generated by the north Toronto urban centres. The City of Toronto's current road network was used to determine the most probable route for these trips and to determine the approximate number of trips that would be use the Highway 401 corridor.

The approximate number of AM peak hour auto and transit trips using the Highway 401 corridor to access north Toronto urban centres is listed in **Table 3.** Because the magnitude of these trips is not consistent throughout the corridor, the number of trips are shown between different boundaries or "screenlines" across the City, listing the approximate number of trips through the corridor by different segments. A summary of the TTS outputs can be found in **Appendix C.**

Table 3: Existing (2001) Regional AM Peak hour trips generated by the North Toronto Urban Centre's

Trips on Highway 401 Originating from or Destined To		SEGMENT 1	Screenline: City of Toronto Western City Limit	SEGMENT 2	Screenline: Humber River	SEGMENT 3	Screenline: Allen Road	SEGMENT 4	SEGMENT 5	Screenline: Victoria Park Avenue	SEGMENT 6	SEGMENT 7	Screenline: City of Toronto Eastern City Limit	SEGMENT 8
		External Areas North and West of Toronto		PD9, PD8		PD10, PD3		PD11, PD4	PD12, PD5		PD16, PD13	PD16, PD15		External Areas North and East of Toronto
Urban Centre	Trip Direction and Type	Number of Trips		Number of Trips		Number of Trips		Number of Trips	Number of Trips		Number of Trips	Number of Trips		Number of Trips
Pearson	IN (Total Trips)	386		278		278		172	156		84	53		53
	IN (Transit Trips)	10		20		20		0	0		0	0		0
	OUT (Total Trips)	2,580		2,019		2,019		1,324	853		407	229		154
	OUT (Transit Trips)	107		173		66		59	22		0	0		0
Humber	IN (Total Trips)	181		196		196		196	129		91	12		12
	IN (Transit Trips)	12		62		41		41	13		0	0		0
	OUT (Total Trips)	772		765		765		257	132		114	47		47
	OUT (Transit Trips)	224		275		52		52	31		8	8		0
York U	IN (Total Trips)	66		175		175		175	175		99	13		13
	IN (Transit Trips)	14		14		72		58	58		35	0		0
	OUT (Total Trips)	401		1,304		1,304		1,304	1,304		739	240		182
	OUT (Transit Trips)	154		154		569		416	416		195	8		8
North York Ctr	IN (Total Trips)	665		1,567		4,604		5,886	1,084		1,084	207		207
	IN (Transit Trips)	32		68		925		1,135	211		211	18		0
	OUT (Total Trips)	929		2,584		5,436		9,068	3,632		3,632	1,020		751
	OUT (Transit Trips)	79		642		1,508		2,449	941		661	136		36
Yonge/Eglinton	IN (Total Trips)	426		721		836		1,417	581		232	73		50
	IN (Transit Trips)	13		143		143		281	139		16	6		0
	OUT (Total Trips)	771		1,073		1,500		2,574	1,074		686	616		193
	OUT (Transit Trips)	242		446		549		619	271		271	96		73
Scarbourough Ctr	IN (Total Trips)	43		83		246		484	810		953	1,095		143
	IN (Transit Trips)	0		12		49		78	367		491	616		0
	OUT (Total Trips)	236		364		1,016		1,516	2,401		2,654	3,792		1,136
	OUT (Transit Trips)	54		83		161		251	611		744	877		134
Scarborough U of T	IN (Total Trips)	30		40		50		95	204		445	10		10
	IN (Transit Trips)	0		0		0		0	132		132	0		0
	OUT (Total Trips)	53		96		125		183	264		264	428		164
	OUT (Transit Trips)	0		6		14		20	51		51	0		0
	TOTAL TRIPS	7,736		11,251		18,748		24,659	12,758		11,481	7,831		3,112
	TOTAL TRANSIT TRIPS	939		2,085		4,165		5,656	3,259		2,812	1,765		250
	Transit Modal Split	12%		19%		22%		23%	25%		24%	23%		8%

6.1.2 Existing Travel Demands

The data shows that the number of AM peak hour regional trips using the Highway 401 corridor, generated the north Toronto urban centre's range from approximately 3,100 trips per hour to 25,000 trips per hour. T busiest segments are segments 3 to 6, which are between York University and the Scarborough Town Cent The total number of trips between these segments range between 10,000 and 25,000 trips per hour. In segments 1 and 2, or west of York University, the number of trips range between 7,700 to 11,000 trips per hour, while in segments 7 and 8, or east of the Scarborough Centre, the number of trips range between 7,80 and 3,000 trips per hour.

The magnitude of transit trips in the corridor range between 900 to 5,600 trips per hour between segments 1 and 4, which are between Pearson International Airport and North York Centre. Trips between segments 5 and 8; or between North York Centre and Toronto's eastern city limit, are between 5,600 to 250 trips per hour.

These results suggest a peak trip demand of approximately 25,000 trips per hour in the corridor. The busies segments lie between York University and Scarborough Centre (segments 3 to 6) where approximately 20% to 25% of these trips are served by transit. Travel demands decrease east of the Scarborough Centre (segme 7 and 8) to approximately 3,000 trips per hour with only 8% of these trips made by transit. West of York University (segments 1 and 2), the demand decreases between 11,000 and 7,700 trips per hour, with 12% to 20% of these trips made by transit.

The percentage of trips made by transit is the highest along the busiest segments of the corridor. This may b the high volume of travelers, as well as the availability of rapid transit as North York Centre and Scarborou Centre are both served by subway lines, regional buses and local bus service. The drop in transit ridership outside of these areas may be due to lower population densities near the fringes of the city, as well as the lac of rapid transit services available in these areas.

6.2 FUTURE PROJECTED TRAVEL PATTERNS

Future Travel Patterns through the Highway 401 corridor were projected for the 2031 horizon year using the City of Brampton's EMME version 2 model. EMME version 2 (EMME/2) is a travel demand forecasting software tool. Recent EMME/2 models have been developed for the GTA, the City of Brampton and the Region of York. Data from the City of Brampton's EMME/2 model was used for this study as Brampton's EMME/2 model is the most recent and also provides travel forecasts for the AM peak hour. Although developed for the City of Brampton, this model includes travel data for the entire GTA.

It should be noted that the EMME/2 model assumes generic population and employment growth throughout the GTA from a 2001 base-year condition. It does not included any of the population and employment growth initiatives identified in the Metrolinx Regional Transportation plans or the Places to Grow strategies, such as population and employment intensification around urban centre's and the creation of mobility hubs. The current 2001 transit network is also assumed in the EMME/2 model with no future rapid transit lines constructed.

Outputs from the EMME/2 model were used to estimate future 2031 travel patterns in north Toronto, including the number of peak trips made to and from the north Toronto urban centre's.

6.2.1 Future Data Retrieval Methodology

The EMME/2 model provides information on travel patterns between planning districts in the GTA and does not breakdown trips by traffic zones. Therefore, trips destined to or originating north Toronto planning districts were outputted from the EMME/2 model. In order to determine the percentage of trips generated by a planning district (PD) that were generated by the urban centre traffic zones within that PD, the same proportion of trips obtained from the 2001 TTS data was applied to the EMME/2 outputs. For example, if the 2001 TTS data indicated that 10% of the total trips generated by Planning District 11 (North York) were destined to or originating from the North York urban centre (Traffic Zones 309, 311, 317, 319, 320, 323), then it was also assumed that 10% of the future trips generated by Planning District 11 in the EMME/2 model were destined to or originating from the North York urban centre.

Future travel patterns were determined based on the origins and destinations of the future trips generated b the north Toronto urban centres. The City of Toronto's current road network was used to determine the mo probable route for these trips and to determine the approximate number of trips that would be using the Highway 401 corridor.

The approximate number of future AM peak hour auto and transit trips using the Highway 401 corridor to access north Toronto urban centres are listed in **Table 4.** A summary of the EMME/2 outputs can be found **Appendix D.**

6.2.2 Findings: Future Travel Demands

The EMME/2 model outputs show the total number of AM peak hour trips generated by north Toronto urba centre's that use the Highway 401 corridor range between 5,000 and 53,000 trips per hour. The busiest segments are segments 1 to 6 which lie between Pearson International Airport and the Scarborough Centre. The total number of trips along these segments range between 22,000 and 53,000 trips per hour. Segments 3 and 4, which are between York University and Scarborough Centre, have peak demands between 40,000 an 53,000 trips per hour. The least busiest segments are segments 7 and 8, east of the Scarborough Centre, whe the number of trips ranges between 5,000 and 11,000 trips per hour.

The future 2031 regional transit demand through the corridor ranges between 475 trips per hour to 10,000 trips per hour. The highest transit demand occurs on segments 3, 4 and 6, which are located between York University and Scarborough Centre. Transit demands on these segments range between 9,000 and 10,000 tri per hour.

Table 4: Future (2031) Regional AM Peak hour trips generated by the North Toronto Urban Centre's

Trips on Highway 401 Originating from or Destined To		SEGMENT 1		SEGMENT 2		SEGMENT 3		SEGMENT 4	SEGMENT 5		SEGMENT 6	SEGMENT 7		SEGMENT 8
		External Areas North and West of Toronto	Screenline: City of Toronto Western City Limit	PD9, PD8	Screenline: Humber River	PD10, PD3	Screenline: Allen Road	PD11, PD4	PD12, PD5	Screenline: Victoria Park Avenue	PD16, PD13	PD16, PD15	Screenline: City of Toronto Eastern City Limit	External Areas North and East of Toronto
Urban Centre	Trip Direction and Type	Number of Trips		Number of Trips		Number of Trips		Number of Trips	Number of Trips		Number of Trips	Number of Trips		Number of Trips
Mississauga	IN (Total Trips)	160		160		160		83	62		40	20		200
	IN (Transit Trips)	7		7		7		4	3		2	1		28
	OUT (Total Trips)	772		772		772		394	201		113	36		847
	OUT (Transit Trips)	33		33		33		15	9		5	1		63
Humber	IN (Total Trips)	2,650		3,319		668		668	318		220	118		92
	IN (Transit Trips)	136		191		55		55	26		16	8		5
	OUT (Total Trips)	1,538		2,048		510		510	209		92	40		33
	OUT (Transit Trips)	112		311		199		199	36		14	2		1
York U	IN (Total Trips)	13,762		13,762		24,353		10,591	10,591		6,709	2,492		181
	IN (Transit Trips)	1,369		1,369		4,145		2,776	2,776		1,583	479		30
	OUT (Total Trips)	7,424		7,424		11,839		4,415	4,415		2,053	416		61
	OUT (Transit Trips)	442		442		1,355		913	913		338	17		4
North York Ctr	IN (Total Trips)	1,362		2,070		4,171		7,430	3,259		3,259	1,048		821
	IN (Transit Trips)	169		324		907		1,708	801		801	128		88
	OUT (Total Trips)	1,379		2,464		6,065		8,336	2,271		2,271	428		329
	OUT (Transit Trips)	73		206		1,303		1,664	381		381	34		12
Yonge/Eglinton	IN (Total Trips)	1,130		1,758		1,758		3,816	2,060		2,060	748		499
	IN (Transit Trips)	247		458		458		1,070	612		612	174		94
	OUT (Total Trips)	756		1,324		1,323		2,346	1,023		1,023	232		171
	OUT (Transit Trips)	60		217		217		422	206		206	22		6
Scarbourough Ctr	IN (Total Trips)	171		247		383		669	1,042		2,284	3,133		849
	IN (Transit Trips)	18		29		56		88	163		316	369		54
	OUT (Total Trips)	181		323		795		1,093	298		298	56		43
	OUT (Transit Trips)	49		117		364		1,094	1,762		4,987	5,037		50
Scarborough U of T	IN (Total Trips)	36		51		72		105	146		210	516		307
	IN (Transit Trips)	3		4		6		9	13		24	38		14
	OUT (Total Trips)	83		143		282		527	841		1,575	2,220		644
	OUT (Transit Trips)	7		18		55		136	194		751	776		25
FUTURE TOTAL TRIPS		31,405		35,865		53,150		40,875	26,725		22,206	11,504		5,076
TOTAL TRANSIT TRIPS		2,725		3,726		9,160		10,173	7,892		10,034	7,085		475
Future Transit Modal Split		9%		10%		17%		25%	30%		45%	62%		9%

7.0 DISCUSSION

7.1 FINDINGS OF DATA ANALYSIS

The results of the data analysis show the existing peak transit demand through the Highway 401 corridor is approximately 5,000 trips per hour. It should be noted that this represents the current demand based on the lack of a north Toronto rapid transit line. There may also be a latent or "hidden" demand for this type of service that cannot be specifically measured since no-such service is in place.

For future conditions, considering existing transportation infrastructure in the City is maintained, the outputs from the EMME/2 model suggest that the future peak transit demand in the corridor will be approximately 10,000 trips per hour. However, as noted in **Section 6.2**, future travel forecasts do not take into account the creation of mobility hubs or strategic growth patterns identified in the Places to grow strategy. Should these initiatives be implemented, it is expected that future travel and transit demands derived from the EMME/2 model would be would be underestimated.

The future EMME/2 model also assumed existing transportation infrastructure, meaning future travel demands in the corridor would have to be accommodated with existing infrastructure. However, Highway 401 and other parallel arterial roads are operating at or near capacity during peak periods today, and there is limited capacity available for additional road widenings to accommodate future demands.

Furthermore, the construction of other rapid transit lines throughout the GTA, including those recommended in the Transit City, MoveOntario 2020 and GO Transit's Inter-Regional BRT plan are also expected to increase the demands for transit service across north Toronto as direct east-west connection will be required to link these transit lines with north Toronto urban centre's.

Increasing gas prices and traffic congestion may also encourage more automobile drivers traveling through the Highway 401 corridor to use a rapid transit system across north Toronto, if it were available.

7.2 ADJUSTED DATA ANALYSIS

In order to get a rough estimate of future transit demands in the corridor assuming increased population and employment growth and intensification at north Toronto urban centre's, including the creation of mobility hubs, future trip forecasts were increased by 40% to represent the amount of future population and employment growth expected to occur in urban centre's as identified in the Places to Grow strategy. A minimum transit modal split of 30% was then applied to each urban centre as recommended for mobility hubs. Urban centre's with future transit modal splits already exceeding 30%, before adjustment, were maintained. The resulting adjusted travel demands in the Highway 401 corridor are illustrated in **Table 5.**

As illustrated in *Table 5* the adjusted AM peak hour future regional transit demands in the corridor would range between 7,000 trips per hour travel demands in the corridor to 22,000 trips per hour. The highest demand would occur on segments 1 to 6, Pearson International Airport and the Scarborough Centre, with hourly transit demands ranging between 13,000 and 22,000 trips per hour. This range is similar to those projected in the GO ALRT program, which estimated 15,000 to 25,000 passengers per hour by 2031.

However, these adjustments do not consider the construction of other rapid transit lines in the GTA. The impact these additional transit lines may have on a north Toronto will not be able to be directly measured until they are constructed. However, it is expected that they would further increase the ridership demand on the north Toronto line. Furthermore, given the impact higher-order transit lines have had in other regions such as the San Francisco Bay Area, Paris and Calgary, ridership may increase even more.

However, in order to remain conservative and consistent with the adjustments made to the data used in this study, a demand of 13,000 to 22,000 trips per hour would be expected between Scarborough Centre and Pearson International Airport / Airport Corporate Centre. This demand would be best served by a LRT metro line between Scarborough Centre and Pearson International Airport, while the demand east of Scarborough Centre, which is in the range of 7,000 trips per hour, would be best served by a BRT system.

Table 5: Adjusted Future Travel Demands in the Highway 401 Corridor

Trips on Highway 401 Originating from or Destined To	SEGMENT 1	Screenline: City of Toronto Western City Limit	SEGMENT 2	Screenline: Humber River	SEGMENT 3	Screenline: Allen Road	SEGMENT 4	SEGMENT 5	Screenline: Victoria Park Avenue	SEGMENT 6	SEGMENT 7	Screenline: City of Toronto Eastern City Limit	SEGMENT 8
	External Areas North and West of Toronto		PD9, PD8		PD10, PD3		PD11, PD4	PD12, PD5		PD16, PD13	PD16, PD15		External Areas North and East of Toronto
TOTAL ADJUSTED TRIPS	43.967		50,210		74,411		57,365	37,415		31.088	16.106		7.107
ADJUSTED TRANSIT TRIPS	13,190		15,063		22,323		17,210	11,224		13.990	9.986		2.132
ADJUSTED TRANSIT MODAL SPLIT	30%		30%		30%		30%	30%		45%	62%		30%

7.3 RECOMMENDED TRANSIT TECHNOLOGY

Based on findings of the original data analysis from the EMME/2 model, future 2031 peak transit demands in the corridor would be approximately 10,000 trips per hour. Based on the findings of the literature review, this demand could be accommodated by a bus rapid transit system stretching across north Toronto.

However, based on the findings of the adjusted data analysis, the expected peak hour transit demand in the Highway 401 corridor would at least be in the range of 13,000 to 22,000 trips per hour between Scarborough Centre and Pearson International Airport, and 10,000 to 2,000 trips per hour east of the Scarborough Centre. These transit demands would be best served by a LRT-metro line between Scarborough Centre and Pearson International Airport and a BRT line east of Scarborough Centre, similar to the Tyne and Wear Metro *(see Section 3.3.3).* It is recommended that the LRT-metro option be considered for a north Toronto transit line, based on expected future development patterns.

7.4 RECOMMENDED ALIGNMENT

Although the proposed north-Toronto rapid transit line is meant to serve trips in the Highway 401 corridor, it is not recommended that the transit route's alignment be constructed along Highway 401. Highway 401 does not directly serve many of the urban centres in the north Toronto corridor. Rather, it runs in close proximity to them, requiring a short drive off the highway to access them. This is not a problem for automobile drivers, however, this situation can be problematic for transit users as the distances between the Highway and urban centre's can be very far to walk to (e.g. greater than 15 minutes). In addition, stations located along highways or in highway medians, such as those on the TTC's Spadina subway line between Eglinton West and Wilson Station's, are often difficult to access, especially for walk in traffic. They are completely reliant on feeder transit service to bring people into the station. Station environment can also be unpleasant and noisy due to the presence of high-speed automobile traffic on the adjacent highway. Furthermore, there are limited opportunities to construct a rapid transit line along Highway 401 between Scarborough Centre and the Pearson International Airport due a lack of horizontal space from adjacent properties and undesirable vertical alignments alongside the Highway and at interchanges.

As indicated in the literature review, the most successful transit systems were the one that provided direct service and access to major destinations. Referring back to the findings of the literature review, available rights-of-way at grade were utilized wherever possible to minimize construction costs. However, this is only beneficial if those rights-of-way provide direct access to major destinations along a route.

Keeping this in mind, a conceptual route plan was devised for the north Toronto rapid transit line, utilizing available rights-of-way and providing the most direct access to north Toronto urban centres. The conceptual route is illustrated in **Figure 16**, including recommended station locations.

Starting from east to west, the proposed LRT line begins from Centennial College, proceeding in a short tunnel beneath Markham Road to a point southwest on Progress Avenue, continuing on grade along an abandoned railway alignment to the vicinity of the Scarborough Rapid Transit's (SRT) train yard. From this point, it continues on an elevated either parallel to or above the existing SRT serving Scarborough Town Centre. The route continues west on an elevated structure parallel to the SRT line beyond Midland Avenue, where it would turn north and continue at grade along joint CN Rail / GO Transit trackage. The possibility for the LRT line to share trackage with GO Transit and CN rail line should be examined as LRT technology allows for this type of joint use. At present there is a single CN/GO rail line is single-tracked and would have to be doubled to accommodate the LRT line.

The LRT line would continue north at grade and turn west through the Finch Avenue hydro corridor, following the corridor as far west as the Etobicoke North GO Station located near Kipling Avenue and Belfield Road. A preliminary examination of the Finch Hydro corridor suggests that a combination of at-grade, below-grade and elevated structures would be required for the LRT line in the hydro corridor due to the existing topography and the number of structures that would need to be crossed. A detailed design study would be required to determine the appropriate construction methods along this segment of the route.

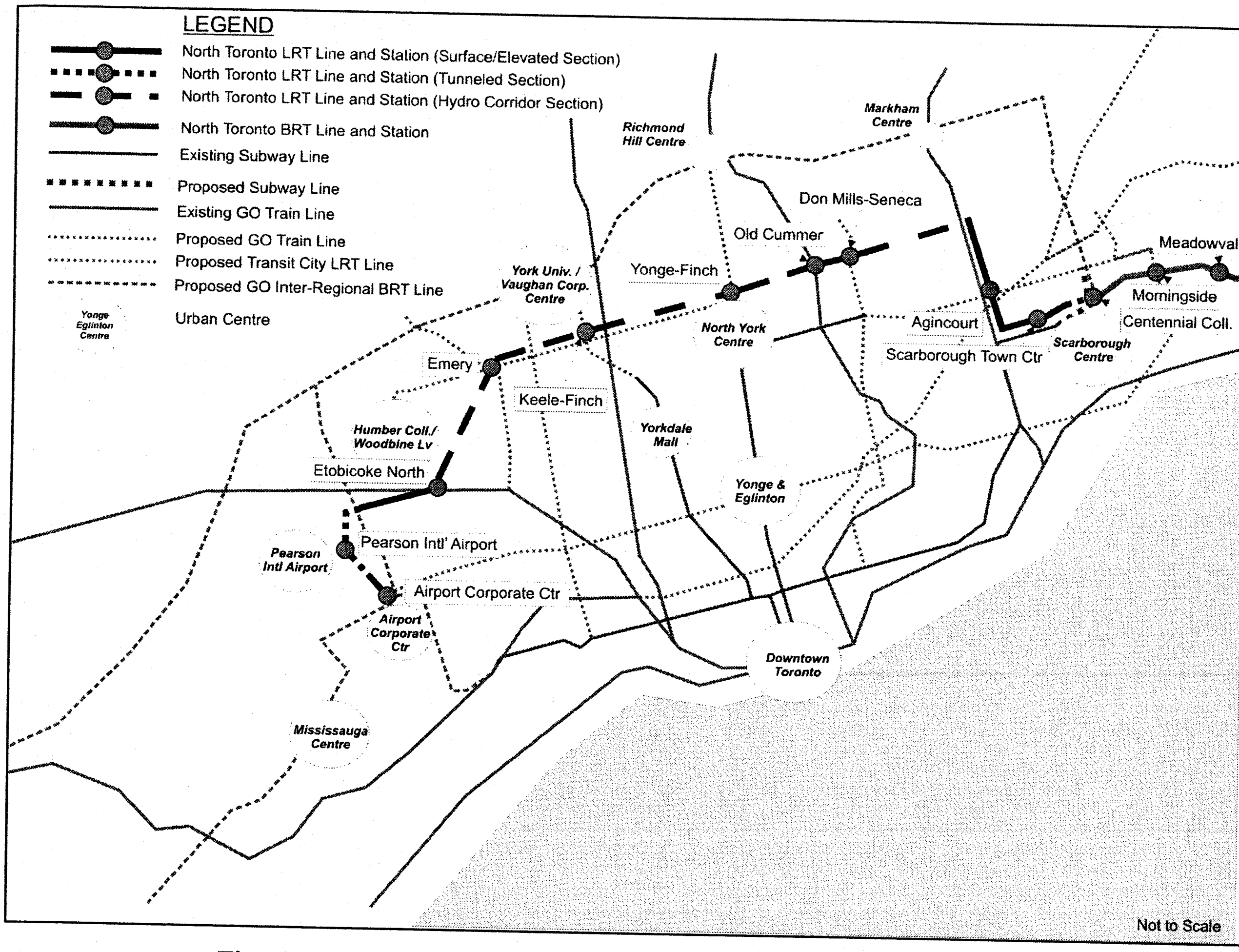


Figure 16: Recommended Alignment of Cross-Town Rapid Transit Line

Beyond the Etobicoke North GO Station, the proposed transit line would continue west direction via Renforth Road on an elevated structure, then parallel Highway 409 into the Pearson International Airport lands. The line would then proceed southwest through a tunnel with a station provided at Terminal 1. The last segment of the route would proceed in a southerly direction in a tunnel, emerging either at grade or in an open cut at Renforth Drive and Eglinton Avenue West. A major bus terminal is proposed at this location as part of GO Transit's Inter-Regional BRT line.

This alignment would provide a direct connection between Scarborough Centre, North York Centre, Pearson International Airport and the Airport Corporate Centre. Connections would also be provided at many existing rapid transit lines in the City such as the Yonge Subway line, the Scarborough RT, the Georgetown, Richmond Hill and Stoufville GO Train lines. This LRT line would also provide connections to other proposed rapid transit lines such as the Spadina subway line's extension to York University and Vaughan, the Bolton GO Train line and TTC's Finch West, Sheppard East and Eglinton LRT lines as well as GO Transit's Inter-Regional BRT line at Centennial College and the Airport Corporate Centre. These connections would allow for quick access off of the LRT line to other destinations that area not directly served by the route, including York University, Humber College, Woodbine Live, Yorkdale Mall, Yonge & Eglinton and downtown Toronto.

For the BRT section between Centennial College and Pickering, the alignment already recommended in GO Transit's Inter-regional BRT initiative can be assumed. This alignment includes an exclusive busway between Centennial College and Morningside Avenue, and the use of shoulder lanes on Highway 401 between Morningside Avenue, continuing east into Pickering. This BRT segment should be constructed in a way that allows for future conversion to LRT if ridership demands east of Centennial College increase.

This route is conceptual and a more detailed environmental assessment of the proposed route would have to undertaken to look at additional factors such as ground and soil conditions, noise impacts, socio-economic impacts and utility relocation for example.

7.5 RECOMMENDED NETWORK OPERATING STRUCTURE

Station spacing on the proposed north Toronto LRT line is every 3.8 km on average. It is recommended that local service be provided on the route with all trains stopping at every station. Based on the expected ridership levels and the limited number of stations along the route, express trains or overlapping "bundled" route structures would not be required for this service. This will allow for basic regular schedules to be maintained, avoiding the scheduling difficulties associated with overlapping services.

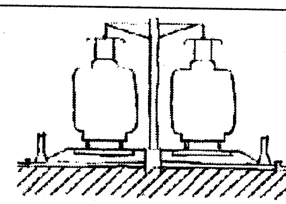
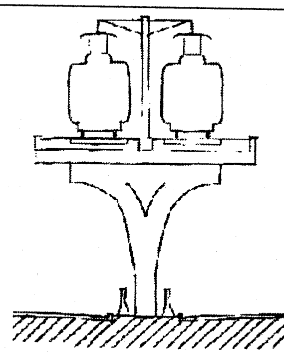
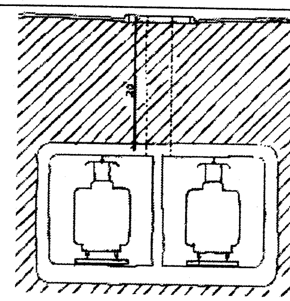
Using a vehicle with a similar capacity to those used on the Tyne and Wear Metro *(see Section 3.3.3)* and assuming a maximum capacity of 230 passengers per car, it is expected that 4 car trains operating every 2.5 minutes, or 6-car trains operating every 4 minutes would be able to handle the anticipated peak demand.

With a route length of approximately 42 km and an average station spacing of 3.8 km, and using a vehicle capable of speeds of up to 120 km/h, (as proposed in the GO ALRT program), it is anticipated that vehicles would operate at an average speed of 70 km/h, taking 36 minutes to travel between the Airport Corporate Centre and Scarborough Centre. The anticipated one-way travel time on the BRT portion of the route between Centennial College and the Scarborough-Pickering border is about 8 to 10 minutes.

7.6 ESTIMATED COST OF RAPID TRANSIT LINE

To give a rough estimate of the total capital cost of the LRT line, the unit costs listed in **Table 6** were assumed. These unit costs are typical LRT construction costs, but may vary between different areas. They are provided to give a rough estimate of the LRT construction costs. A more detailed cost estimate would have to be derived during a detailed design exercise which is beyond the scope of this project.

Table 6: LRT Construction Unit Costs

Construction Method	Unit Cost (Million $ / km)	Example
At Grade	$10	
Elevated Structure	$40	
Below Grade / Tunnel	$145	

Source: "Comparing LRT and Subway Construction Costs", Retrieved 25 August, 2008 from the Toronto LRT Information Page at www.lrt.daxack.ca

Approximately 24.5km of the proposed route is located in the Finch hydro corridor. This portion of the route would require a combination of at grade, elevated and below grade construction. Due to the lack of a detailed design study, to remain conservative, these three construction methods were assigned equally to one-third of the 24.5 km segment. Applying the unit costs listed from *Table 6*, the cost of the hydro corridor segment of the route would be $1.6 billion.

The remaining 17.5 km of the route, outside of the hydro corridor, include 4 km of tunneled sections, 10 km of elevated sections and 3.5 km of at-grade construction. Again, applying the unit costs listed from Table 6, the cost of the remaining portion of the route would be approximately $1 billion.

The GO Transit Inter-Regional BRT initiative indicates that the capital cost of the BRT portion between Centennial College and Pickering would be $56.8 million,[119] which translates to approximately $43 million dollars between Centennial College and the Scarborough-Pickering Border.

Therefore, a rough estimate of the total capital cost of the proposed cross-town LRT would be in the magnitude of $2.6 billion dollars, while the BRT segment would be $43 million, equating to a total cost of $2.643 billion dollars.

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[119] Mc Cormick Rankin Corporation "GO Transit Inter-Regional BRT Service" Report, Table 1.1 BRT Spine Line Infrastructure Cost ($Million) p.6

8.0 SUMMARY AND CONCLUSIONS

8.1 SUMMARY OF FINDINGS

Highway 401 is North America's busiest highway and is heavily congested in north Toronto during both peak and off-peak hours. With an additional 3.7 million people expected to move into the GTA by 2031, traffic demands in north Toronto will undoubtedly increase. In an effort to reduce traffic congestion and accommodate future traffic demands in the GTA, numerous studies and initiatives have been undertaken proposing new transit lines throughout the GTA to encourage alternative non-auto modes of travel. Few of these proposals have identified a rapid transit line across north Toronto. Many major regional destinations are located in north Toronto in close proximity to Highway 401, such as Pearson International Airport, York University, North York Centre and Scarborough Centre and there is no direct rapid transit line connecting them. This paper examined the feasibility of implementing a higher-order regional rapid transit line across north Toronto, connecting all of these destinations.

This project included background information on the study area, a literature review of existing regional rapid transit technologies and applications throughout the world as well as existing transit services in the north Toronto area, past and present transit proposal in GTA, a data analysis of existing and future traffic and transit demands along the Highway 401 corridor and a recommended regional rapid transit line across North Toronto, *including the technology type, a conceptual route and estimated the cost.*

8.1.1 Summary of Literature Review

The literature review examined various regional applications heavy rail transit, (HRT), light rail transit (LRT) and bus rapid transit. The findings of the literature review showed that HRT can yield the highest ridership levels and provide the highest quality of service when compared to LRT and BRT; however it can be costly to construct and is only appropriate when transporting in excess of 20,000 people per hour. LRT is suitable for transporting between 15,000 and 25,000 persons per hour and is typically less costly than HRT systems. BRT systems are usually less costly than LRT systems and are typically designed to transport less than 10,000 persons per hour. The most successful applications of regional rapid transit networks were those that provided the most direct connections between major urban and suburban centres.

8.1.2 Summary of Existing Transit Services in the GTA

The review of the existing transit systems in the Greater Toronto Area (GTA) showed that there are no cross-town rapid-transit services in north Toronto in the vicinity of Highway 401. The only regional transit operator GO transit, provides heavy rail rapid transit service in and out of downtown Toronto. Regional buses serving destinations in north Toronto operate in mixed traffic, are infrequent and are subjected to the same delays experienced by other road users.

8.1.3 Summary of Background Studies

The review background studies for past and present development proposals and transit initiatives identified two studies recommending a regional rapid transit line across north Toronto. They were GO ALRT program of the 1980's, which was cancelled in 1985 due to a change in federal legislature and the high cost, and the Metrolinx Regional Transportation Plan, which is still in draft and is scheduled for release in September 2008

The MoveOntario 2020 study released by the provincial government in 2007 recommended the construction of 52 separate transit projects throughout the GTA within the next 20 to 25 years. However, none of the 52 projects include a rapid transit line across north Toronto. Other transit initiatives such as TTC's Transit City plan and GO Transit's Inter-Regional BRT Initiative do not address rapid transit connections across north Toronto.

The "Places to Grow" strategy and the Metrolinx Regional Transportation reports both identify a series of urban centre's or mobility hubs where 40% of all future growth in the GTA will be concentrated. Major urban centres in North Toronto identified in these studies include Scarborough Centre, North York Centre, York University and Pearson International Airport, all of which are in close proximity to Highway 401. The proposed "Mobility Hubs" at these urban centre's will be areas of medium to high-density development, population and employment and will be fully integrated with both local and regional higher-order transit services. A minimum transit-modal split of 30% is desired at these locations.

8.1.4 Review of Existing and Future Data Analysis

Data from the 2001 Transportation Tomorrow Survey (TTS) was used to assess existing travel conditions in the Highway 401 corridor, including the current vehicular and transit demand for trips generated by north Toronto urban centres. The results from the TTS data suggest an AM peak hour trip demand of 3,000 to 25,000 trips throughout the corridor, with the busiest segment located between Scarborough Centre and York University. This demand is for trips originating from or destined to urban centres in north Toronto and does not include other trips traveling through the Highway 401 corridor. The existing AM peak hour transit demand is in the range of 900 to 5,600 trips per hour.

Data from the City of Brampton's EMME/2 model was used to assess future 2031 travel conditions in the Highway 401 corridor, including future auto and transit demand in the corridor. The results from this model suggested a future AM peak hour trip demand between 5,000 and 53,000 trips per hour. The peak hour transit demand would be in the range of 500 to 10,000 trips per hour. However, the EMME/2 model does not take into account the creation of mobility hubs or other strategic growth principles identified in the Places to grow strategy, thus underestimating the number of future trips that would be generated by these urban centres. Therefore, future travel demands in the corridor were adjusted to reflect the strategies recommended in the Places to Grow strategy and the Metrolinx Regional Transportation Plan. The adjusted AM peak hour trip demands in the corridor would increase to 7,700 and 53,000 trips per hour. Adjusted future AM peak hour transit demands would be in the range of 13,000 to 22,000 trips per hour between Scarborough Centre and the Pearson International Airport/Airport Corporate Centre, and 2,000 to 10,000 trips per hour between Scarborough Centre and the Scarborough-Pickering border.

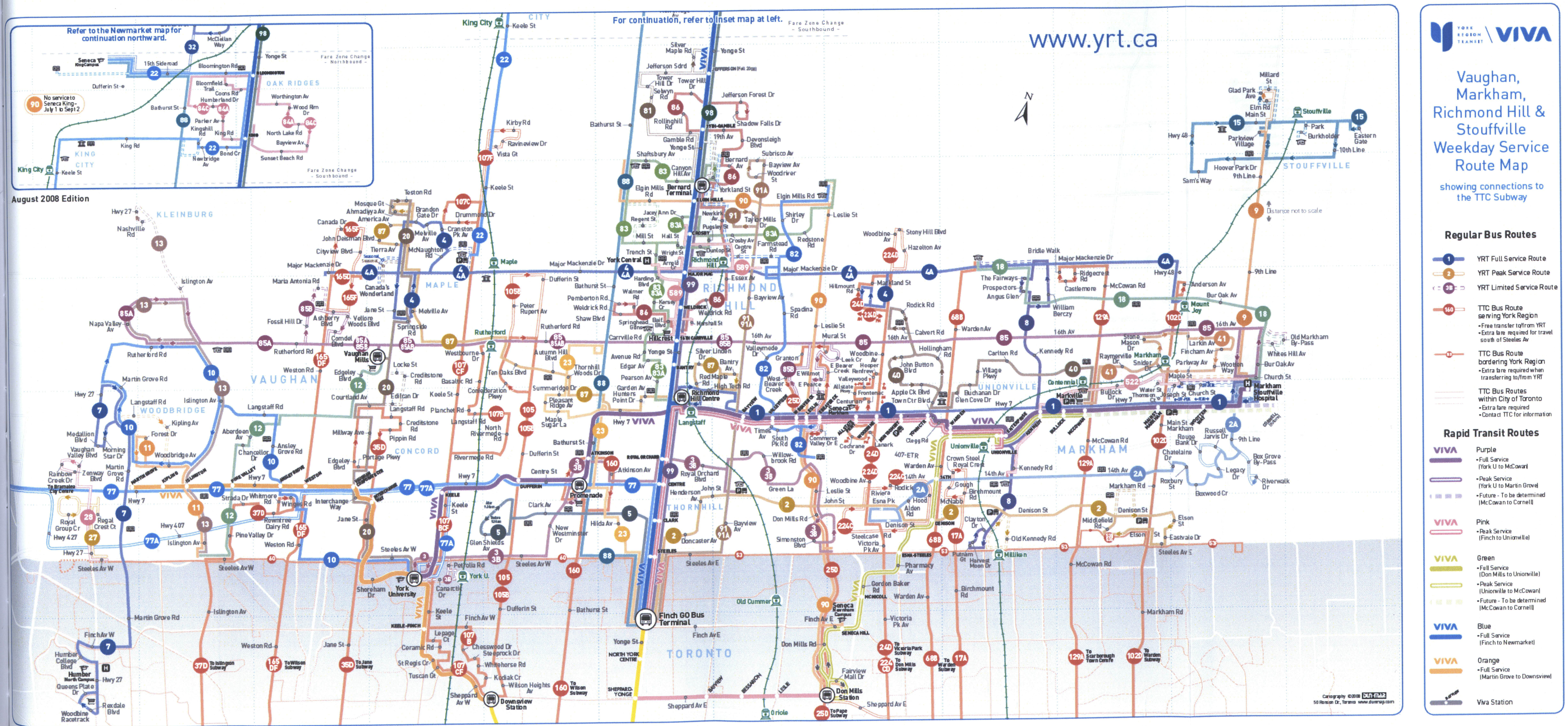
8.2 CONCLUSIONS AND RECOMMENDATIONS

Based on existing capacity constraints in the Highway 401 corridor and future transportation demands expected in the corridor, a Light Rail Transit "metro" line is recommended in north Toronto between the Scarborough urban Centre (Centennial College) and the Pearson International Airport / Airport Corporate Centre. A Bus Rapid Transit busway is recommended between Centennial College and Pickering. The estimated cost for these lines is $2.643 billion dollars.

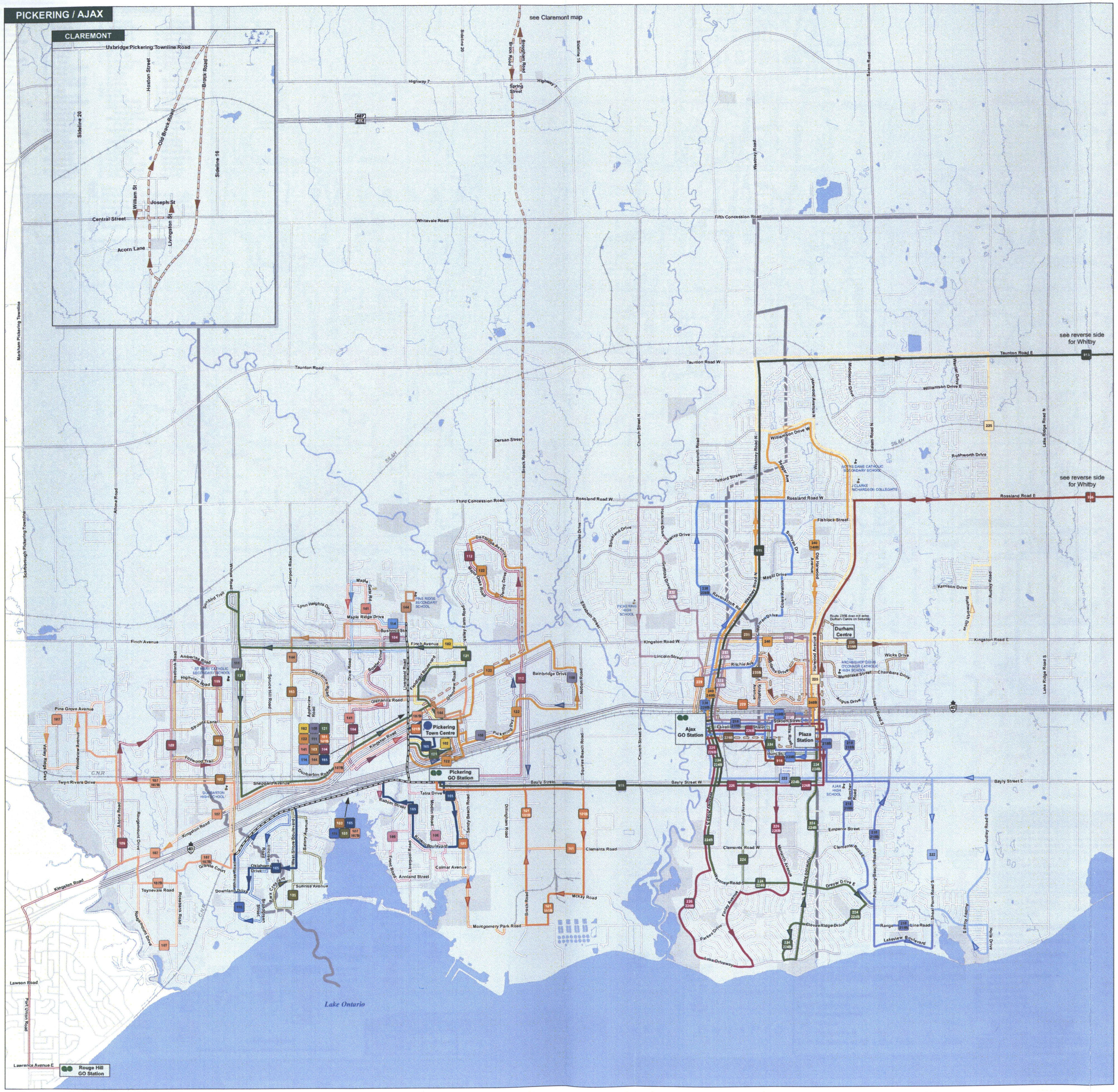
Although costly, transportation constraints in the north Toronto area suggest the need for additional transportation capacity in the corridor. With limited opportunities for road widening, the desire to encourag non-auto modes of transportation and to support the initiatives of the Places to Grow strategy and Metrolinx Regional Transportation plan, a rapid Regional Rapid Transit route across North Toronto is required. Based on the success of other Regional Rapid Transit systems in cities such as Paris, San Francisco and Calgary, it expected that the North Toronto Rapid Transit line would be of great benefit to the citizens of the Greater Toronto Area and will help to accommodate future travel demands in the City.

Appendix A

Existing Transit System Maps



Vaughan, Markham, Richmond Hill & Stouffville Weekday Service Route Map
showing connections to the TTC Subway
www.yrt.ca
August 2008 Edition
Regular Bus Routes
YRT Full Service Route
YRT Peak Service Route
YRT Limited Service Route
TTC Bus Route serving York Region
•Free transfer to/from YRT
•Extra fare required for travel south of Steeles Av
TTC Bus Route bordering York Region
•Extra fare required when transferring to/from YRT
TTC Bus Routes within City of Toronto
•Extra fare required
•Contact TTC for information
Rapid Transit Routes
VIVA Purple
•Full Service (York U to McCowan)
•Peak Service (York U to Martin Grove)
•Future - To be determined (McCowan to Cornell)
VIVA Pink
•Peak Service (Finch to Unionville)
VIVA Green
•Full Service (Don Mills to Unionville)
•Peak Service (Unionville to McCowan)
•Future - To be determined (McCowan to Cornell)
VIVA Blue
•Full Service (Finch to Newmarket)
VIVA Orange
•Full Service (Martin Grove to Downsview)
Viva Station
Refer to the Newmarket map for continuation northward.
For continuation, refer to inset map at left.
Fare Zone Change - Southbound -
Fare Zone Change - Northbound -
No service to Seneca King - July 1 to Sept 2
Distance not to scale
VAUGHAN
MAPLE
CONCORD
WOODBRIDGE
KLEINBURG
RICHMOND HILL
THORNHILL
MARKHAM
UNIONVILLE
STOUFFVILLE
TORONTO
OAK RIDGES
KING CITY
Finch GO Bus Terminal
Richmond Hill Centre
Downsview Station
Don Mills Station
York University
Markham Stouffville Hospital



Legend

Ajax / Pickering

Route	Name	am rush hour	midday	pm rush hour	evening	saturday	sunday
103	Amberlea	●		●			
240 240B	Applecroft	●	●	●		●	
222	Audley South	●		●			
225	Audley North	●		●			
106	Bay Ridges	●		●			
165	Bay Ridges & West Shore		●			●	
218 218B	Beach	●	●	●		●	
112	Brock Road	●		●			
	Claremont Community Bus		●	(Fri Only)			
226 226S	Duffins	●		●		●	
229	Elm	●		●			
111	Finch/HWY 2	●		●			
104	Glendale	●					
141	Glendale/Maple Ridge			●			
224 224B	Harwood	●	●	●		●	
101 101B	Industrial	●	●	●		●	
102	Liverpool	●		●			
121	Liverpool Finch/HWY2		●			●	
115	Lookout Point	●		●			
114	Maple Ridge	●					
144	Maple Ridge/Glendale		●			●	
235B	Puckrin Elm		●			●	
235	Puckrin	●		●			
107 107B	Rosebank	●	●	●		●	
916	Rossland ♿	●	●	●	●	●	●
109	Rouge Hill Shuttle	●		●			
915	Taunton ♿	●	●	●	●	●	●
232 232B	Village	●	●	●		●	
108	Village East	●		●			
122	Village East/Brock Road		●			●	
105	West Shore	●		●			
220 220B	Westney	●	●	●		●	

Note: Please refer to the schedule booklet for additional bus route and schedule information.

Regular
Rush Hour
Limited
Multiple Routes

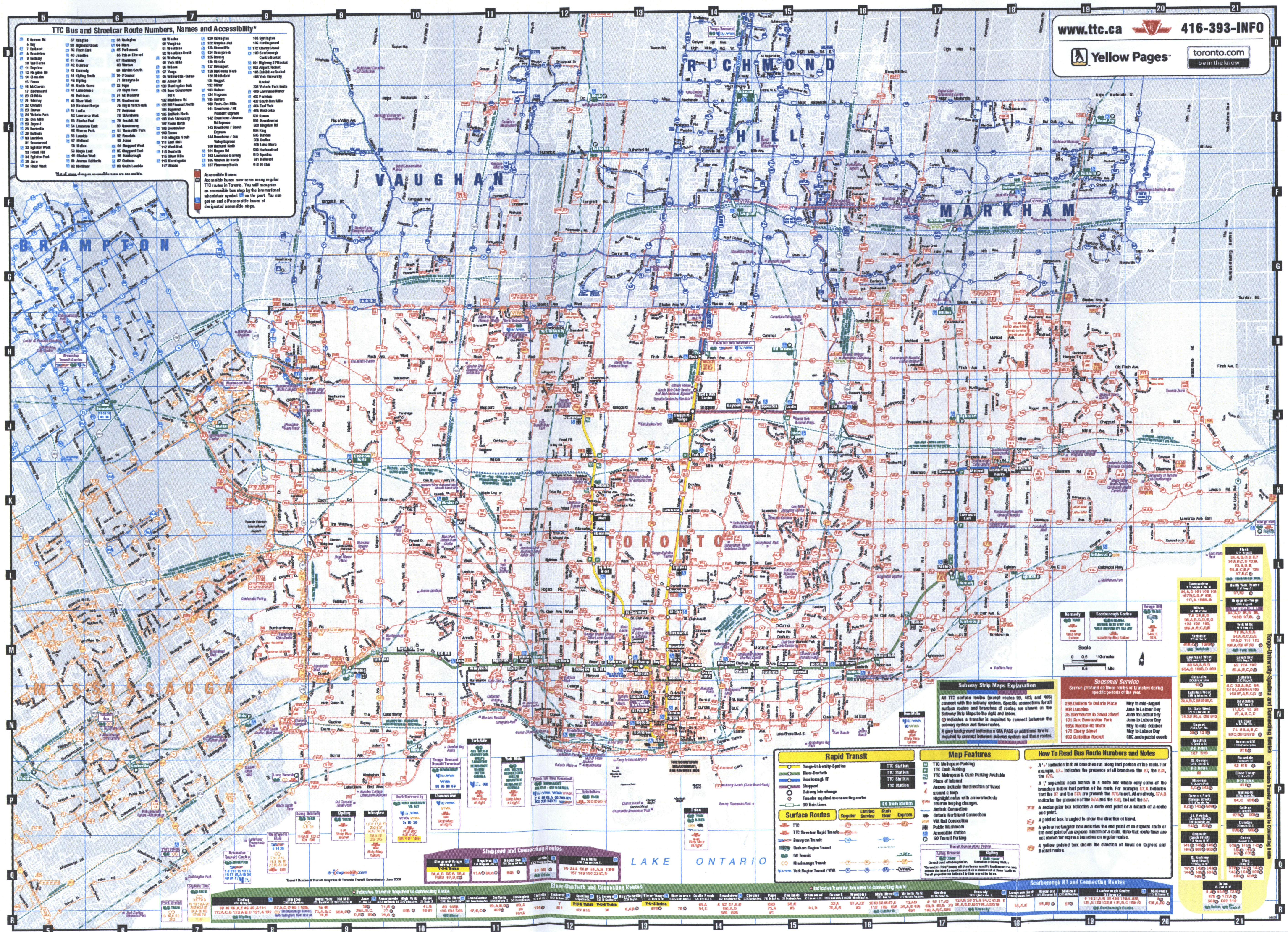
Alternative / Private
Catholic Secondary
Public Secondary
College
Accessible Bus (Not all stops accessible)
F.A.R. (Fully Accessible Route)

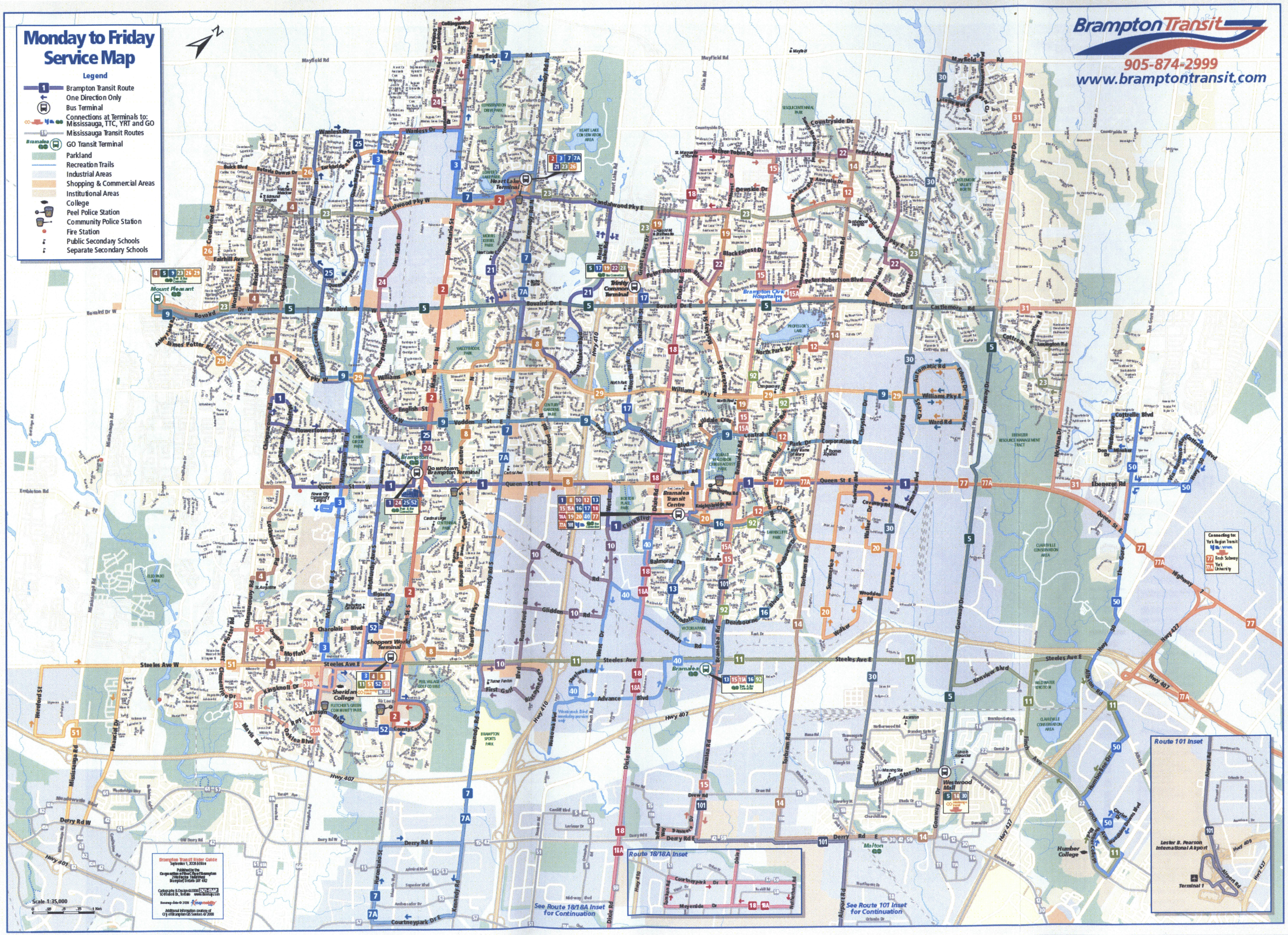
Railway
Highways
Arterials
Collectors
Locals

DurhamRegion Transit

AJAX - PICKERING

Effective July 28, 2008


TTC Bus and Streetcar Route Numbers, Names and Accessibility*
www.ttc.ca
416-393-INFO
Yellow Pages
toronto.com
be in the know
RICHMOND
HILL
VAUGHAN
MARKHAM
BRAMPTON
TORONTO
MISSISSAUGA
LAKE ONTARIO
Subway Strip Maps Explanation
Seasonal Service
Rapid Transit
Map Features
How To Read Bus Route Numbers and Notes
Surface Routes
Sheppard and Connecting Routes
Bloor-Danforth and Connecting Routes
Scarborough RT and Connecting Routes

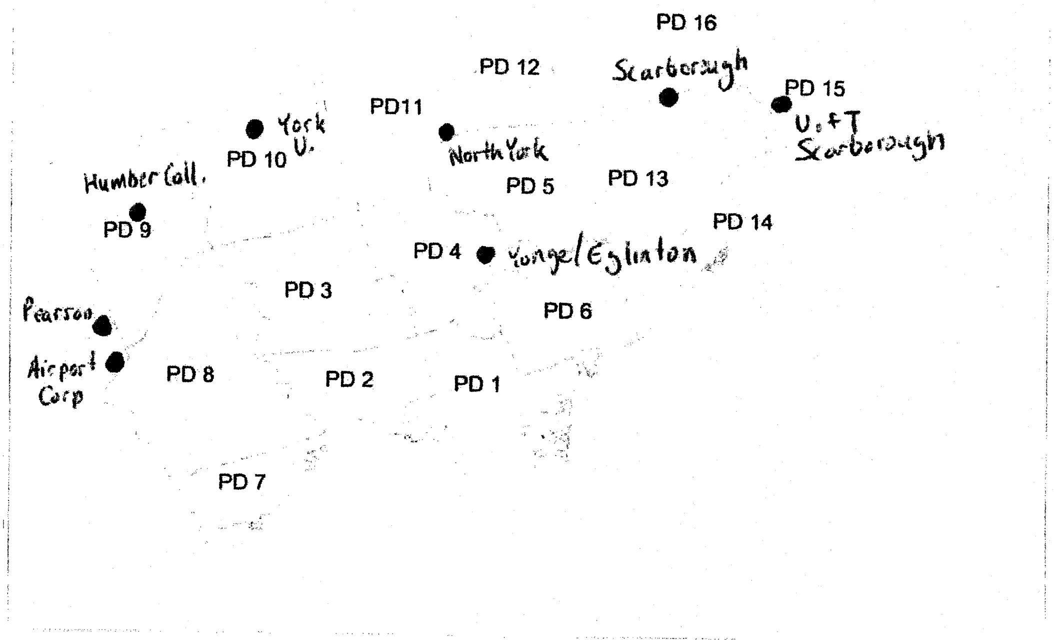

Monday to Friday Service Map
Legend
Brampton Transit Route
One Direction Only
Bus Terminal
Connections at Terminals to: Mississauga, TTC, YRT and GO
Mississauga Transit Routes
GO Transit Terminal
Parkland
Recreation Trails
Industrial Areas
Shopping & Commercial Areas
Institutional Areas
College
Peel Police Station
Community Police Station
Fire Station
Public Secondary Schools
Separate Secondary Schools
Brampton Transit
905-874-2999
www.bramptontransit.com
Route 101 Inset
Route 18/18A Inset
See Route 18/18A Inset for Continuation
See Route 101 Inset for Continuation
Downtown Brampton Terminal
Bramalea Transit Centre
Shoppers World Terminal
Heart Lake Terminal
Trinity Common Terminal
Mount Pleasant
Sheridan College
Humber College
Westwood Mall
Malton
Bramalea
Lester B. Pearson International Airport
Terminal 1
Queen St E
Steeles Ave E
Steeles Ave W
Bovaird Dr W
Bovaird Dr E
Sandalwood Pky E
Williams Pky E
Mayfield Rd
Countryside Dr
Castlemore Rd
Hwy 407
Hwy 410
Hwy 427
Hwy 401
Derry Rd E
Courtneypark Dr E


Mississauga Transit
weekday service map
Scale 1:38 500 (approx.)
0 1/2 1 Kilometre
0 1/4 1/2 Mile
Legend
Regular Route (SOLID LINE)
Rush Hour (Peak) Route (LONG DASHED LINE)
Express Rush Hour Route (HIGHLIGHTED PINK LINE)
Express Route (HIGHLIGHTED GOLD LINE)
Limited Service Routes (SHORT DASHED LINE)
GO Train Shuttle (DOTTED LINE)
City Centre Shuttle
Multiple Routes on Street (IN CONGESTED AREAS OF MAP)
Route Terminal
Route with Accessible Buses
Route Direction
Major Bus Stop (WITH STOP NUMBER & DIRECTION)
Oakville Transit Route
Brampton Transit Route
TTC Route
TTC Bloor-Danforth Subway
GO Train & Station
Major Shopping Centres
Dixie Outlet Mall R 15
Erin Mills Town Centre J 4
Meadowvale Town Centre D 4
Rockwood Mall L 16
Sheridan Centre Q 4
Sherway Gardens Q 17
South Common Centre M 4
Square One L 11
Westdale Mall N 6
Westwood Mall B 22
Woodbine Centre E 24
Hospitals
Credit Valley Hospital K 5
Trillium Health Centre Q11/Q16
University & College
Humber College U17/B24
University of Toronto at Mississauga (Erindale Campus) N 6
Sheridan College A 11
Community Centres
Public High Schools
Separate High Schools
Lake Ontario
Streetsville
Malton
Clarkson
Port Credit
Erin Mills
Lester B. Pearson International Airport
City Centre Transit Terminal
Square One
Islington
Kipling

Appendix B

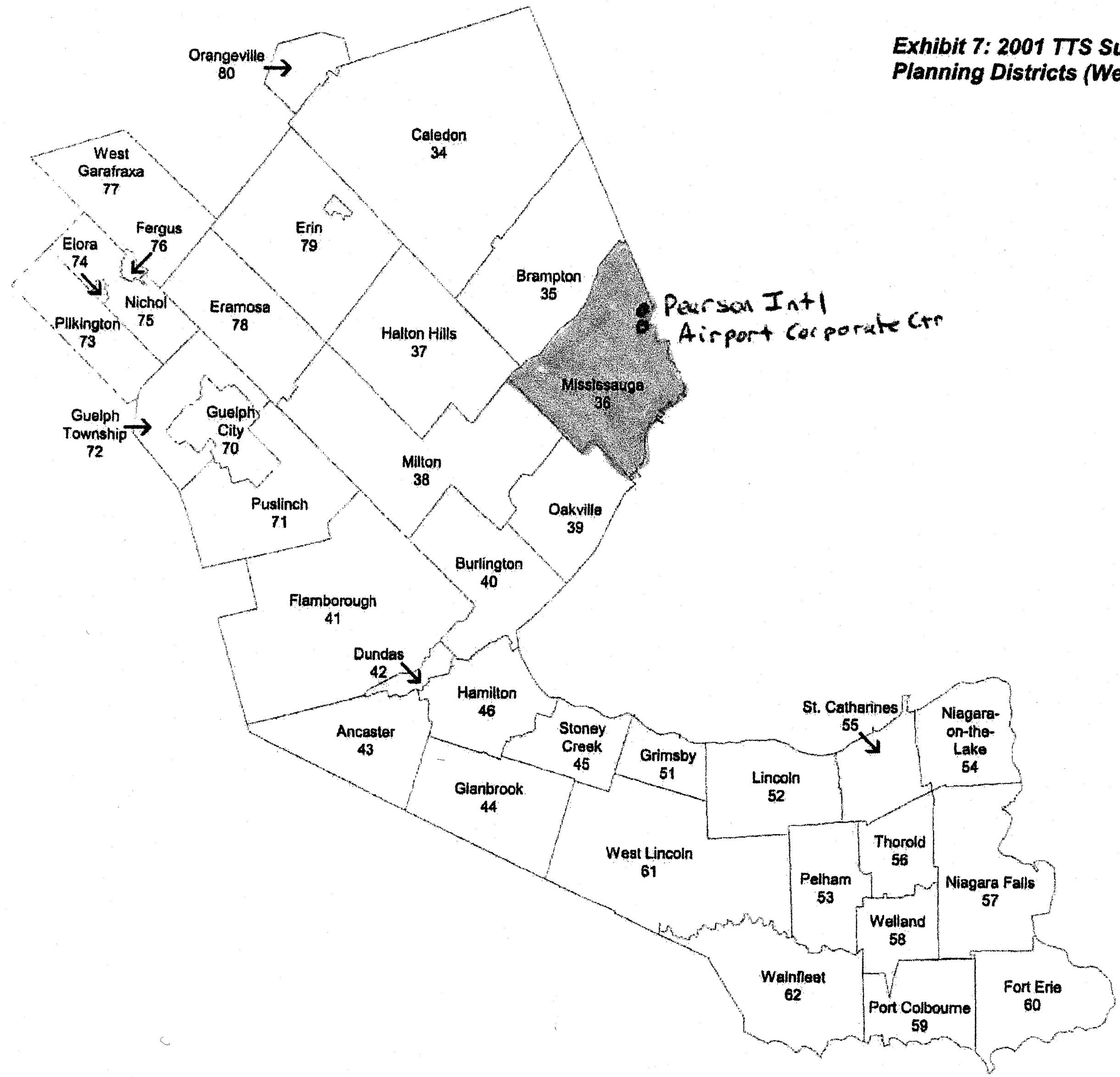
North Toronto Planning Districts and Traffic Zones

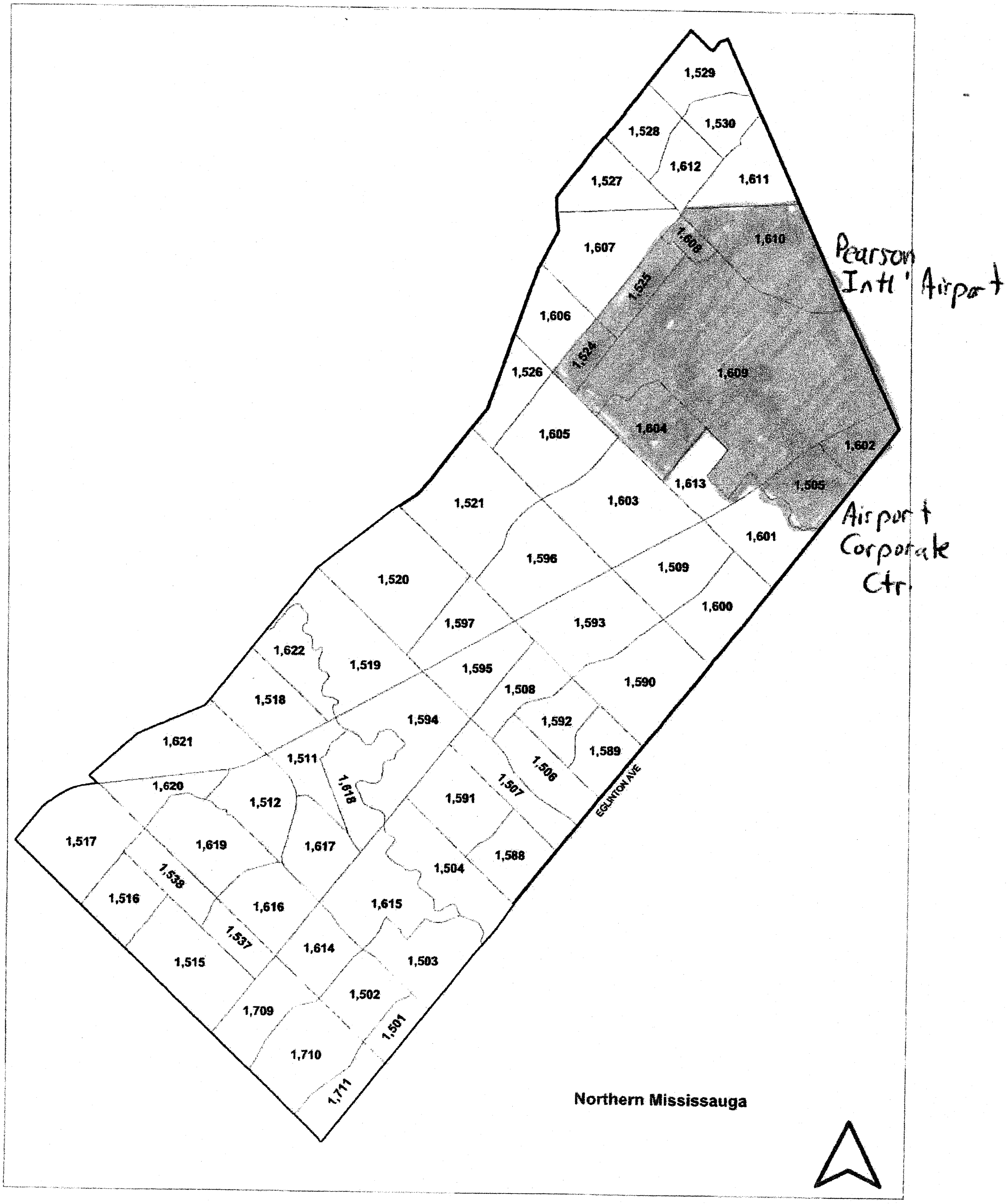
Exhibit 5: 2001 TTS Survey Area Planning Districts (City of Toronto)



• Urban Centre

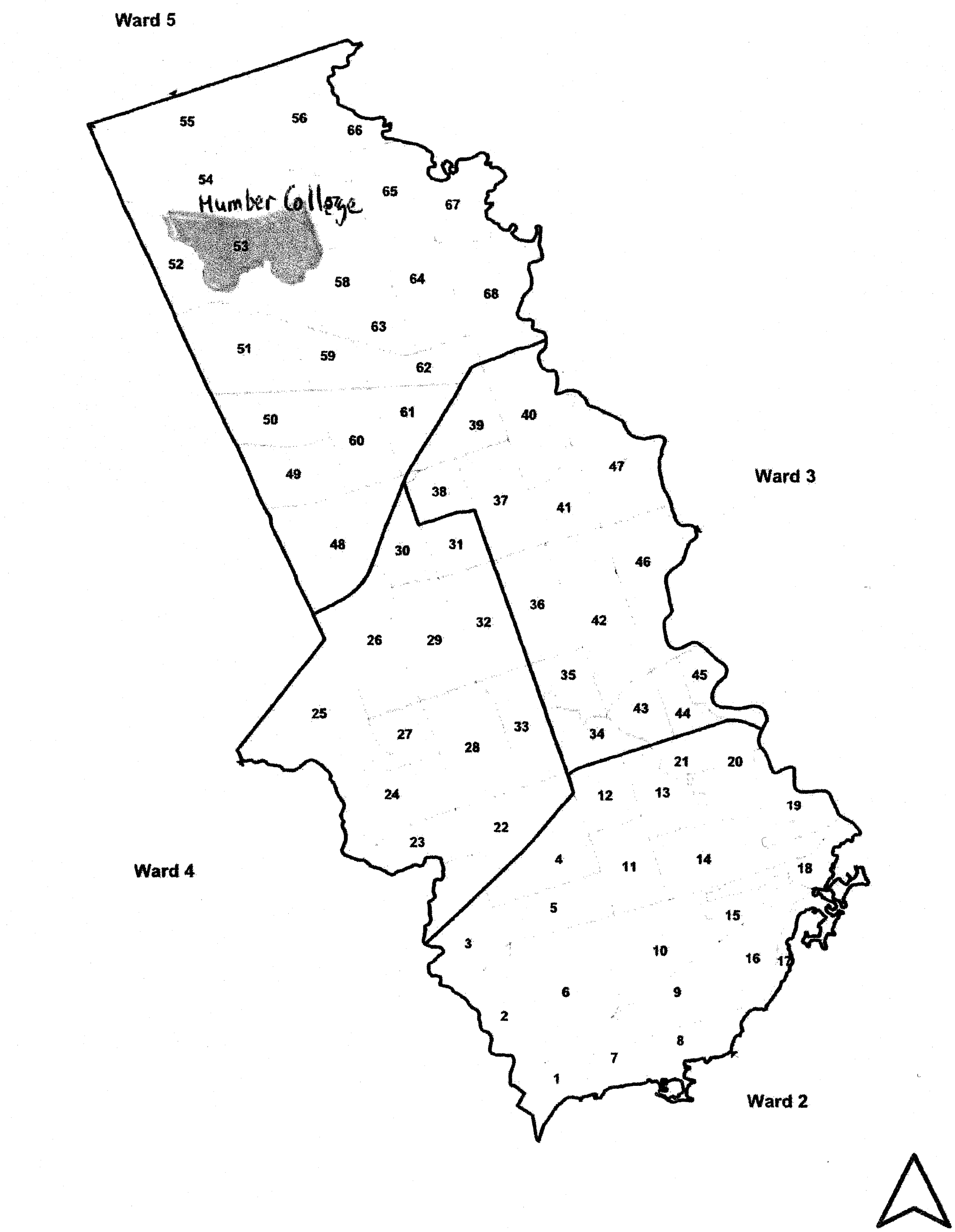
Exhibit 7: 2001 TTS Survey Area Planning Districts (Western Half)





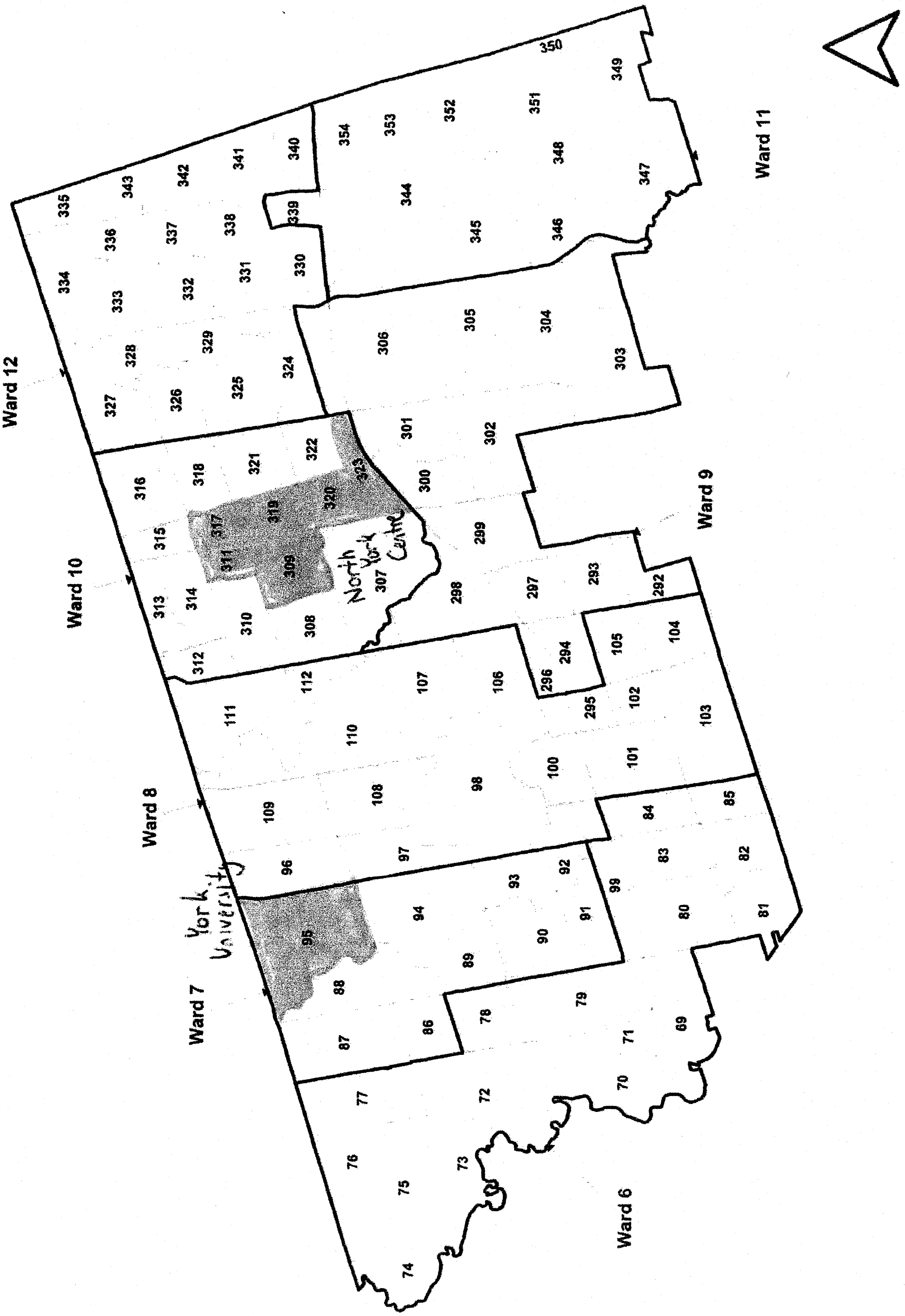
1996 GTA TRAFFIC ZONES
PEEL REGION

JOINT PROGRAM IN TRANSPORTATION
UNIVERSITY OF TORONTO



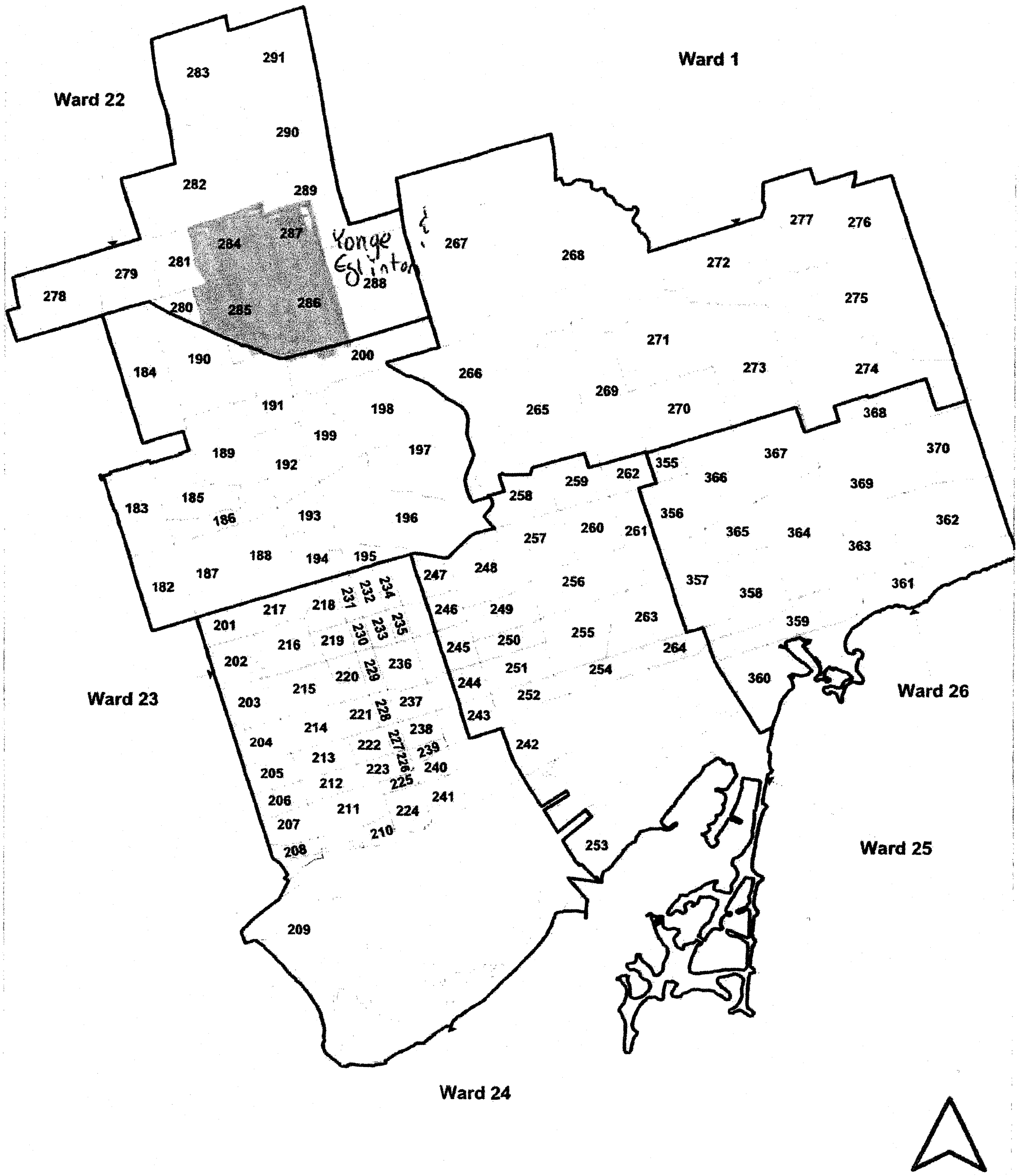
1996 GTA TRAFFIC ZONES
CITY OF TORONTO

JOINT PROGRAM IN TRANSPORTATION
UNIVERSITY OF TORONTO



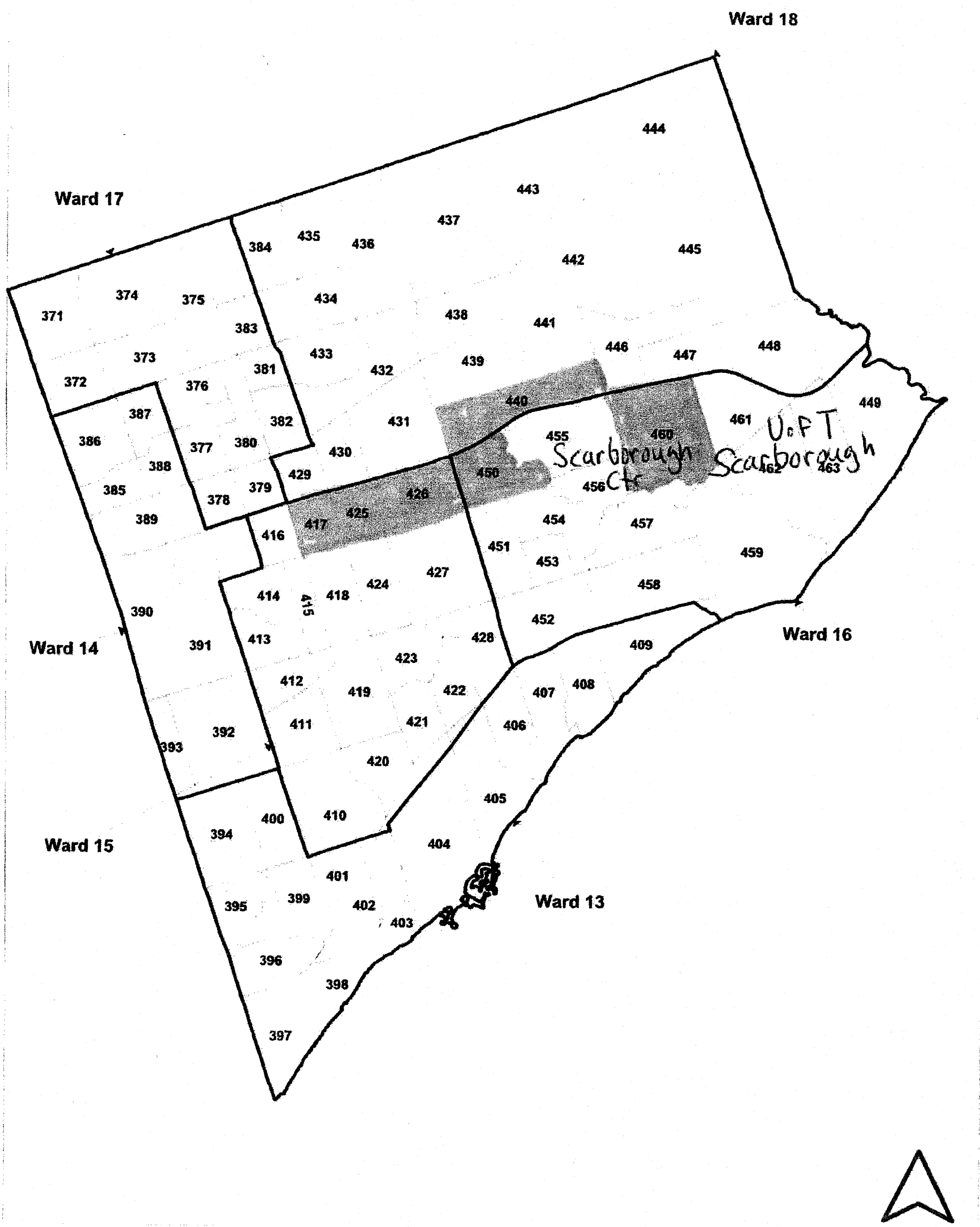
1996 GTA TRAFFIC ZONES
CITY OF TORONTO

JOINT PROGRAM IN TRANSPORTATION
UNIVERSITY OF TORONTO



1996 GTA TRAFFIC ZONES
CITY OF TORONTO

JOINT PROGRAM IN TRANSPORTATION
UNIVERSITY OF TORONTO



1996 GTA TRAFFIC ZONES
CITY OF TORONTO

JOINT PROGRAM IN TRANSPORTATION
UNIVERSITY OF TORONTO

Appendix C

TTS Data (Outputs)

Existing 2001 Total Trips Summarized by Planning Districts			
Mississauga (PD 36)	Auto Trips	Transit Trips	Total
IN	133,641	13,439	147,079
OUT	140,425	6,511	146,936
PD 9 (Humber College)	Trips	Transit Trips	Total
IN	17,174	2,977	20,151
OUT	22,613	2,592	25,205
PD 10 (York University)	Trips	Transit Trips	Total
IN	25,674	6,411	32,084
OUT	34,890	6,578	41,468
PD 11 (North York)	Trips	Transit Trips	Total
IN	34,269	8,598	42,867
OUT	36,057	6,897	42,953
PD 4 (Yonge & Eglinton)	Trips	Transit Trips	Total
IN	47,652	13,114	60,766
OUT	44,832	12,782	57,614
PD 13 & 16 (Scarborough)	Trips	Transit Trips	Total
IN	82,615	19,717	102,331
OUT	77,398	11,370	88,768
PD 15 (U of T Scarborough)	Trips	Transit Trips	Total
IN	16,716	3,094	19,810
OUT	10,612	1,332	11,943

Existing 2001 Travel Patterns Summary by Urban Centre Traffic Zones Districts			
Pearson Intl' Zones	Auto Trips	Transit Trips	Total
IN	1,011	61	1,071
OUT	5,446	103	5,548
Humber College Zones	Trips	Transit Trips	Total
IN	2,112	270	2,382
OUT	4,140	886	5,026
York University Zones	Trips	Transit Trips	Total
IN	1,943	599	2,542
OUT	6,756	2,144	8,900
North York Centre Zones	Trips	Transit Trips	Total
IN	9,919	2,491	12,409
OUT	15,537	3,012	18,549
Yonge & Eglinton Zones	Trips	Transit Trips	Total
IN	8,568	3,548	12,115
OUT	10,910	4,386	15,296
Scarborough Ctr Zones	Trips	Transit Trips	Total
IN	3,113	676	3,788
OUT	9,281	1,784	11,064
U of T Scarborough Zones	Trips	Transit Trips	Total
IN	1,447	178	1,624
OUT	1,391	225	1,616

Percentage of Total Trips Generated by Urban Centre Traffic Zones		
Pearson International Airport (PD 36)	Auto Trips	Transit
IN	1%	0%
OUT	4%	2%
Humber College (PD 9)	Trips	Transit
IN	12%	9%
OUT	18%	34%
York University (PD 10)	Trips	Transit
IN	8%	9%
OUT	19%	33%
North York Centre (PD 11)	Trips	Transit
IN	29%	29%
OUT	43%	44%
Yonge & Eglinton (PD 4)	Trips	Transit
IN	18%	27%
OUT	24%	34%
Scarborough Town Centre (PD 13 & 16)	Trips	Transit
IN	4%	3%
OUT	12%	16%
UofT Scarborough (PD 15)	Trips	Transit
IN	9%	6%
OUT	13%	17%

Appendix D

EMME/2 Data (Outputs)

□(s0p15H□&l6C

EMME/2	Module:	3.14	Date:	2007DE28	14:32	User:	E760/iTRA	Page:	3011
Project:	YRTP	Model	Version	1.1					
Matrix	mf70:	TotTrp	AM	Pk	Pd	Total	Trips	(mf7+8+43+44+45+46)	

Matrix mf70: TotTrp (AM Pk Pd Total Trips (mf7+8+43+44+45+46))

Ensemble:	gp:	Planning	District	2003DE04	14:32
Aggregation:	sum				

	destination groups / origin groups	gp00	gp01	gp02	gp03	gp04	gp05	gp06	gp07	gp08	gp09	gp10
		gp00	gp01	gp02	gp03	gp04	gp05	gp06	gp07	gp08	gp09	gp10
Toronto	gp00	0	5072	339	930	1297	772	285	354	1803	2520	3408
	gp01	775	39325	7119	4362	11036	2724	6769	1061	2261	767	2149
	gp02	544	35015	15056	5212	4559	1244	1404	928	4387	1248	2025
	gp03	810	21515	8052	22256	8842	2009	1193	923	4490	3081	5956
	gp04	645	32909	2087	4827	22201	4958	2864	287	1265	1068	2842
	gp05	551	9878	525	1026	5011	11475	2810	105	573	479	1385
	gp06	536	35954	1893	1649	6818	3810	17555	362	1049	468	1162
	gp07	347	7353	1562	889	945	272	309	5591	4530	1030	676
	gp08	653	12886	3512	3965	2709	809	541	2261	21227	4748	3052
	gp09	308	2211	744	1484	782	452	187	364	3162	9440	3409
	gp10	429	5300	1075	4477	2554	1229	437	272	2077	3611	17770
	gp11	429	16924	924	2931	7072	3635	909	158	971	1180	5424
	gp12	149	5237	282	624	1578	3232	579	44	296	322	1335
	gp13	403	16319	844	1430	4267	7006	4870	182	616	543	1596
	gp14	202	6144	463	357	1386	1530	1977	87	232	133	376
	gp15	314	4421	248	411	1084	1607	934	39	238	215	649
	gp16	548	9451	542	1084	3029	4738	1767	129	604	689	2245
Durham Region	gp17	746	125	3	9	13	21	6	1	6	8	20
	gp18	227	115	7	22	117	90	20	3	14	19	50
	gp19	247	196	5	15	36	46	15	2	10	13	113
	gp20	620	4958	236	402	1080	1564	722	46	247	240	887
	gp21	696	3352	129	281	558	772	398	26	192	185	548
	gp22	1662	3422	68	274	481	625	258	18	89	155	411
	gp23	1692	4439	65	144	338	544	319	16	82	80	277
	gp24	3514	1600	32	74	154	283	250	9	42	98	86

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EMME/2	Module:	3.14	Date:	2007DE28	14:32	User:	E760/iTRA	Page: 3011
Project:	YRTP	Model	Version	1.1				
Matrix	mf70:	TotTrp	AM	Pk	Pd	Total	Trips	(mf7+8+43+44+45+46)

Matrix mf70: TotTrp (AM Pk Pd Total Trips (mf7+8+43+44+45+46))

Ensemble: gp: Planning District 2003DE04 14:32
Aggregation: sum

	destination groups / origin groups	gp00	gp01	gp02	gp03	gp04	gp05	gp06	gp07	gp08	gp09	gp10
		gp00	gp01	gp02	gp03	gp04	gp05	gp06	gp07	gp08	gp09	gp10
York Region	gp25	475	354	17	49	71	151	29	7	37	81	194
	gp26	552	805	44	128	152	217	56	20	103	367	495
	gp27	1457	1720	83	188	239	389	101	27	186	188	853
	gp28	710	1635	151	229	283	318	180	26	179	269	518
	gp29	599	11277	257	748	1759	1911	515	129	620	888	3444
	gp30	241	457	23	64	216	237	57	8	193	54	221
	gp31	573	20556	560	1375	3896	4615	1379	197	892	1211	4281
	gp32	577	374	147	136	118	65	16	27	162	291	513
	gp33	1116	16908	1350	4716	4235	2488	507	678	3247	5634	13190
Peel Region	gp34	1433	827	184	307	246	146	32	128	875	1519	1035
	gp35	1921	10224	1054	2418	1709	866	318	968	4754	8534	5781
	gp36	2965	29217	3114	4384	3043	1628	741	3673	13878	8735	5360
Halton Region	gp37	747	1779	79	218	116	72	21	75	380	451	259
	gp38	428	2125	112	288	317	92	30	122	623	595	387
	gp39	1117	12969	536	584	480	247	167	715	2271	1108	590
	gp40	1760	5540	188	206	184	96	84	315	798	319	196
Hamilton	gp41	1043	364	45	32	21	13	6	25	92	59	34
	gp42	509	203	7	9	8	3	3	9	61	13	8
	gp43	603	159	11	12	42	5	4	15	45	55	11
	gp44	447	68	3	3	2	1	1	4	12	5	3
	gp45	1470	234	17	36	14	7	6	24	73	28	15
	gp46	3727	2241	73	81	104	28	29	77	272	131	83

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destination destination groups

origin groups	gp11	gp12	gp13	gp14	gp15	gp16	gp17	gp18	gp19	gp20	gp21	gp22
	gp11	gp12	gp13	gp14	gp15	gp16	gp17	gp18	gp19	gp20	gp21	gp22
gp00	1541	725	1028	241	12	1021	1115	386	1256	879	384	1409
gp01	2819	932	2467	329	238	1194	0	1	29	200	101	139
gp02	1453	422	1023	168	135	415	0	1	1	122	39	17
gp03	3302	815	1301	164	139	744	1	2	1	270	88	92
gp04	5151	1173	1980	251	157	1268	1	16	2	357	173	113
gp05	2922	2217	3974	418	315	1987	2	5	3	483	206	85
gp06	1660	1150	4348	1275	367	1415	1	18	2	468	197	74
gp07	367	83	198	36	18	149	0	0	0	33	14	6
gp08	1217	410	643	62	124	484	0	33	1	130	55	32
gp09	861	191	298	34	38	247	0	1	1	93	47	11
gp10	3958	696	953	63	100	621	1	3	1	185	61	26
gp11	19104	3062	1939	210	231	2128	2	6	4	459	176	72
gp12	3771	5969	1590	103	148	2624	1	5	3	357	167	51
gp13	2686	2577	25181	4331	1861	7822	2	31	8	1986	955	319
gp14	524	537	4826	4829	877	1667	1	6	4	793	369	126
gp15	786	790	5118	1868	6857	4417	3	21	13	2898	1134	506
gp16	4428	4743	10414	1091	2944	27139	6	55	56	2923	1174	550
gp17	22	19	31	4	8	64	2715	457	252	99	75	119
gp18	75	81	134	16	83	309	260	2303	316	493	317	295
gp19	42	72	99	12	29	205	214	612	4329	390	371	854
gp20	1083	1068	4135	610	1313	5189	93	135	86	25179	5493	2338
gp21	623	600	2443	235	960	2615	139	132	115	7469	21201	3928
gp22	410	341	1537	149	412	1841	119	349	979	4583	5958	34927
gp23	423	309	1170	158	561	1424	482	445	1667	3932	5023	17894
gp24	157	286	604	73	176	723	84	175	766	1846	1957	5888

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destination	destination groups										
	gp11	gp12	gp13	gp14	gp15	gp16	gp17	gp18	gp19	gp20	gp21	gp22
origin groups												
	gp11	gp12	gp13	gp14	gp15	gp16	gp17	gp18	gp19	gp20	gp21	gp22
gp25	165	99	154	13	24	229	539	162	50	75	34	30
gp26	294	254	319	21	33	368	78	239	46	188	74	57
gp27	505	452	396	19	28	437	26	63	26	176	46	35
gp28	427	292	223	20	29	351	17	53	25	147	56	42
gp29	3539	1564	1224	112	207	1714	21	72	32	700	224	118
gp30	180	215	462	41	113	807	169	236	91	585	142	163
gp31	6050	4901	6867	555	1121	11691	19	183	169	2332	865	470
gp32	166	58	89	4	5	63	4	10	5	34	37	10
gp33	8134	1829	1820	116	202	1918	9	109	15	495	235	198
gp34	221	109	84	7	78	115	5	12	5	43	17	11
gp35	1825	356	866	44	154	516	3	8	4	316	84	37
gp36	1967	605	1201	125	107	794	1	3	2	372	174	178
gp37	92	25	43	4	4	28	0	0	0	12	5	69
gp38	127	35	157	6	6	40	0	0	0	18	8	3
gp39	295	73	142	17	55	98	0	0	0	39	17	7
gp40	93	62	77	7	5	119	12	0	0	14	6	3
gp41	16	5	9	1	1	6	0	13	0	4	33	1
gp42	5	1	3	0	0	1	0	0	0	1	0	0
gp43	6	2	3	0	0	2	0	0	0	1	1	0
gp44	1	0	1	0	0	1	0	0	0	0	0	0
gp45	8	2	5	1	0	3	0	0	0	2	1	0
gp46	51	10	33	22	2	11	0	0	0	22	3	1

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destination origin groups	gp23	gp24	gp25	gp26	gp27	gp28	gp29	gp30	gp31	gp32	gp33	gp34
	destination groups											
	gp23	gp24	gp25	gp26	gp27	gp28	gp29	gp30	gp31	gp32	gp33	gp34
gp00	2708	1755	521	684	5836	1763	2438	748	3495	1379	6476	2084
gp01	46	79	76	7	35	13	861	73	2960	6	1989	34
gp02	8	2	3	8	18	15	220	56	709	97	1924	28
gp03	29	5	7	21	49	66	422	33	1685	63	5722	126
gp04	31	10	11	24	65	120	565	45	2689	92	2426	29
gp05	113	48	14	31	101	53	674	113	3310	32	1230	14
gp06	99	43	24	19	51	32	399	44	2315	9	743	10
gp07	3	1	1	4	8	8	61	5	216	15	1039	34
gp08	12	4	5	16	34	64	380	19	937	76	3759	160
gp09	26	2	3	13	29	41	218	16	668	58	5120	267
gp10	36	3	58	27	161	102	752	40	1981	172	11164	115
gp11	34	10	19	81	136	135	2056	97	5813	119	5831	109
gp12	24	7	14	30	131	52	802	64	4219	14	1092	9
gp13	322	134	18	124	131	73	932	250	6953	29	1599	15
gp14	58	17	5	12	24	20	191	59	1573	29	388	4
gp15	279	61	12	84	45	39	311	176	2842	9	518	7
gp16	251	121	64	91	200	182	1739	510	15178	73	2403	19
gp17	59	21	697	247	164	33	92	188	348	21	53	8
gp18	104	32	169	531	155	112	185	733	1148	41	131	18
gp19	762	368	194	149	108	50	87	253	749	27	92	12
gp20	1317	333	44	109	113	56	504	674	5847	78	582	17
gp21	2434	558	29	65	35	28	205	278	2698	147	262	8
gp22	9743	1602	70	144	93	55	270	638	2527	126	472	16
gp23	44902	7728	132	196	108	72	271	611	2515	70	229	20
gp24	12071	26087	39	77	40	28	187	186	884	17	230	8

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destination / origin groups	gp23	gp24	gp25	gp26	gp27	gp28	gp29	gp30	gp31	gp32	gp33	gp34
	gp23	gp24	gp25	gp26	gp27	gp28	gp29	gp30	gp31	gp32	gp33	gp34
gp25	127	3	9928	2437	2221	958	585	655	1899	170	589	24
gp26	109	7	1914	8919	6774	1953	1339	1064	3642	450	1706	79
gp27	13	4	743	3042	15926	3588	1543	796	3737	715	2126	99
gp28	16	5	338	752	2495	9397	3146	727	3354	1149	1961	73
gp29	57	78	211	472	1161	1803	32016	970	18394	1248	10235	240
gp30	96	11	125	334	676	806	843	5515	5866	105	762	27
gp31	250	80	268	783	1171	1216	8174	3168	89530	512	7920	102
gp32	4	1	47	222	477	734	717	97	695	2110	2398	429
gp33	53	55	177	371	929	1117	5699	700	11021	1995	81546	865
gp34	4	1	46	147	249	142	202	86	524	657	4311	10596
gp35	16	5	55	120	204	112	608	84	2147	469	15331	6462
gp36	75	7	9	31	135	70	395	59	1664	176	6733	821
gp37	69	0	2	5	10	11	79	4	98	52	538	591
gp38	42	1	1	3	5	6	40	3	175	11	514	77
gp39	4	1	1	3	69	51	146	4	231	51	671	119
gp40	1	0	0	1	3	3	20	2	66	5	259	35
gp41	0	0	0	1	1	1	7	1	24	2	105	10
gp42	0	0	0	0	0	0	2	0	6	0	22	2
gp43	0	0	0	0	0	0	2	0	7	1	28	3
gp44	0	0	0	0	0	0	0	0	2	0	6	1
gp45	0	0	0	0	0	0	2	0	8	13	156	3
gp46	1	0	0	0	1	1	10	1	35	2	110	137

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destination / origin groups	gp35	gp36	gp37	gp38	gp39	gp40	gp41	gp42	gp43	gp44	gp45	gp46
	gp35	gp36	gp37	gp38	gp39	gp40	gp41	gp42	gp43	gp44	gp45	gp46
gp00	4842	9249	1547	685	1398	2061	151	116	59	143	1138	3758
gp01	1263	5258	291	178	182	241	2	1	1	86	88	333
gp02	840	3518	28	55	445	93	64	2	2	1	9	104
gp03	1453	5565	82	127	426	164	8	2	59	1	86	147
gp04	641	2106	20	36	180	46	3	1	1	0	4	39
gp05	350	1015	10	18	58	17	1	11	0	0	2	22
gp06	246	1266	9	99	134	36	2	1	1	0	4	45
gp07	795	4160	40	65	579	135	8	3	3	1	37	77
gp08	2422	11913	118	241	1002	299	71	5	6	14	24	247
gp09	2657	4834	52	104	305	122	5	1	2	1	7	47
gp10	1976	4617	56	105	380	66	5	1	22	1	7	73
gp11	770	2026	21	39	157	32	2	1	1	0	3	40
gp12	232	574	6	10	31	9	1	0	0	0	1	7
gp13	337	1104	39	102	93	19	1	0	1	0	2	13
gp14	71	322	23	6	29	8	1	0	0	0	1	6
gp15	116	419	4	8	26	7	1	0	0	0	1	47
gp16	371	1466	13	25	98	59	2	0	1	0	2	14
gp17	16	98	0	0	1	0	0	0	0	0	0	272
gp18	37	47	1	1	2	1	0	0	0	0	0	0
gp19	25	31	0	0	1	0	0	0	0	0	0	30
gp20	256	755	5	9	29	9	1	0	0	0	1	7
gp21	140	450	3	5	16	5	0	0	0	0	0	4
gp22	74	253	2	3	10	3	0	0	0	0	0	3
gp23	106	422	2	3	9	3	0	0	0	0	0	2
gp24	32	203	1	2	5	2	0	0	0	0	68	1

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destination / origin groups	gp35	gp36	gp37	gp38	gp39	gp40	gp41	gp42	gp43	gp44	gp45	gp46
	gp35	gp36	gp37	gp38	gp39	gp40	gp41	gp42	gp43	gp44	gp45	gp46
gp25	47	56	2	2	5	27	0	0	0	0	0	1
gp26	172	276	6	6	17	5	0	0	0	0	1	77
gp27	220	300	8	7	22	7	1	0	0	0	1	5
gp28	223	278	7	7	60	6	0	0	0	0	1	5
gp29	991	1445	18	26	164	22	2	1	1	36	3	31
gp30	75	107	2	2	164	2	0	0	0	0	0	1
gp31	1027	2189	65	85	115	156	2	1	1	0	3	132
gp32	276	388	12	10	62	7	1	0	0	0	1	6
gp33	5483	6786	134	257	537	210	9	3	21	1	55	109
gp34	8756	4778	473	208	214	199	8	1	2	0	5	31
gp35	134272	55479	2710	2130	2223	721	43	8	10	3	32	404
gp36	24104	194074	1346	3006	13145	3057	209	51	65	13	142	1136
gp37	4285	5157	11882	2536	1368	629	57	9	10	3	30	244
gp38	2402	7923	1779	21239	3728	2238	466	23	25	8	86	721
gp39	2243	18767	724	2504	49965	8668	342	59	131	29	379	2375
gp40	865	6562	573	2418	11760	39877	1117	208	351	222	959	6593
gp41	258	1001	171	1046	1457	3722	4570	626	455	127	380	4538
gp42	98	233	37	129	406	828	580	2199	264	87	193	3565
gp43	58	330	42	164	747	1499	734	432	4587	501	411	7389
gp44	123	103	9	37	177	354	86	87	300	565	578	3282
gp45	62	550	48	234	1346	2684	313	153	433	532	8828	13336
gp46	239	1782	182	894	3924	8544	2037	1329	2804	1712	7471	84687

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EMME/2	Module:	3.14	Date:	2007DE28	14:30	User:	E760/iTRA	Page:	3003
Project:	YRTP	Model	Version	1.1					
Matrix	mf69:	TotTrn	AM	Pk	Pd	Transit	Trips	(mf43+44+45+46)	

Matrix	mf69:	TotTrn	(AM	Pk	Pd	Transit	Trips	(mf43+44+)
Ensemble:	gp:	Planning	District	2003DE04	14:32			
Aggregation:	sum							

TRANSIT TRIPS

destination groups

	origin groups	gp00	gp01	gp02	gp03	gp04	gp05	gp06	gp07	gp08	gp09	gp10
Toronto	gp00	0	1174	0	0	62	19	19	58	19	0	24
	gp01	88	25327	3120	1737	5798	1003	2771	109	672	259	1057
	gp02	36	23653	3978	1608	2134	415	651	181	1204	273	689
	gp03	40	14009	3131	6837	3197	481	386	201	937	634	1778
	gp04	0	21171	677	1014	5175	952	785	33	256	199	722
	gp05	27	6049	162	160	1246	2552	987	17	121	46	287
	gp06	32	22973	781	560	2716	795	4924	81	299	124	479
	gp07	0	4998	592	137	468	58	69	1289	1425	165	126
	gp08	0	8029	1002	857	967	120	166	288	3591	825	491
	gp09	0	1430	257	270	210	68	22	59	759	1704	662
	gp10	0	3465	224	1478	853	236	157	26	352	854	5074
	gp11	12	12711	343	754	3449	884	310	22	153	129	1750
	gp12	0	3688	121	151	658	941	146	6	33	50	427
	gp13	21	11468	367	408	1563	1805	1802	54	147	61	434
	gp14	14	3811	131	76	441	319	443	10	65	12	95
	gp15	0	2850	54	65	339	246	393	6	30	29	157
	gp16	0	6212	160	158	875	856	550	23	71	78	575
Durham Region	gp17	0	18	0	0	1	0	0	0	0	0	1
	gp18	0	43	1	1	12	1	1	0	0	0	2
	gp19	0	90	0	0	2	1	1	0	0	0	3
	gp20	0	2611	78	30	172	71	137	4	19	11	96
	gp21	0	2008	32	51	126	48	40	3	14	18	82
	gp22	0	2295	19	22	96	46	38	3	14	21	88
	gp23	0	3334	19	22	88	47	58	2	14	7	45
	gp24	78	1118	6	7	27	14	27	1	5	2	5

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EMME/2	Module:	3.14	Date:	2007DE28	14:30	User:	E760/ITRA Page:	3003
Project:	YRTP	Model	Version	1.1				
Matrix	mf69:	TotTm	AM	Pk	Pd	Transit	Trips	(mf43+44+45+46)

Matrix	mf69:	TotTm	(AM	Pk	Pd	Transit	Trips	(mf43+44+)
Ensemble:	gp:	Planning	District	2003DE04	14:32			
Aggregation:	sum							

TRANSIT TRIPS

	origin groups	gp00	gp01	gp02	gp03	gp04	gp05	gp06	gp07	gp08	gp09	gp10
		destination groups										
York Region	gp25	0	95	1	2	6	2	1	0	1	2	7
	gp26	0	490	4	8	17	5	4	1	3	15	31
	gp27	0	1069	8	15	44	18	7	1	7	12	89
	gp28	16	1120	7	14	45	12	57	1	6	14	43
	gp29	0	8268	45	89	464	218	69	7	45	67	528
	gp30	0	250	3	4	21	8	4	0	2	2	20
	gp31	0	14585	108	160	1004	478	152	12	72	143	703
	gp32	0	218	48	5	10	2	1	0	2	4	19
	gp33	0	11008	138	374	790	251	97	22	171	311	1321
Peel Region	gp34	0	249	6	8	11	3	2	1	7	24	17
	gp35	0	5593	123	187	258	104	56	21	234	556	528
	gp36	41	17903	534	460	705	159	187	251	1400	729	663
Halton Region	gp37	20	1204	15	32	28	8	4	3	27	55	42
	gp38	0	1170	17	15	82	8	5	7	48	18	13
	gp39	0	8770	55	42	174	26	27	53	136	84	70
	gp40	0	3778	37	15	37	10	11	27	45	16	16
Hamilton	gp41	0	191	2	1	3	1	1	1	2	1	0
	gp42	0	167	1	1	3	1	1	1	2	1	1
	gp43	0	109	1	1	14	0	1	0	1	0	0
	gp44	0	17	0	0	0	0	0	0	0	0	0
	gp45	16	130	2	1	3	1	1	1	2	1	1
	gp46	22	1767	22	14	55	7	12	7	20	14	18
	□											

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destination groups

origin groups	gp11	gp12	gp13	gp14	gp15	gp16	gp17	gp18	gp19	gp20	gp21	gp22
	gp11	gp12	gp13	gp14	gp15	gp16	gp17	gp18	gp19	gp20	gp21	gp22
gp00	38	0	19	0	0	0	0	0	0	17	0	0
gp01	1490	399	1107	99	63	341	0	0	0	40	2	0
gp02	533	160	330	20	16	75	0	0	0	6	2	1
gp03	828	146	312	42	25	91	0	0	0	7	4	32
gp04	1723	288	376	47	12	158	0	0	0	10	6	1
gp05	787	546	914	125	46	286	0	0	0	24	7	2
gp06	753	287	1099	388	103	246	0	0	0	23	10	2
gp07	97	17	43	4	6	15	0	0	0	3	1	0
gp08	247	60	140	7	7	42	0	31	0	7	3	8
gp09	193	33	36	2	2	26	0	0	0	3	1	0
gp10	1184	182	244	5	5	72	0	0	0	8	3	1
gp11	4945	784	364	14	51	417	0	0	0	16	8	2
gp12	1201	1167	380	28	28	451	0	0	0	10	23	1
gp13	850	664	7284	1654	651	1566	0	0	0	97	58	10
gp14	109	93	1086	1127	309	196	0	0	0	39	14	4
gp15	137	96	1162	684	1025	596	0	0	0	86	37	12
gp16	1365	938	2431	274	782	5065	0	0	0	91	35	9
gp17	1	0	0	0	0	1	15	0	0	0	0	0
gp18	2	3	3	0	1	4	0	0	0	0	0	0
gp19	1	1	2	0	1	2	0	0	0	3	1	0
gp20	75	48	289	32	53	145	0	0	0	471	173	36
gp21	66	25	216	14	80	103	0	0	0	255	1035	57
gp22	73	25	191	14	46	138	1	0	0	229	367	1151
gp23	71	22	176	14	56	100	0	0	0	219	330	307
gp24	15	10	40	4	15	26	0	0	0	65	82	63

destination groups

origin groups	gp11	gp12	gp13	gp14	gp15	gp16	gp17	gp18	gp19	gp20	gp21	gp22
	gp11	gp12	gp13	gp14	gp15	gp16	gp17	gp18	gp19	gp20	gp21	gp22
gp25	5	1	2	0	0	2	3	0	0	0	0	0
gp26	15	3	4	0	1	5	0	0	0	1	0	0
gp27	42	16	17	1	1	12	0	0	0	2	1	0
gp28	36	12	7	1	1	9	0	0	0	2	1	0
gp29	592	181	116	5	20	191	0	0	0	20	7	2
gp30	13	12	17	1	3	25	0	0	0	2	0	0
gp31	735	529	722	24	84	844	0	1	0	35	12	3
gp32	8	1	8	0	0	1	0	0	0	0	0	0
gp33	919	205	202	7	25	130	0	0	0	14	5	1
gp34	8	2	2	0	1	3	0	0	0	0	0	0
gp35	187	34	73	3	30	53	0	0	0	8	4	1
gp36	283	76	177	9	14	90	0	0	0	23	8	2
gp37	17	3	5	0	1	3	0	0	0	1	0	0
gp38	17	3	4	0	1	2	0	0	0	1	0	0
gp39	40	8	19	2	3	12	0	0	0	4	1	0
gp40	13	3	10	1	1	4	0	0	0	1	0	0
gp41	1	0	1	0	0	0	0	0	0	0	0	0
gp42	1	0	0	0	0	0	0	0	0	0	0	0
gp43	1	0	0	0	0	0	0	0	0	0	0	0
gp44	0	0	0	0	0	0	0	0	0	0	0	0
gp45	1	0	1	0	0	0	0	0	0	0	0	0
gp46	14	3	9	1	0	2	0	0	0	1	0	0

origin groups	gp23	gp24	gp25	gp26	gp27	gp28	gp29	gp30	gp31	gp32	gp33	gp34
	gp23	gp24	gp25	gp26	gp27	gp28	gp29	gp30	gp31	gp32	gp33	gp34
gp00	0	0	0	0	19	0	0	0	0	0	0	0
gp01	18	0	0	0	0	0	171	0	605	0	337	0
gp02	0	0	0	0	0	0	22	0	115	7	235	0
gp03	0	0	0	0	0	0	35	0	193	0	588	0
gp04	1	0	0	0	0	0	62	0	342	10	301	0
gp05	1	0	0	0	1	0	52	1	397	4	84	0
gp06	4	0	0	0	0	0	39	0	304	0	123	0
gp07	0	0	0	0	0	0	5	0	27	0	52	0
gp08	0	0	0	0	0	0	20	0	81	0	214	0
gp09	0	0	0	0	0	0	17	0	60	0	401	0
gp10	0	0	0	0	0	1	73	0	263	10	1385	0
gp11	1	0	0	0	0	1	298	1	1033	10	829	0
gp12	1	0	0	0	0	0	113	1	757	0	113	0
gp13	9	1	0	0	1	1	91	2	889	3	152	0
gp14	2	0	0	0	0	0	13	0	122	0	31	0
gp15	11	1	0	0	0	0	27	1	194	0	44	0
gp16	6	1	0	0	1	1	174	4	1750	0	216	0
gp17	0	0	7	2	2	0	2	0	2	0	1	0
gp18	0	0	0	0	0	0	2	2	14	0	2	0
gp19	0	0	0	0	0	0	1	0	5	0	1	0
gp20	35	3	0	0	16	0	14	1	129	3	15	0
gp21	110	4	0	0	0	0	6	0	70	0	9	0
gp22	166	8	0	0	0	0	7	1	86	8	19	0
gp23	2526	80	0	0	0	0	6	1	57	4	9	0
gp24	180	22	0	0	0	0	1	0	11	0	2	0

origin groups	gp23	gp24	gp25	gp26	gp27	gp28	gp29	gp30	gp31	gp32	gp33	gp34
gp25	0	0	105	43	58	7	10	0	12	2	9	0
gp26	1	0	14	28	136	25	30	0	36	5	36	0
gp27	0	0	16	51	1160	165	94	0	106	20	78	0
gp28	0	0	1	3	40	121	154	0	61	9	62	0
gp29	1	0	0	1	6	26	3703	3	1873	8	639	0
gp30	1	0	0	0	0	0	20	0	183	0	16	0
gp31	2	0	0	0	3	25	693	21	6119	13	512	0
gp32	0	0	0	0	2	1	7	0	9	0	25	0
gp33	1	0	0	0	1	5	435	2	749	43	3649	0
gp34	0	0	0	0	1	1	1	0	3	1	16	1
gp35	1	0	0	0	0	0	15	0	114	4	276	3
gp36	1	0	0	0	0	0	23	0	141	12	250	1
gp37	0	0	0	0	0	0	3	0	10	1	24	1
gp38	0	0	0	0	0	0	2	0	8	0	11	0
gp39	0	0	0	0	0	0	9	0	33	0	39	0
gp40	0	0	0	0	0	0	1	0	7	0	7	0
gp41	0	0	0	0	0	0	0	0	1	0	0	0
gp42	0	0	0	0	0	0	0	0	1	0	1	0
gp43	0	0	0	0	0	0	0	0	0	0	0	0
gp44	0	0	0	0	0	0	0	0	0	0	0	0
gp45	0	0	0	0	0	0	0	0	1	1	1	0
gp46	0	0	0	0	0	0	2	0	10	0	12	0

destination groups

origin groups	gp35	gp36	gp37	gp38	gp39	gp40	gp41	gp42	gp43	gp44	gp45	gp46
	gp35	gp36	gp37	gp38	gp39	gp40	gp41	gp42	gp43	gp44	gp45	gp46
gp00	0	39	0	0	19	0	0	0	0	0	0	20
gp01	34	751	0	0	45	3	0	0	0	0	0	95
gp02	15	384	0	1	8	1	0	0	0	0	0	3
gp03	38	392	1	1	17	1	0	0	0	0	38	22
gp04	15	149	0	0	18	0	0	0	0	0	0	4
gp05	23	59	0	0	2	0	0	10	0	0	0	11
gp06	20	120	0	0	7	1	0	0	0	0	0	2
gp07	10	266	0	1	34	4	0	0	0	0	0	3
gp08	43	854	1	2	28	4	0	0	0	0	0	13
gp09	76	245	0	1	6	0	0	0	0	0	0	1
gp10	51	369	1	1	18	1	0	0	0	0	0	1
gp11	23	138	1	0	4	0	0	0	0	0	0	1
gp12	4	29	0	0	1	0	0	0	0	0	0	0
gp13	23	123	0	0	28	1	0	0	0	0	0	1
gp14	2	39	0	0	1	0	0	0	0	0	0	0
gp15	2	29	0	0	1	0	0	0	0	0	0	9
gp16	7	116	0	0	10	1	0	0	0	0	0	1
gp17	0	0	0	0	0	0	0	0	0	0	0	0
gp18	0	1	0	0	0	0	0	0	0	0	0	0
gp19	0	0	0	0	0	0	0	0	0	0	0	0
gp20	7	41	0	0	1	0	0	0	0	0	0	0
gp21	2	27	0	0	1	0	0	0	0	0	0	0
gp22	2	25	0	0	1	0	0	0	0	0	0	0
gp23	2	30	0	0	1	0	0	0	0	0	0	0
gp24	1	8	0	0	0	0	0	0	0	0	0	0

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origin groups	destination groups gp35	gp36	gp37	gp38	gp39	gp40	gp41	gp42	gp43	gp44	gp45	gp46
	gp35	gp36	gp37	gp38	gp39	gp40	gp41	gp42	gp43	gp44	gp45	gp46
gp25	0	1	0	0	0	0	0	0	0	0	0	0
gp26	2	4	0	0	0	0	0	0	0	0	0	0
gp27	3	10	0	0	1	0	0	0	0	0	0	0
gp28	3	8	0	0	0	0	0	0	0	0	0	0
gp29	17	90	0	0	10	0	0	0	0	0	0	1
gp30	1	3	0	0	16	0	0	0	0	0	0	0
gp31	19	107	0	0	12	15	0	0	0	0	0	39
gp32	1	2	0	0	1	0	0	0	0	0	0	0
gp33	67	167	1	1	8	1	0	0	0	0	0	2
gp34	22	33	0	0	0	0	0	0	0	0	0	0
gp35	3598	1753	24	3	53	3	0	0	0	0	0	9
gp36	612	11951	3	17	334	34	0	0	0	0	1	54
gp37	139	158	71	1	9	1	0	0	0	0	0	1
gp38	18	281	1	44	23	1	0	0	0	0	0	1
gp39	19	521	1	2	1026	157	0	0	0	0	1	56
gp40	6	171	1	1	458	1083	0	1	0	0	4	109
gp41	1	9	0	0	23	29	23	0	0	0	0	0
gp42	0	7	0	0	10	37	0	12	2	0	4	240
gp43	0	4	0	0	12	18	0	3	10	0	3	224
gp44	0	1	0	0	2	4	0	0	0	0	1	30
gp45	0	8	0	0	26	34	0	3	1	0	152	470
gp46	4	77	1	2	116	350	4	106	29	7	305	11291

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