2. BACKGROUND STUDIES AND MAJOR FUNCTIONAL DESIGN OPTIONS

A number of studies were undertaken to resolve the selection of transit method (technology) for this line, and the major design elements. This chapter describes the studies undertaken, and the resultant recommendations. The studies include:

- Transit Methods: To determine the preferred method of providing a fast, reliable and safe transit service;
- Feasibility Studies – To confirm that an LRT system was feasible, and determine a feasible alignment for the central project;
- Single Bore vs. Twin Bore Tunnel Configuration: To address the constructability issues and benefits between a single bored tunnel, and twin bored tunnels;
- Changes in Traffic Operations: To address the changes in traffic operations as a result of the construction of the surface sections of the LRT line; and
- Area Specific Studies: There were a number of studies conducted to deal with issues in a specific geographic area of the corridor. They are presented in order, from west to east, along the corridor.

The results of the studies provided input to the preferred design, which is described in detail in Chapter 3.

2.1 Transit Technologies

A transit system will be considered successful if it can attract new transit riders by offering a fast, reliable and safe transit service. Investing in rapid transit facilities is an important tool available to governments to help shape urban growth and to create areas and corridors of compact, sustainable urban development. To achieve this transit must be an attractive enough mode of travel that the private automobile users will alter their location choices and travel habits. The existing bus service along Eglinton Crosstown LRT corridor is operating in mixed traffic and therefore does not provide enough incentive, from a travel time and reliability perspective, to become an attractive alternative.

The following sections will describe the objectives of the transit technology selction process and the transit technologies that are available available. A summary of the benefits of each technology is provided in a brief evaluation summary, contributing to the final recommendation provided.

2.1.1 Study Objectives

A study was conducted to determine the preferred method of providing a fast, reliable and safe transit service to provide a connection on Eglinton Avenue between Kennedy Subway Station and Pearson International Airport in a manner that:

- Makes transit a much more attractive travel option relative to the private auto so that more people will choose to use transit instead of their cars;
- Is affordable;
- Supports the City's growth objectives for a better variety and density of transit-oriented developments, particularly along the section of Eglinton Avenue that is designated in the Official Plan as „Avenue'; and
- Gives appropriate consideration to other important City objectives such as good urban design, and an improved walking and cycling environment.

In addition, the recommended design must be developed in a manner that respects other road users, adjacent properties, and the natural environment.

2.1.2 Identification of Alternative Transit Technologies

The City of Toronto's Official Plan forecasts a 270,000(10%) increase in the population of the City by 2031 and explicitly indicates that the travel needs related to this growth will be accommodated through increased non-auto travel. The plan does not support the construction of any significant additional road capacity. Transit is expected to accommodate the largest proportion of the forecast growth in travel demand in the City and the Transit City Light Rail Plan, of which the Eglinton Crosstown LRT Line is a part, has been proposed to achieve this City objective.

Ridership forecasts indicate that the demand for transit services in the Eglinton corridor will significantly exceed the capacity of surface transit services operating in mixed traffic. As illustrated in **Exhibit 8**, surface transit vehicles in mixed traffic operating through a normal grid of road traffic signals, have a practical capacity of approximately 2000 passengers per hour per direction. The transit ridership forecast for the Eglinton corridor is expected to be two to three times this level during peak operating conditions.

Various potential transit methods were identified and evaluated in previous TTC studies, including Do Nothing – with or without Transit Priority Improvements, Travel Demand Management/Transportation System Management, High Occupancy Vehicle (HOV) or reserved curb bus lanes, Bus Rapid Transit, Light Rail Transit etc.

The previous studies concluded that, in order to attract more people to use public transit, the new transit system must be significantly faster and more reliable than the existing bus service transit system, and provide a quality of service comparable to that of private automobiles. Hence, the „Do Nothing' option with buses operating in mixed traffic represents a continuation of current trends with no significant infrastructure or operational improvements, and does not satisfy the principal objectives of the City's program.

Travel Demand Management (TDM) / Transportation System Management provide measures to reduce the number of vehicles, primarily single-occupant travel operating on the roadway especially during peak periods. Examples include increasing transit usage and encouraging carpooling. The travel forecasting and modeling shows that TDM alone cannot fully address the projected future demand, existing traffic operation concerns, and safety issues. However, TDM should still be used in conjunction with the preferred transit methods for this study.

To achieve the study objective, transit service must have a much greater degree of "protection" from the delays associated with mixed traffic operation. HOV lanes in tandem with bus transit may improve the reliability of bus service, but examples from existing Eglinton Avenue or other locations in Toronto have shown that HOV lanes are extremely difficult to enforce because of the lack of physical separation between the transit lane and general traffic lanes. Also, transit reliability would remain poor during off-peak periods and weekends, when the HOV lanes would not be effect.

For these reasons, the "Do Nothing" alternative, and the option of curb bus lanes, as used in other parts of the city, were not carried forward for further consideration.

There are two key elements when designing transit facilities that operate in reserved lanes:

1. The lanes must be reserved for transit only and not shared with other traffic; and
2. There must be some form of physical separation to ensure that motorists do not travel in the travel lanes illegally.

Given the above criteria, three alternative transit methods were considered for the Eglinton Crosstown LRT corridor:

1. Fully Exclusive Right-of-way: Subway/Rapid Transit or LRT Technology – Electrically powered rail vehicles that operate on a fully exclusive right-of-way – such as a subway, the elevated Scarborough Rapid Transit (SRT) line or LRT vehicles coupled into trains. With no surface operation across any roadways, there is no influence from other traffic. These systems are capable of carrying high volumes of people, quickly and reliably.
2. Light Rail Transit (LRT) – Electrically powered vehicles that operate on a partially exclusive right-of-way (reserved lanes) with traffic crossings at signalized intersections. These systems are capable of carrying medium to high volumes of people with some reduction in speed and reliability compared to fully exclusive right of way operation, but with significantly improved speed and reliability over mixed traffic operation.
3. Bus Rapid Transit (BRT) – Diesel or hybrid powered buses that operate on a partially exclusive right-of-way (reserved lanes) with traffic crossings at signalized intersections. These systems are capable of carrying medium volumes of people with some reduction in speed and significantly reduced reliability compared to fully exclusive right of way operation.

2.1.3 Evaluation of Transit Technologies

2.1.3.1 Elimination of Subway/SRT Technologies

Based on the City's population and employment forecasts for the Eglinton Crosstown LRT corridor, the City and the TTC have projected that the transit demand in the corridor will increase to 5,400 passengers per hour in the peak direction at the busiest point on the line by 2031. The choice of transit technologies is one of matching the technology to the expected level of passenger demand on the corridor in the most cost-effective way. At very high ridership volumes (greater than 10,000 passengers per hour) a fully exclusive right-of-way is required; however in the 2,000 to 10,000 passenger per hour range a partially exclusive right of way can accommodate the demand. Passengers can be provided with a higher speed service on a fully exclusive right of way however increased speeds, alone, would result in only modest increases in transit ridership (access to the transit service, and service reliability are more important factors in attracting passengers).

Typically, the capital cost to construct fully grade separated facilities is four to five times greater than the cost of a surface partially exclusive right of way; depending on circumstances, partially exclusive right of ways therefore can be significantly more cost-effective than fully exclusive right of ways.

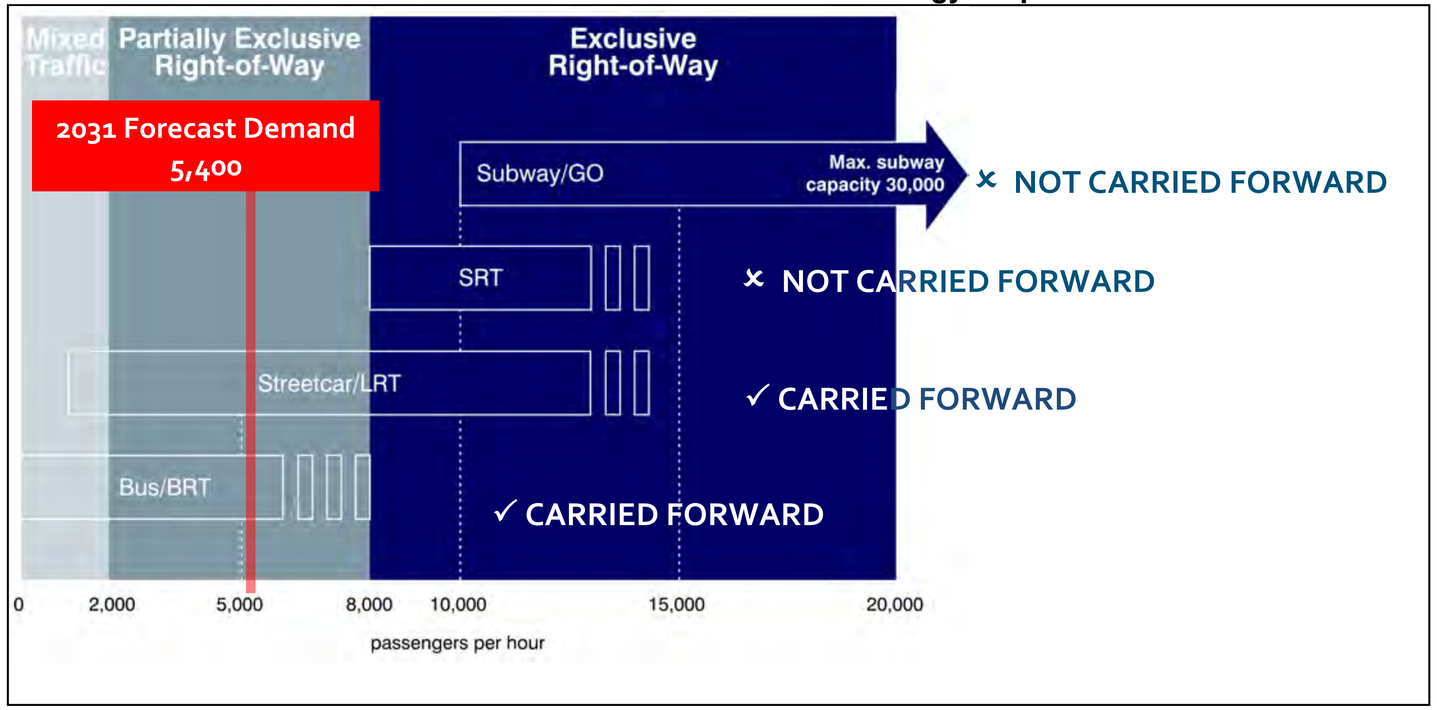
Subway and Rapid Transit (SRT) technology require a fully-exclusive right of way as a result of the vehicle design, whereas BRT and LRT technologies can operate in both a partially-exclusive right of way arrangement, and in a fully exclusive right of way arrangement. The fully exclusive right of way required for SRT technology is not justified if the peak hour demands are not approaching the range of 10,000 people per hour during peak hour in the busiest direction.

As shown in **Exhibit 8**, Transit Forecast Demand and Technology Requirements, the expected future travel demand on Eglinton Crosstown LRT corridor is well below what would be required to justify the high costs of subway or elevated transit-ways. As such, subway or elevated rapid transit (i.e. SRT) were screened out and not carried forward as alternative transit solutions.

The remaining options, LRT and BRT, were evaluated based on four factors:

- Air Quality – Must utilize sustainable technologies – Air quality impacts must be minimized in order to achieve the City's design objectives of a walkable, distinctive, and beautiful community;
- Capacity/Reliability – Capable of accommodating forecast travel demand – In order to invest in infrastructure that supports the City's Official Plan policies and designated growth areas, the proposed transit systems must be able to satisfy the anticipated transit demand resulting from the forecasted development;
- Land Use – Must meet City's Official Plan Policies – This project builds on considerable planning and policy decisions that have already been made for the area and therefore a solution that is in conflict with one or more of these previous decisions are not considered reasonable; and,
- Costs - Reduce operational and maintenance costs while simultaneously improving ridership.

Exhibit 8: Transit Forecast Demand and Technology Requirements



2.1.3.2 Bus Rapid Transit (BRT)

Air Quality

BRT would result in less reduction in emissions at point source locations than LRT, as it is normally provided by bus vehicles powered by diesel or hybrid systems.

Capacity/Reliability

Buses are smaller than rail vehicles and cannot be "coupled" together to operate in pairs or three car trains. As such, a local BRT service – one that services all stops - has less carrying capacity than LRT. High BRT capacities would only be feasible with by-pass lanes to allow some buses to operate express and pass one another at stops, and there is not sufficient space for a 3.5 metres by-pass lane in the Eglinton Crosstown LRT corridor right-of-way while providing a "comfortable" walking environment, bicycle lanes, four through lanes and left turn lanes for traffic.

Moreover, a standard 12 metres bus typically has an average capacity of 50 people per vehicle over the peak period. Given that transit forecast demand is in the order of 5,400 passengers; approximately 108 buses would be required, per hour, to service the demand. Even if articulated buses were purchased, it would only reduce the minimum number of buses to 72 per hour. In a partially grade-separated operating environment, transit service reliability is closely tied to traffic signal operation. As the frequency of service increases to be close to the normal traffic signal cycle length (40 cycles per hour) it becomes increasingly difficult to prevent bunching and gaps between vehicles, resulting in unreliable service.

Land Use

As described in Chapter 1, the Official Plan for the City of Toronto identifies Eglinton Avenue as an Avenue, where redevelopment and growth is encouraged. To achieve the desired redevelopment and growth, high quality, reliable transit is essential.

As stated earlier, BRT service would suffer from capacity and reliability issues in the Eglinton Crosstown LTR Corridor. Unreliable service would serve as a deterrent toward promoting redevelopment and growth, and development interest would move to other locations where transit service is more reliable. Therefore, since BRT could not provide high quality, reliable transit service in the Eglinton Avenue corridor, BRT was judged to be unab le to meet the goals of the Official Plan regarding land use.

Cost

BRT costs less than LRT to implement – roughly $10 million per kilometre.

2.1.3.3 Light Rail Transit (LRT)

Air Quality

Since LRT vehicles are electrically powered, no emissions would be produced on the street.

Capacity/Reliability

The new Light Rail Vehicles that will be designed for the TTC have a much higher carrying capacity than BRT. A 30 metres LRT vehicle can comfortably carry an average of 130 people. A peak point demand of 5,400 passengers per hour would require a vehicle about every 1 minute, 30 seconds. This frequency would likely be difficult to operate and may result in vehicle „bunching'. Therefore, when approaching this demand, the Light Rail Vehicles would be „coupled' or „tripled' in two or three car trainsets and operated (i.e. 60 metres or 90 metres), so that the time between vehicles would be about 3 to 4 minutes, which makes for a more-manageable operation.

Land Use

LRT technology was found to meet the travel demand needs of the Eglinton Avenue corridor as stated earlier. Further, as described in Chapter 2, the traffic signal system, with modifications to the turning movements at nine key intersections, is able to accommodate LRT service reliably. Because the LRT mode can provide reliable service that meets projected demand, LRT was judged to be able to meet the goals of the Official Plan regarding land use.

Cost

While it costs more to construct than BRT – roughly with a total cost of over $30 million per kilometre on the surface, LRT can be more efficient than BRT in operational costs.

LRT outperforms BRT in lifespan of vehicles as well. Buses generally have an operating life of approximately around 15 years, after which they either require major improvements or complete replacement. LRT vehicles have records of operating smoothly for up to 35 to 40 years thereby being nearly 50% more efficient in the long run.

2.1.4 Recommended Transit

LRT was recommended as the preferred transit method over Subway/SRT and Bus Rapid Transit mainly due to its passenger carrying capacity. The City forecast peak point demand for the Eglinton Crosstown LRT corridor as shown in **Exhibit 8** is 5,400 passengers per hour which is below the threshold of 10,000 passengers per hour that is normally required to justify the very high cost of constructing Subway/SRT facilities. BRT would not adequately accommodate the forecast peak hour demand of 5,400 people and address other City objectives (i.e. attractive walking and cycling environment).

LRT makes transit a more attractive travel alternative to the private auto, particularly in the future with increased travel demand and congestion. It also supports the City's objectives, for development in the corridor related to urban design and providing a more attractive walking and cycling environment.

Therefore LRT is the recommended Transit Solution as it fulfills passenger requirements, integrates with the physical environment, and provides flexibility for future growth. Also, it supports the City's official plan policies to create a better integrated transit system, reduce car dependency on roads (thereby lowering emissions) and increased ridership along this corridor.

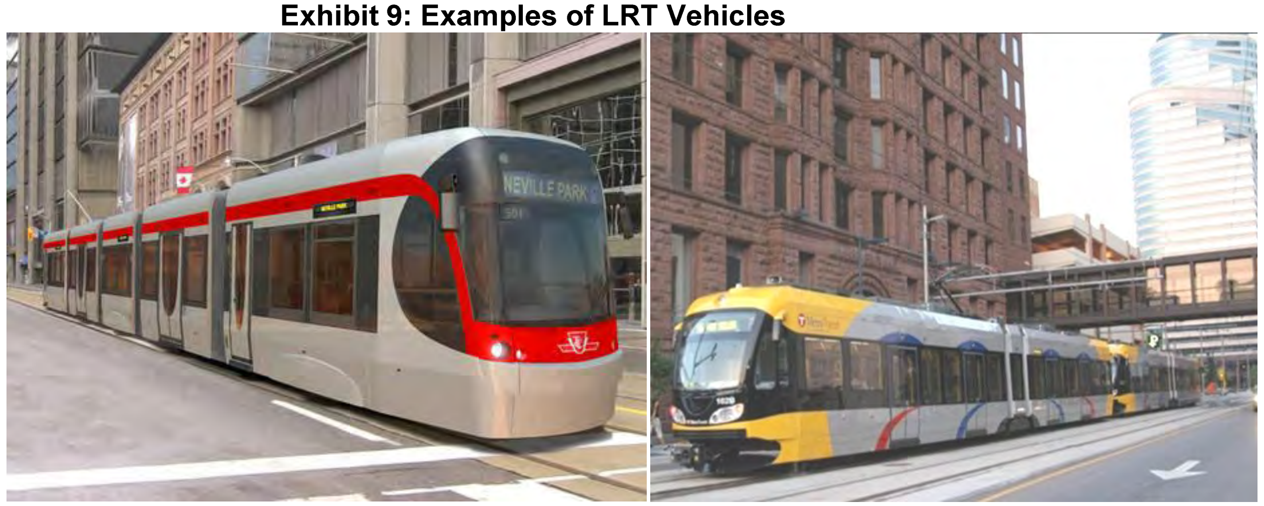
LRT vehicles will be of modern European-style design with a length of approximately 30 metres. Trainsets will consist of two cars initially, with opportunity to expand to three cars when ridership levels warrant. The capacity of the LRT for planning purposes is 260 passengers for two car trainsets and 390 passengers for three car trainsets. Maximum operating speed is 60 km/hr; though vehicles will not be permitted to operate above the posted speed limit along Eglinton Avenue. The vehicle's average speed including stops is projected to be 28-31 km/hr in the west surface section, 22-25 km/hr in the east surface section and 32 km/hr underground.

Trains will be powered by electricity from overhead catenary wires. Train operations on the surface sections of the LRT corridor, both train control and opening/closing of doors, will be controlled by on-board staff. In the underground section of the LRT corridor, vehicles may be controlled by automatic train operation (ATO).

The LRT vehicles will be fully accessible to all riders, with low floor vehicles with level boarding from platforms. Boarding will occur on all doors to reduce time spent serving stops/stations. Doors will be located on both sides of the vehicle to accommodate centre and parallel platforms. Operator cabs will be located on both ends of the trainsets to permit operation in either direction without the requirement for turn around loops.

The track technology to be used is a combination of a continuously welded rail with a rubber sleeve that isolates the rail from the concrete. This elimination of rail joints combined with the isolating sleeve provides a smooth operation with limited noise and vibration that is no different than the noise levels of a busy street.

Exhibit 9: Examples of LRT Vehicles



Proposed Toronto Streetcar Vehicle **Minneapolis, USA**

2.2 Feasibility Studies

During the preliminary planning phase, feasibility studies were conducted to determine the feasibility of the surface sections, feasibility of the underground sections, and stop and station locations. The studies confirmed, in general, the ability to construct the surface sections in the corridor, and the limits of the underground section.

2.2.1 Renforth to Kennedy Station

Following the endorsement of Transit City in March 2007, the Toronto Transit Commission conducted a study to investigate the feasibility of a surface LRT right-of-way along Eglinton Avenue. The limits of the project were from Renforth Avenue in the west and Kennedy Road in the east. The study was carried out to identify preliminary LRT surface right of way requirements as well as other major physical constraints that may impede the construction of a LRT line along Eglinton Avenue. Various conceptual subsurface configurations and station layouts were developed for the interfaces with the Yonge Subway line at Yonge Street and the Spadina Subway line at Allen Road. The study concluded that an LRT was feasible with engineered solutions required to overcome constraints.

The analysis revealed that there were three portions to the Eglinton Avenue corridor:

- West segment (7.7 kilometres, Renforth Drive to Jane Street), predominant right of way width equal to or greater than 35 metres. Surface LRT can be designed through the section.
- Centre segment (12.6 kilometres, Jane Street to Leslie Avenue), predominant right of way width between 20 and 25 metres. The standard surface design LRT cannot be provided through this section; therefore an underground alignment is required.
- East segment (6.9 kilometres, Leslie Avenue to Kennedy Road), predominant right of way width equal to or greater than 35 metres. Surface LRT can be supported through this section.

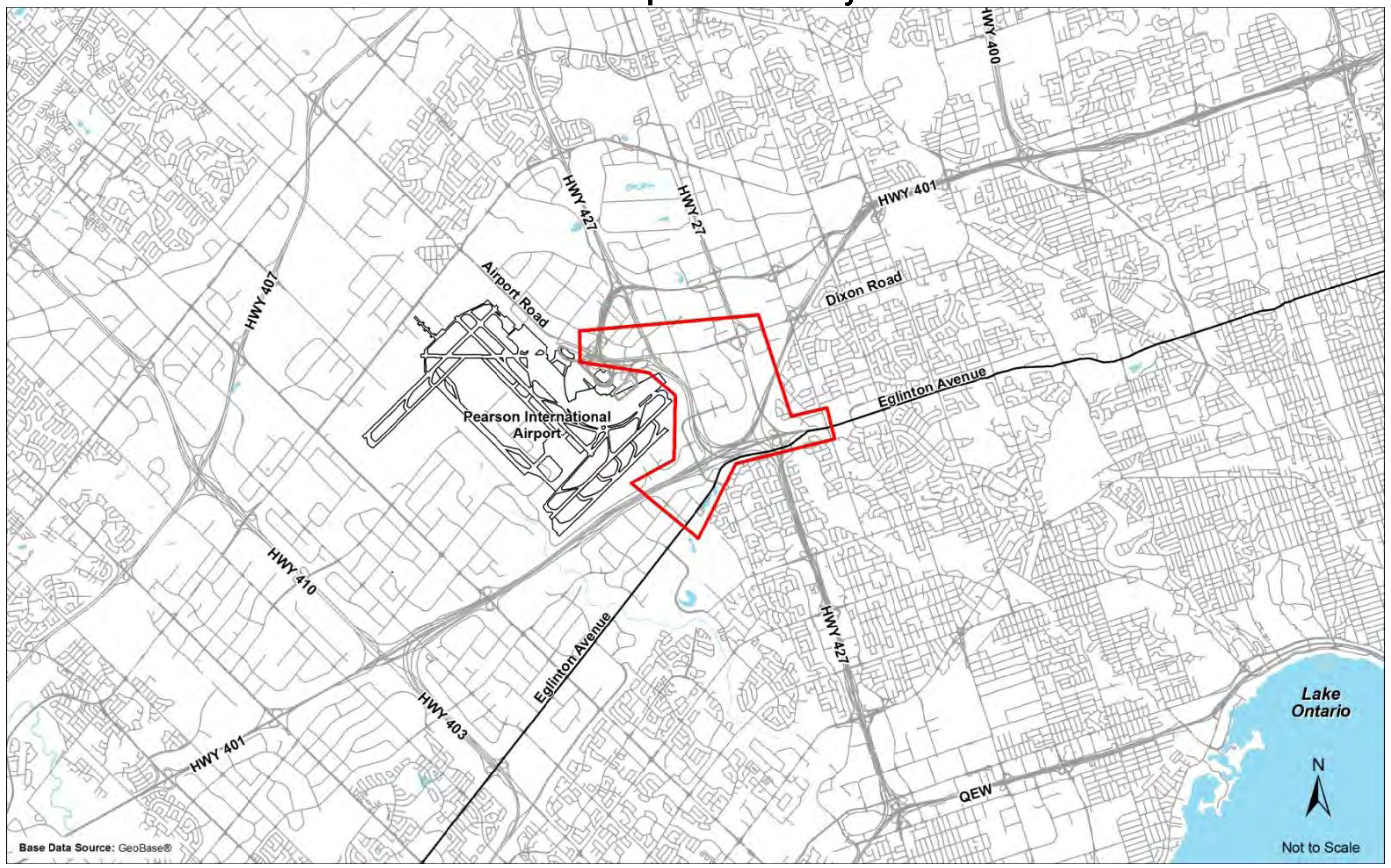
The report recommended that the minimum underground section extend from east of Black Creek Drive to east of Brentcliffe Road.

As part of the Transit Project Assessment, the limits of the underground alignment were studied further to evaluate whether further extensions of the underground section were warranted. A study, “Jane Street to Keele Street – An Evaluation of Vertical Alignment” which evaluates the west limit of the underground section is summarized in **Section 2.2.10** and is included in **Appendix K** of this report.

2.2.2 Airport Link Pearson International Airport to Martin Grove

A feasibility study for the Airport Link area was conducted to determine if there was a logical and feasible connection to Pearson International Airport from Eglinton Avenue for the Eglinton Crosstown LRT and, if so, to identify a preferred alignment. Limits of this evaluation are Eglinton Avenue to the south, Martin Grove Road to the east, Pearson International Airport/Orbitor Drive to the west and Dixon Road to the north as shown in **Exhibit 10.**

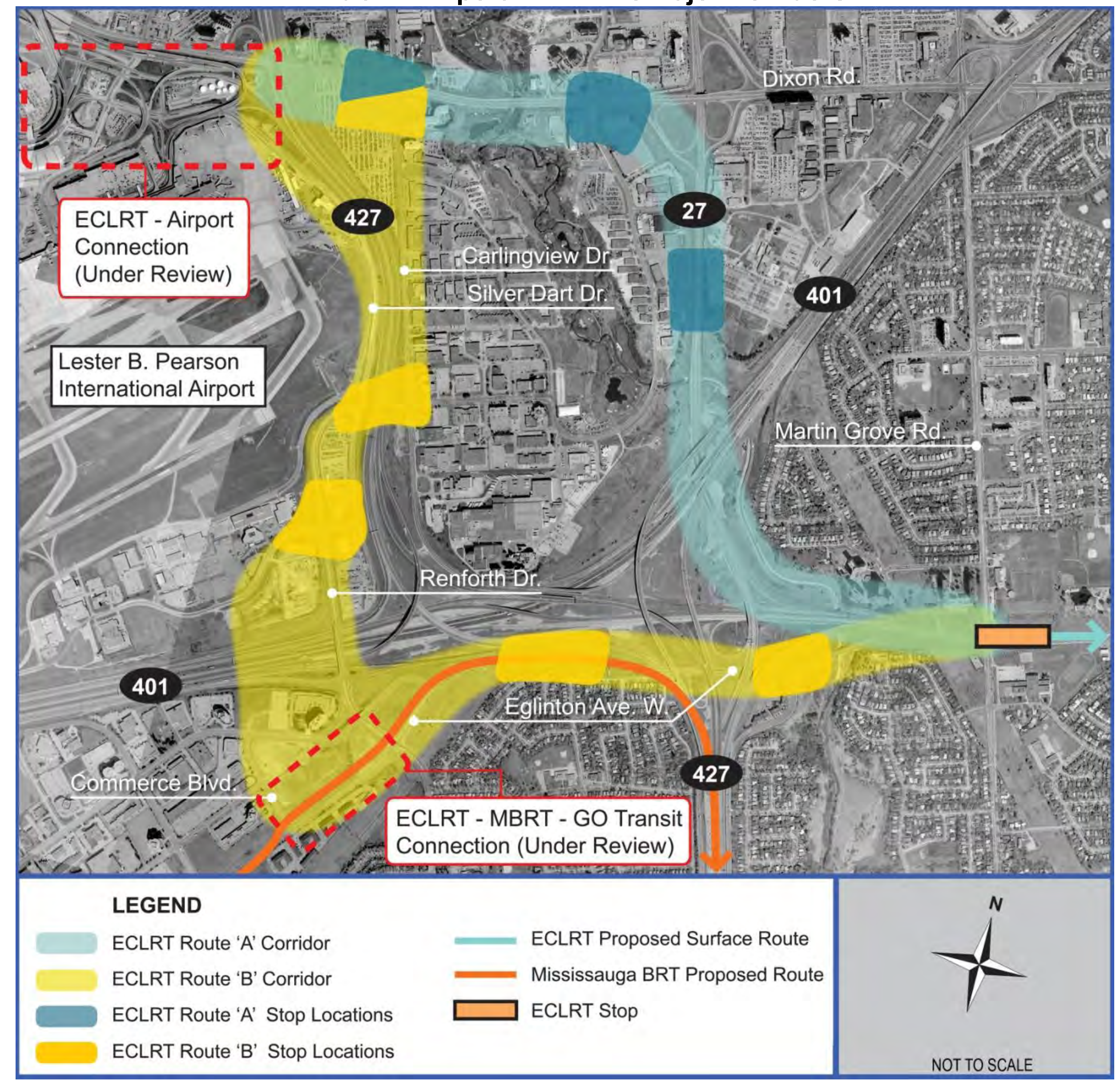
Exhibit 10: Airport Link Study Area



The study area contains an unusually complex system of major highways: Highways 427, 27 and 401 all traverse the area, and are interconnected by a number of bridges, ramps, collector and express lanes.

Two main corridors were considered for the connection between the intersection of Eglinton Avenue and Martin Grove Road and the Pearson International Airport as shown in **Exhibit 11,** with multiple alternative routes within each.

Exhibit 11: Airport Link - Two Major Corridors



2.2.3 Key Challenges and Constraints

Key challenges and constraints were identified and researched in the process of developing route options. The overall challenge was to determine the best route for providing an LRT link from Martin Grove Road to Pearson International Airport. The main challenge was to ensure the technical feasibility of constructing the LRT through the complex highway system with the following objectives:

- Minimizing the cost and logistical problems associated with relocating or avoiding major utilities;
- Keeping the LRT tracks, traffic lanes and sidewalks within existing rights-of-way with minimum impact to adjacent properties;
- Avoiding costly alterations and additions to existing bridge structures;

- Minimizing impacts on the built and natural environments;
- Providing a route with the greatest potential for promoting and supporting future development;
- Providing a route with the least travel time while maintaining convenient public accessibility.
- Providing a route that would meet forecasted travel demands including the proposed Mississauga BRT and GO Transit BRT facilities; and
- Providing efficient interfaces with all transportation modes.

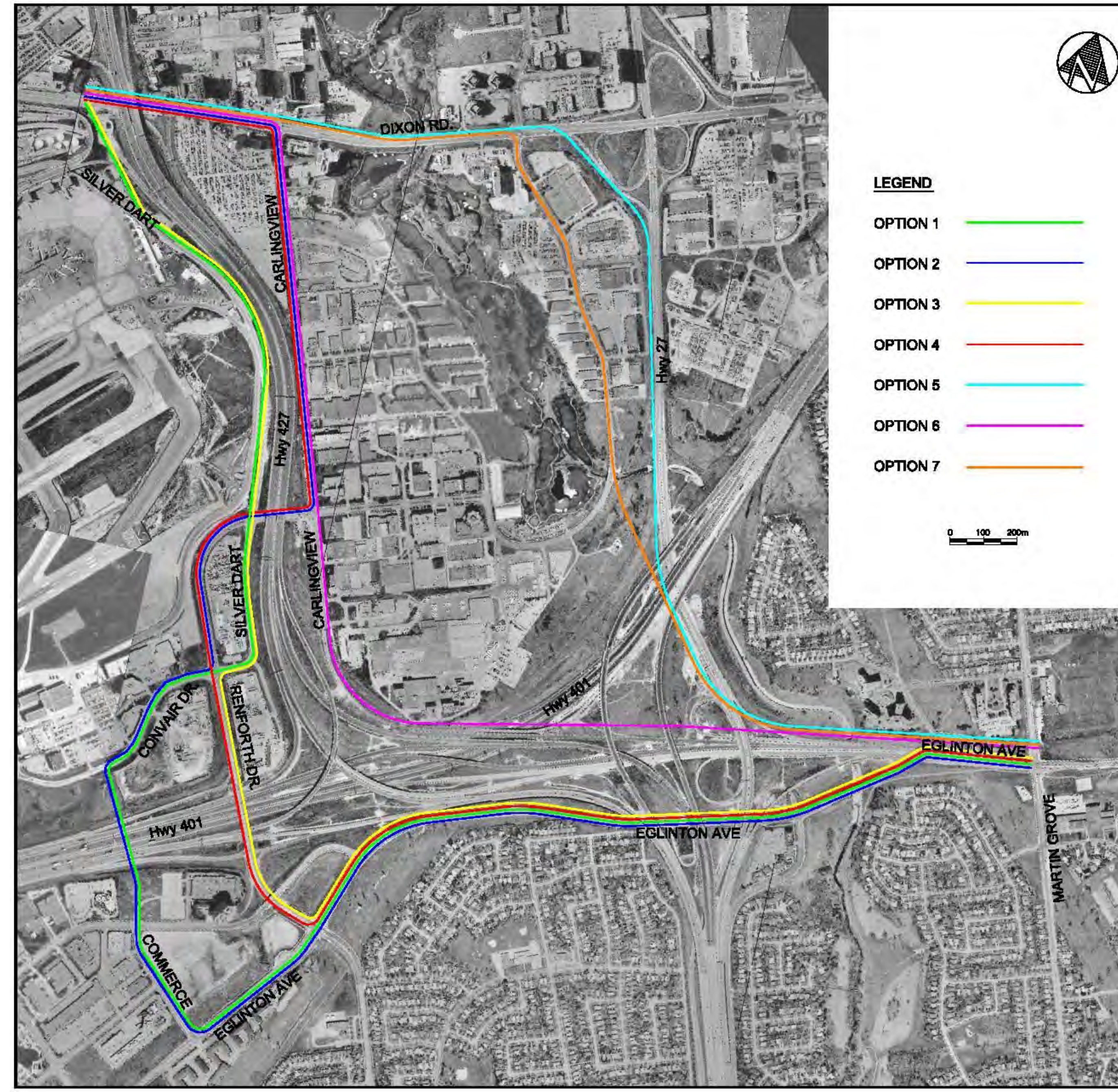
2.2.4 Options

Two major corridors, one located along Renforth/Commerce and one located along Highway 27, and eight alignment options located within the two corridors, were identified including:

- Option 1 - Eglinton/Commerce/Convair/Silver Dart;
- Option 2 - Eglinton/Commerce/Renforth/Carlingview/Dixon;
- Option 3 - Eglinton/Renforth/Convair/Silver Dart;
- Option 4 - Eglinton/Renforth/Carlingview/Dixon;
- Option 5 – Highway 27 Underground then to Dixon;
- Option 6 - Martin Grove/Hwy 427 (underground)/Carlingview/Dixon;
- Option 7– Highway 27 at Surface; and
- Option 8 – Highway 27 Spur Line. This option includes a combination of the options to Renforth Drive and the options up the Highway 27 corridor. A “spur” line is provided from Martin Grove Road to Renforth Drive, and the connection to the airport is provided via the Highway 27 corridor.

The two major corridors and eight alignment options are presented in **Exhibit 12**.

Exhibit 12: Airport Link - Eight Alignment Options



2.2.5 Evaluation

2.2.5.1 Renforth/Commerce Corridor

Routes along this corridor would follow Eglinton Avenue and would pass under the eight bridges west of The East Mall carrying Highways 427/27 and ramps. Initial studies of the horizontal and vertical clearances with the addition of the LRT tracks showed that there is adequate clearance for the LRT tracks and traffic lanes through the underpasses. No major impacts are anticipated with the addition of the LRT tracks.

However, the following structural work would be required if the route were to fall within the Renforth/Commerce corridor:

- A retaining wall would be required on the south side of Eglinton Avenue due to the introduction of a sidewalk in the existing side slope under the Highway 427 underpass;
- At Mimico Creek, the Eglinton Avenue bridge would require widening;
- At Renforth Drive over Highway 401, a bridge structure carrying the LRT over Highway 401 will be required;
- At Renforth Drive under Highway 427, studies showed that there is insufficient clearance between structure abutments to accommodate LRT and required traffic lanes/sidewalks; and
- At Highway 427 over Dixon /Airport Road, it was determined that it would not be feasible to implement an elevated guideway for the LRT due to the extreme height required to clear Highway 427. A surface option with the LRT on Dixon/Airport Road would be feasible, with the LRT on centre road alignment.

2.2.5.2 Highway 27 Corridor

Study results indicated that the most significant challenge is the crossing of Highway 27/Highway 427. There is no available space to accommodate the LRT under the existing bridges. Any route crossing at this location would require rebuilding the overpasses, or accommodation of the LRT in a tunnel.

In addition, Mimico Creek falls within a regional flood plain, and the implementation of the LRT would impact the flood plain. These impacts presented challenges in relation to the location of the LRT above the regional 500 year flood elevation, and to other potential environmental impacts.

Relocation of major utilities is a lengthy and expensive process that should be avoided or minimized, where possible. Research of available existing utility plans shows that several major utilities are located within the study area. These have the potential to impose technical constraints in locating the LRT: Sun Canadian oil and gas pipelines, Toronto Hydro corridors, and a 54" sanitary sewer all traverse the area. Storm water, sanitary sewer and water mains, as well as telecommunications and electrical distribution systems, will impact each alternative route. Accommodation of these utilities, with relocations where necessary, will be addressed at the preliminary engineering design stage.

For the Commerce/Renforth corridor, no major storm or sanitary drainage impacts were identified.

2.2.5.3 Screening

The development and evaluation of alternative alignment concepts was conducted in five stages: Information gathering, route development, initial screening, refinement, and evaluation of options.

After initial screening, three routes were eliminated due to significant issues which disqualified them for further consideration:

- Option 5 - Martin Grove/Hwy 427 (underground)/Carlingview/Dixon Option
  - This route failed to meet the criterion for ease of implementation, due to the major tunnelling operation that would be required to traverse from Martin Grove Road to the junction with Carlingview Drive. The east tunnel portal would lie in the 500 year flood plain of Mimico Creek
  - There would be a relative lack of opportunity to serve a significant number of transit users: The eastern half of the route would have no feasible place to locate a stop, and the line would be inaccessible to any potential users south of Eglinton Avenue
  - There are high costs associated with the complex tunnelling operation, with relatively little benefit
  - Poor inter-regional connectivity would result from this route's remoteness from the Mississauga BRT hub at the Renforth gateway.
- Option 6 – Highway 27 at Surface
  - This route failed to meet criteria for ease of implementation, because there is insufficient clearance through the Highway 401 overpasses to allow surface construction. This would necessitate tunnelling, with construction difficulties,
  - As in the previous alternative, there would be a relative lack of opportunities to serve a significant number of transit users, again with the eastern portion having no user access,
  - If this route were to be implemented, there would be high costs associated with the tunneling, and
  - Poor inter-regional connectivity would result from this route's remoteness from the Mississauga BRT hub at the Renforth gateway.
- Option 8 – Highway 27 Spur Line.
  - This route's primary drawback was the high additional cost of constructing a special LRT spur line to make the connection for passengers to the Mississauga BRT station at Renforth gateway,
  - There would be high operational costs associated with this option, resulting from the inability to easily maintain headways, and
  - The inter-regional connectivity would be poor and only available for those passengers who selected the LRT service travelling the spur line.

The remaining route alignments were carried forward for further evaluation.

2.2.5.4 Interface with Mississauga BRT/GO Transit

Three alternatives were proposed for the interfae with the future Mississauga/GO Trans BRT facility. The City of Mississauge is planning the facility on the north-east quadrant of Eglinton Avenue and Commerce Blvd. **Exhibit 13, 14 and 15** show three alternatives 1, 2, and 3 for the LRT station.

Exhibit 13: Alternative 1 – Eglinton Avenue Single Centre Platform

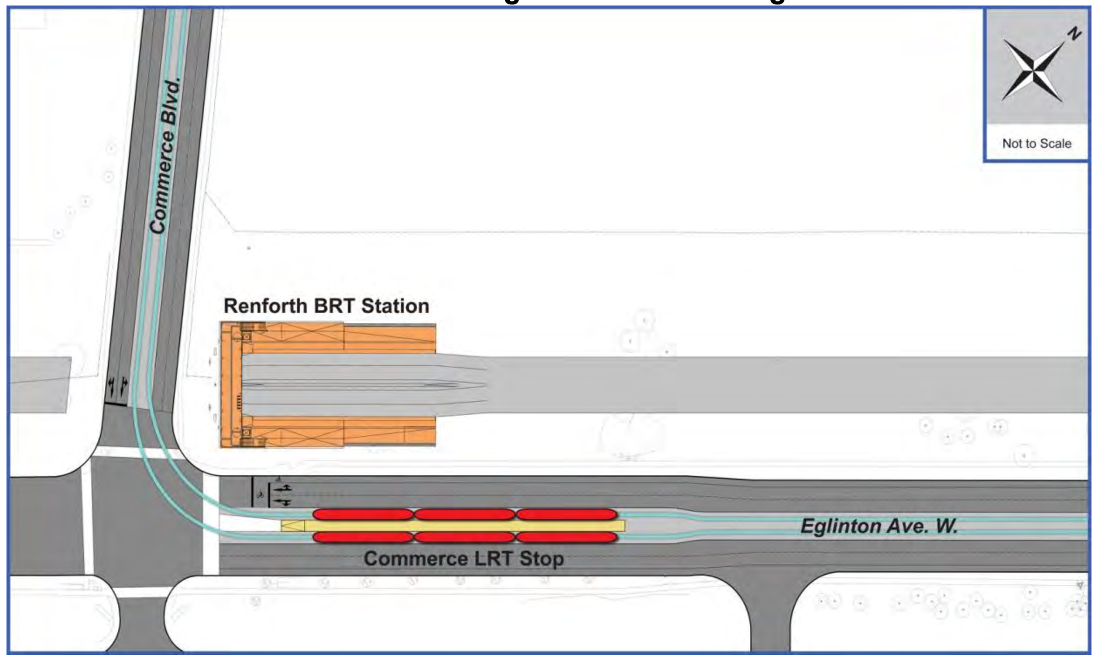


Exhibit 14: Alternative 2 – Commerce Boulevard Single Centre Platform

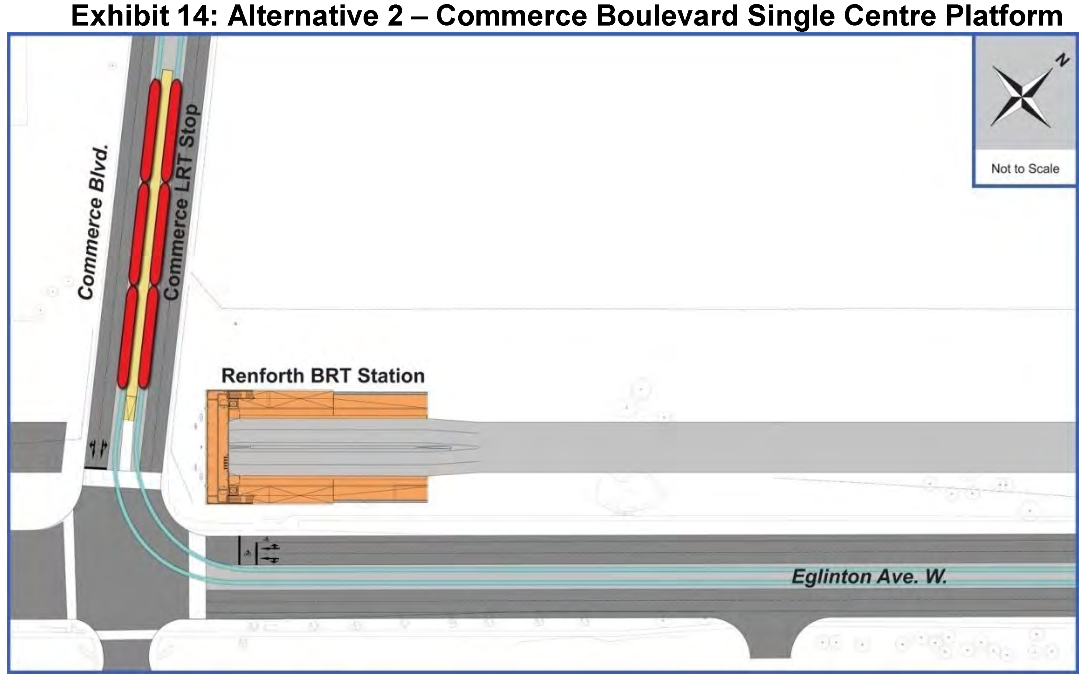
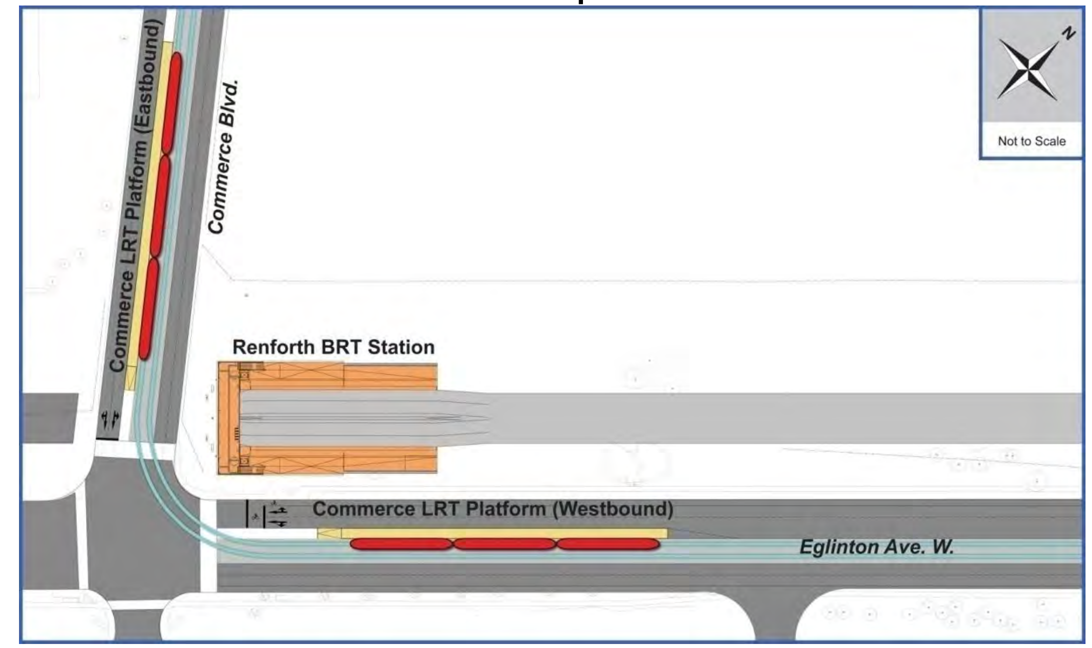


Exhibit 15: Alternative 3 – Split Platform Locations



The selection of a preferred scenario became the subject of a special traffic study to determine the impacts on traffic and pedestrian movements, signalization design, and the quality of interface with Mississauga BRT. The traffic study concluded that Alternative 2, with the LRT stop located on Commerce Boulevard, with centre platform, was the preferred option.

2.2.5.5 Summary

The five remaining route options to the airport were carried forward for further study. The core criteria that were used for final evaluation were:

- Technical Feasibility: The engineering issues, including physical fit (potential conflicts with roadways and major underground utilities, and resultant need for bridges and/or tunnels), property impacts, and traffic operations impacts.
- Travel Time: The predicted travel time for the LRT service from Martin Grove Road to the airport “gateway” immediately west of Highway 427.
- Estimated Capital Cost: The engineering and construction costs.
- Development Opportunity: The potential to serve planned development with 500 metres of the proposed stop locations for each alternative.
- Ridership Forecast (2031): The ability of each alternative to attract ridership, based on 2031 population and employment forecasts for the area.
- Inter-Regional Connectivity: The ability of each alternative to provide a convenient connection with the Mississauga BRT facility.

For each alternative, a score between 1 to 5 is given for each criteria where 1 is least preferred, and 5 is most preferred. The score is not a rank, i.e. more than one alternative may be given the same score under the same criteria. At the conclusion of the evaluation process, the alternative with the ***highest total score*** was determined the ***most preferred***.

The evaluation scoring summary is shown in **Exhibit 16.**

Exhibit 16: Airport Link - Route Evaluation Scoring Summary

CRITERIA	ROUTE OPTIONS				
	RENFORTH/COMMERCE				HIGHWAY 27
	Option 1	Option 2	Option 3	Option 4	Option 5
EASE OF IMPLEMENTATION	4	2	3	2	1
TRAVEL TIME	3	1	4	3	5
ESTIMATED CAPITAL COST	4	1	5	3	2
DEVELOPMENT OPPORTUNITY (2031)	4	5	3	5	4
RIDERSHIP FORECAST (2031)	3	3	3	3	3
INTER-REGIONAL CONNECTIVITY (Mississauga BRT and GO Transit)	5	5	3	3	1
Note: Scores above are 1 (least preferred) through 5 (most preferred).					
TOTAL SCORE	23	17	21	19	16
OVERALL RANKING	First	Fourth	Second	Third	Fifth

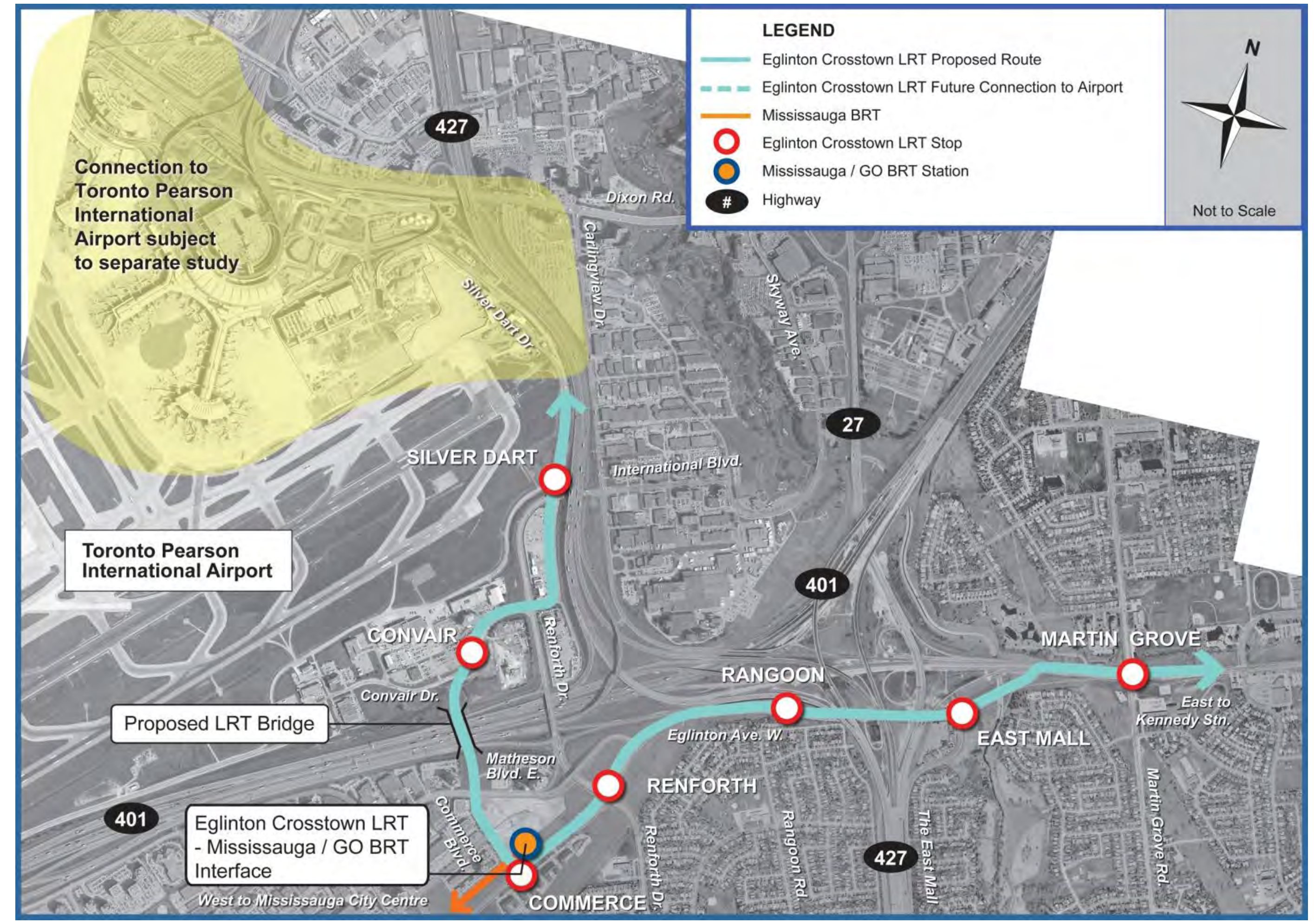
2.2.6 Recommendation

The preferred alignment was Option 1 – Eglinton/Commerce/Convair/Silver Dart as shown in **Exhibit 17** because it scored the highest. This alignment includes a proposed bridge located over Highway 401 to connect Commerce Boulevard with Convair Drive.

This alignment was selected based on two major factors:

- It offers the least cost for the greatest benefit in terms of connection and transfer convenience to the Mississauga/GO BRT; and
- It has the least technical constraints, including shortest guideway span across Highway 401 and with no impacts to existing on/off ramps.

Exhibit 17: Preferred Alignment Option 1 – Eglinton/Commerce/Convair/Silver Dart



2.3 Single Bore vs. Twin Bore Tunnel Configuration

A comparative study, "*Eglinton Crosstown LRT: Single vs. Twin Tunnelling – A Preliminary Study",* between Single Bore and Twin Bore tunnelling options for the Eglinton Crosstown LRT was conducted to investigate benefits that single and twin tunnels offer. This study investigated the advantages of single bore technology reducing the impacts of the station construction process. The primary feature of a Single Bore tunnel configuration is that station platforms, crossovers and tail tracks are all accommodated within the tunnel cross section. Therefore, the location of each of these major elements can be adjusted along the entire corridor to maximize design efficiency and minimize construction impacts. Another key feature is that station structures can be located on either side of of the road. This allows such structures, which are constructed using cut-and-cover, to be built with minimal impact on traffic. However, on the other hand, the single bore tunnel must be significantly deeper underground, which means that more stairs and escalators are required at the stations.

Under a Twin Bore tunnel configuration, two tunnels are bored, one to accommodate each direction of LRT rail track. The station platforms, crossovers, and tail tracks are constructed using cut and cover construction. An approximate 6 metres diameter tunnel for the Twin Bore option and an approximate 13 metres diameter tunnel for the Single Bore option were assumed. Single and twin bore tunnel cross sections are presented in **Exhibit 18** and **Exhibit 19**.

2.3.1 Key Challenges and Constraints

2.3.1.1 Stations

The following criteria and/or assumptions are common to both Single Bore and Twin Bore station types:

- All stations will have at least two entrances (main and secondary) and one emergency exit;
- Main entrance is fully accessible with one elevator;
- Automatic entrances (second entry) occur only at Allen and Yonge Stations; and
- All other stations include standard second entrances with stairs only.

Exhibit 18: Single Bore Station Cross Section

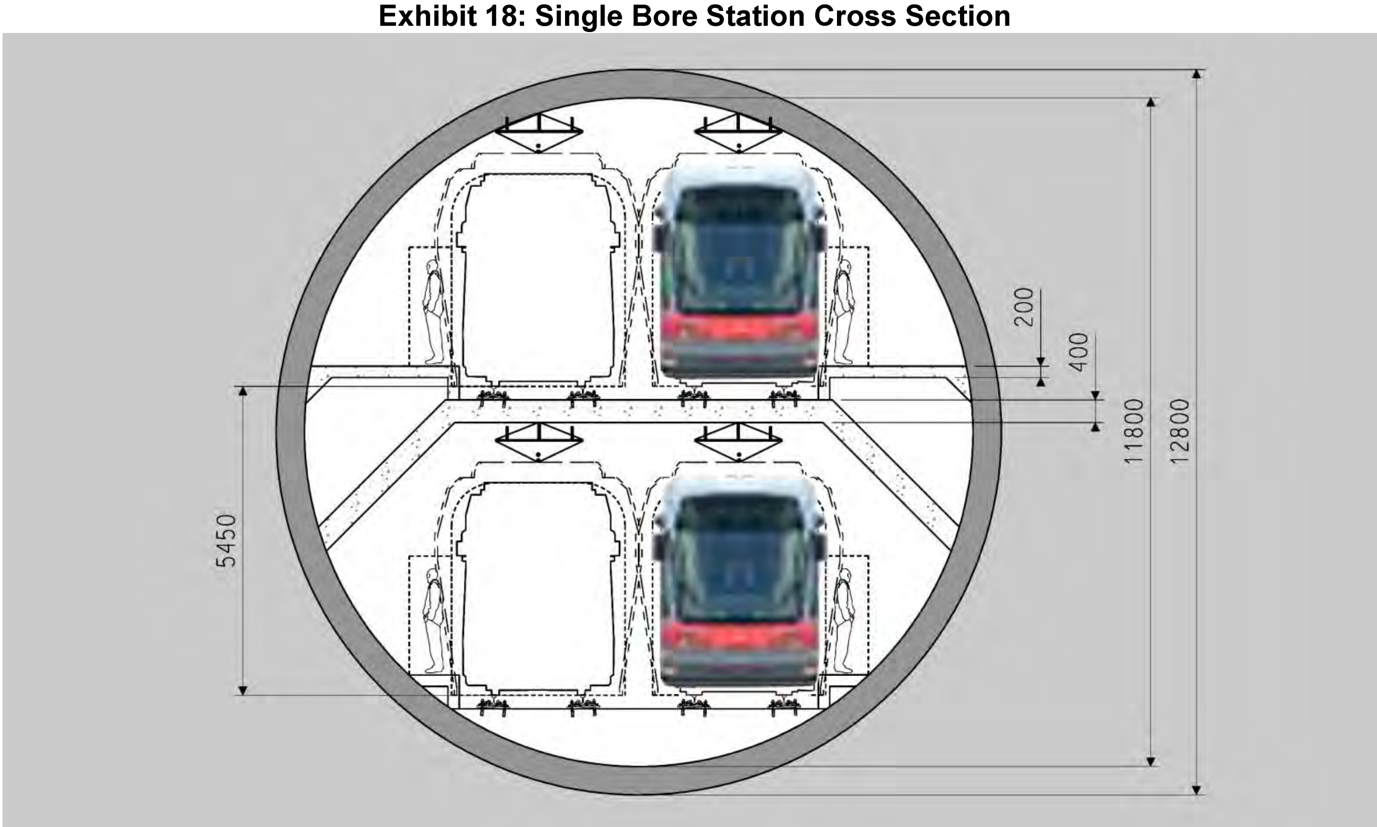
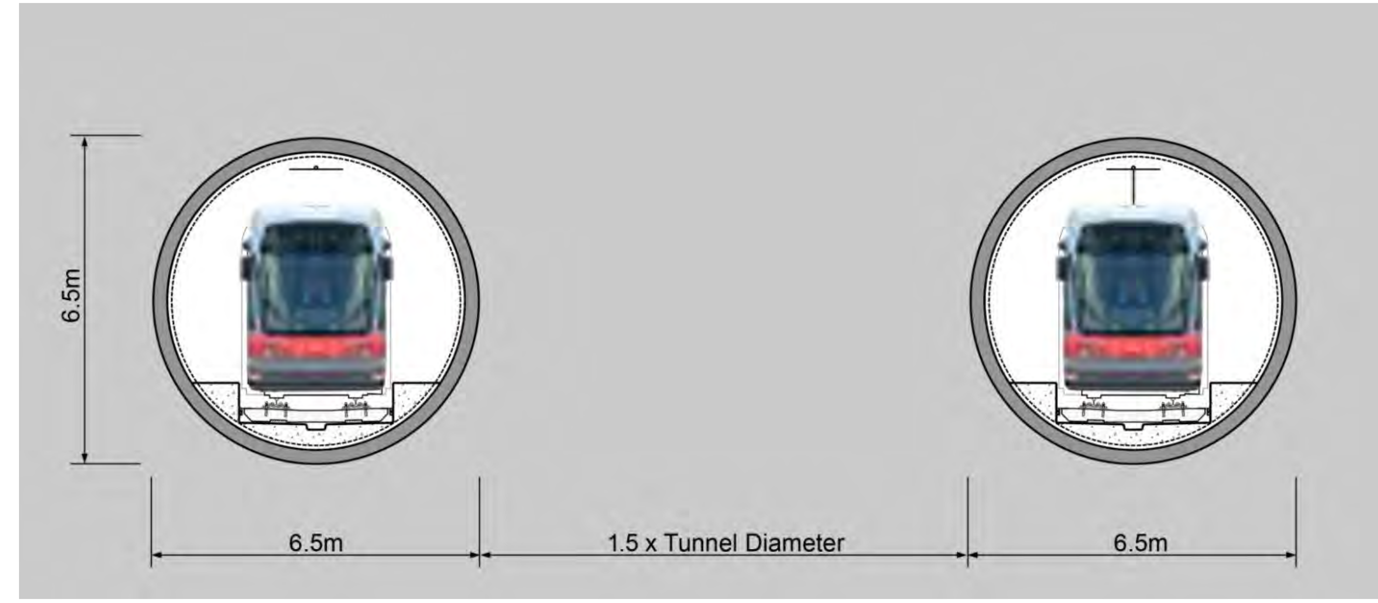


Exhibit 19: Twin Bore Station Cross Section



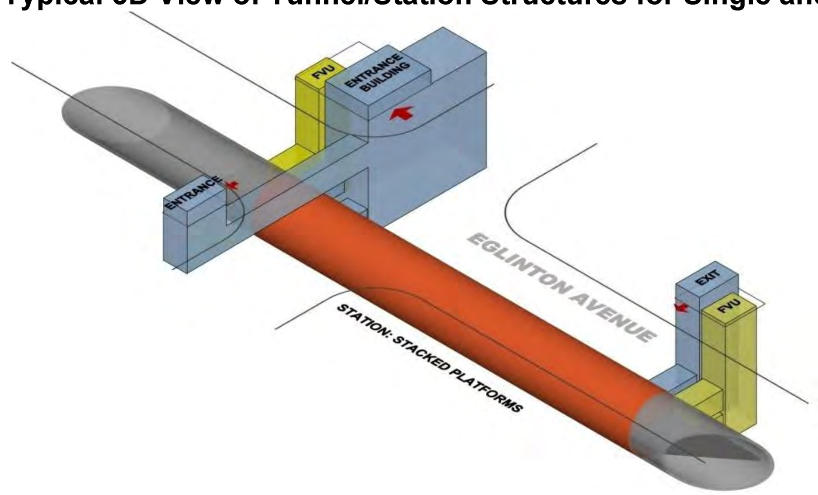
2.3.1.2 Design Approach

Stations constructed with a Single Bore tunnel include platforms located within the tunnel itself, one at each level and to one side of the runningway.Therefore, a single point of entry/egress to/from both platforms could be located anywhere along the length of the platform(s). In addition, the stacked side platforms can be located to either side of the runningway within the tunnel depending on the preferred location of the main entrance building. The upper platform is located at a depth of approximately 18 metres and the lower platform would be at a depth of approximately 23.5 metres. Structures would include a main entrance building and at least one emergency exit building located at either end of the station. These structures would be separate entities connected to the Single Bore tunnel and platforms via separate pedestrian tunnels and shafts approximately 7 metres in length when located within the typical 26 metres right-of-way. The main vertical circulation would include two sets of escalators. Due to the depth of the station platforms, an additional escalator could be required to facilitate faster passenger access between the platforms and the street. The size of the entrance building and underground structure would depend on the type of vertical circulation and its organization.

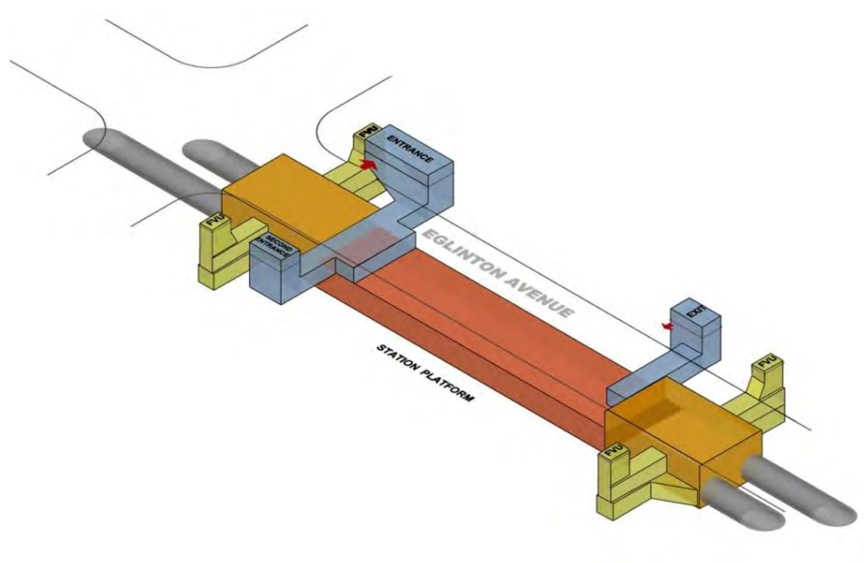
Stations constructed with a Twin Bore tunnel are generally independent box structures based on standard subway design. These station boxes consist of a 90 metres centre platform and 30 metres service areas at either end of the station box including a concourse above the platform. The centre platform is generally not as deep as a single tunnel and would be located approximately 13 to 16 metres below street level depending on site conditions but can also be deeper (over 20 metres) due to topography, existing utilities or subway alignments. The concourse would occupy a smaller footprint above the platform and can be a separate box structure above the platform box structure or it can be an architectural element within a larger 2-storey station box structure allowing passengers to see the platform below. Entrances would connect directly to the concourse from either side of the roadway whereas emergency exits would have direct connection to the centre platform. Entrances can be smaller in size compared to those provided to and from an underground station constructed with a Single Bore tunnel, due to lesser requirements for escalators.

Exhibit 20 presents a three dimensional view of the tunnel and station structures constructed with single and twin bore tunnels.

Exhibit 20: Typical 3D View of Tunnel/Station Structures for Single and Twin Bore



Single Bore



Twin Bore

2.3.1.3 Construction Methodology

For cost and schedule estimate purposes, the study was carried out under the assumption that four, approximately 6 metres diameter TBMs would be needed for the Twin Bore or two, approximately 13 metres diameter TBMs would be needed for the Single Bore. Under either option, the TBMs will be launched from each end of the underground alignment, around Black Creek Drive in the west and Brentcliffe Road in the east. They would be retrieved (taken out of the ground) around the midpoint of the tunnel near Chaplin Station.

Construction of the platforms occurs within the Single Bore tunnel and would have no impact on adjacent properties or surface activities. In addition, the continuity and independence of the tunnel from the vertical structures allows for increased capacity with ability to lengthen the platforms without additional impacts. The platforms will be 96 metres long to accommodate a three-car train without requiring additional construction or structural work outside the tunnel. Additionally, should demand warrant, these platforms can be extended even further, limited only by the vertical alignment constraints and special trackwork

The stations along a twin tunnel alignment would be constructed using a cut and cover method affecting street level activities, causing business interruption and necessitating utility relocation during the construction phase of the station. To avoid major impacts at intersections, it is preferable to locate the station box outside the intersection where possible. This increases the passenger travel distance between the platform and connecting surface stops. If passenger movement is provided underground, this results in longer tunnels. From a planning and passenger perspective platforms are preferred to be located as close to the intersection as possible to reduce the transfer time between connecting surface transit routes.

Exhibit 21 and **Exhibit 22** show typical construction impact for single bore and twin bore tunnels.

Exhibit 21: Construction Impact Assuming Both Stations are Located at the Centre of the Intersection

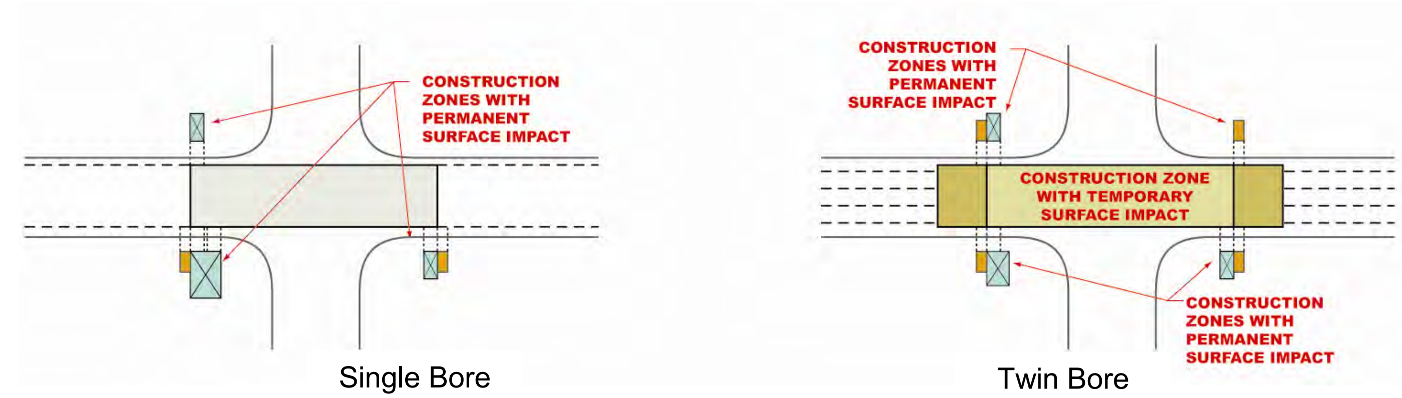
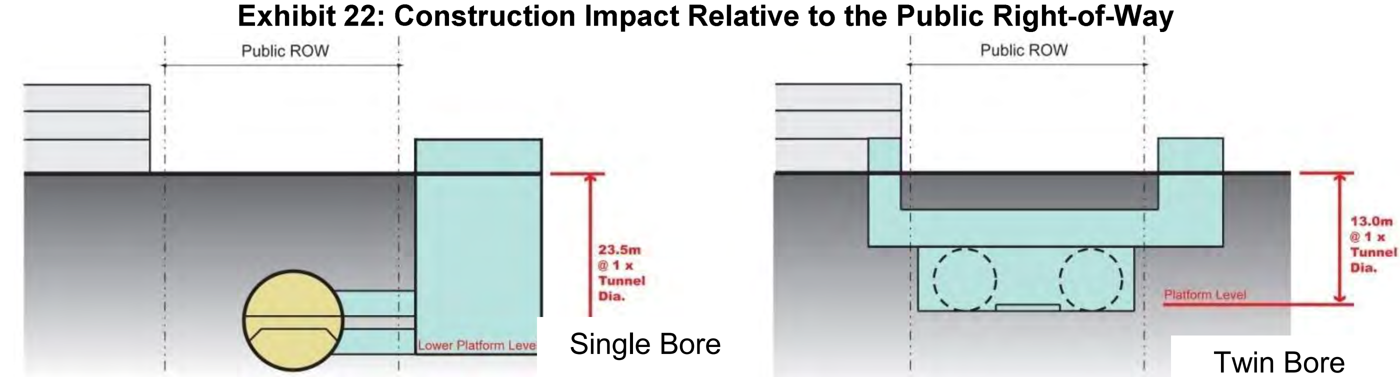


Exhibit 22: Construction Impact Relative to the Public Right-of-Way



2.3.2 Options

The two options considered were:

- Single Bore tunnel configuration; and
- Twin bore tunnel configuration.

2.3.3 Evaluation

The criteria used to evaluate the single bore vs. the twin bore tunnel options included:

- Order of magnitude construction cost estimates;
- Preliminary construction schedules;
- Effects of geological conditions along the corridor;
- Track alignments;
- Station configurations;
- Aspects of the fire/life safety systems;
- Construction staging;
- Environmental concerns such as surface disruptions, maintenance and protection of vehicular and pedestrian traffic; and
- The potential for secondary project concerns such as Transit Oriented Development and LEED certification.

Single bore was considered potentially less disruptive at the surface in the vicinity of stations. However, this option was less desirable due to the following:

- A single bore tunnel would be in excess of 13 metres in diameter and would be the largest bore ever attempted in North America.
- Soil conditions within the existing geological strata would make it difficult to control settlements at the surface and to adjacent buildings during the boring operations.
- There are a limited number of contractors locally/nationally that have experience with boring large diameter tunnels which would limit competition.
- The time required to manufacture a tunnel boring machine of that diameter would be longer than the time necessary to manufacture the small tunnel boring machines and thus may have a negative impact on the construction schedule.
- The lower station platform of the single bore tunnel scheme would have been at a depth that would cause a significant cost increase in achieving the fire and life safety criteria as established by TTC as well as adding distance to pedestrian travel between the surface and platform levels.
- The station areas would require more private property.

2.3.4 Recommendation

Based on the foregoing evaluation, twin bore tunnel was selected as the preferred tunnel configuration.

2.4 Change in Traffic Operations

The implementation of the Eglinton Crosstown LRT in reserved lanes on Eglinton is projected to change the way traffic operates along Eglinton Avenue. The anticipated changes to traffic operation and their associated impact on traffic operation are shown in **Exhibit 23.**

Exhibit 23: Operational Traffic Changes and Impacts

Change	Impact
Left-turn will be prohibited at existing unsignalized side-streets and entrances (i.e. to become right-in and right-out accesses)	Will redirect left-turning traffic to nearby signalized intersections.
East-west left turns at signalized intersections will operate as protected only (i.e. will operate only under a dedicated left-turn phase) to prevent collisions with LRV.	Will reduce the east-west left turn capacity of signalized intersections on Eglinton Avenue.
Reduced roadway capacity due to the removal of one travel lane in each direction along Eglinton Avenue East.	Will reduce the east-west through capacity of traffic signals on Eglinton Avenue East.

With the LRT operating in its own right-of-way in the centre of the road, there are two types of changes to traffic operations: at unsignalized driveways and intersections, and at signalized intersections.

At driveways and unsignalized intersections, under existing conditions drivers can make left turns, as shown in **Exhibit 24**. However, with the construction of the LRT right-of-way in the middle of the road, left turns will no longer be permitted. Instead, drivers will be required to make right turns, and then make u-turns at the next downstream signalized intersection, as shown in **Exhibit 25**.

At signalized intersections, left turns and U-turns will be permitted. However, with the number of left turns and U-turns projected at some major intersections, there may be constraints to transit and traffic operations.

Exhibit 24: Existing Left Turn

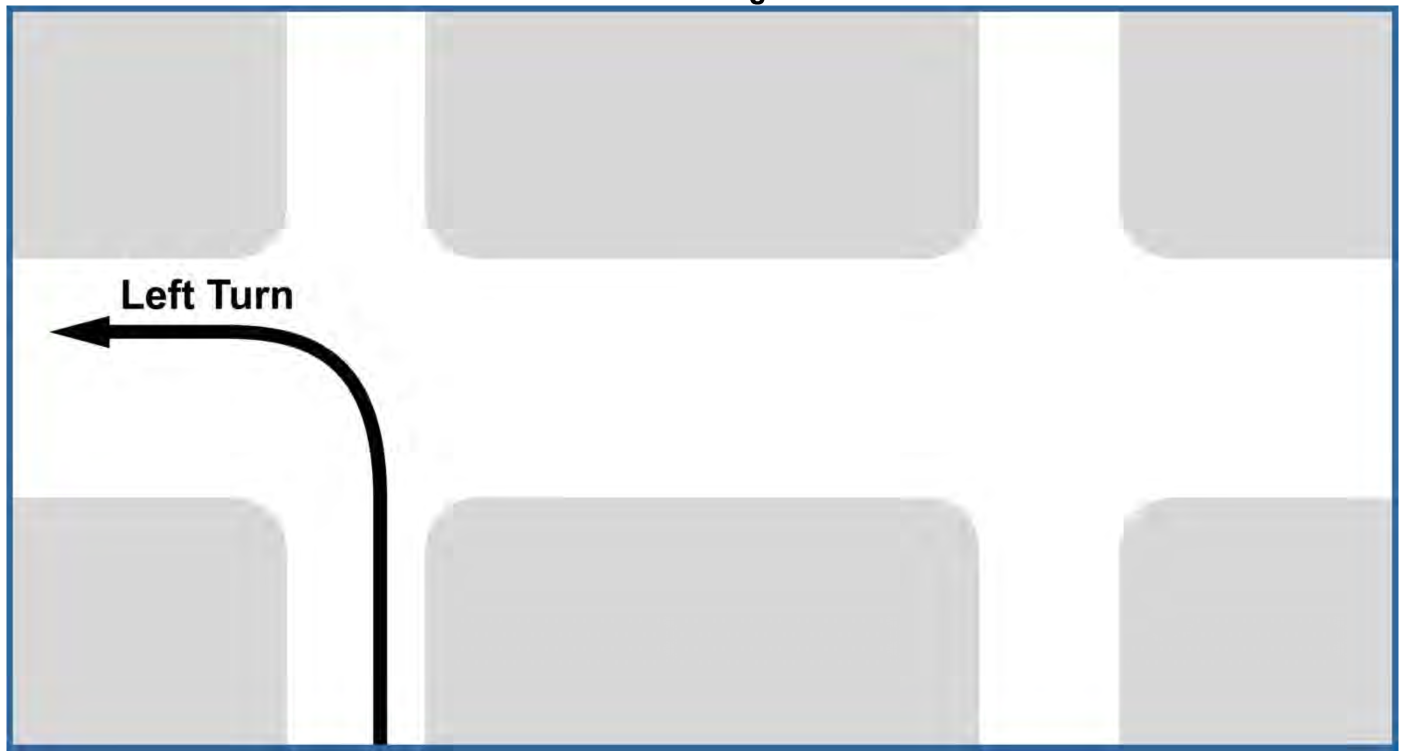
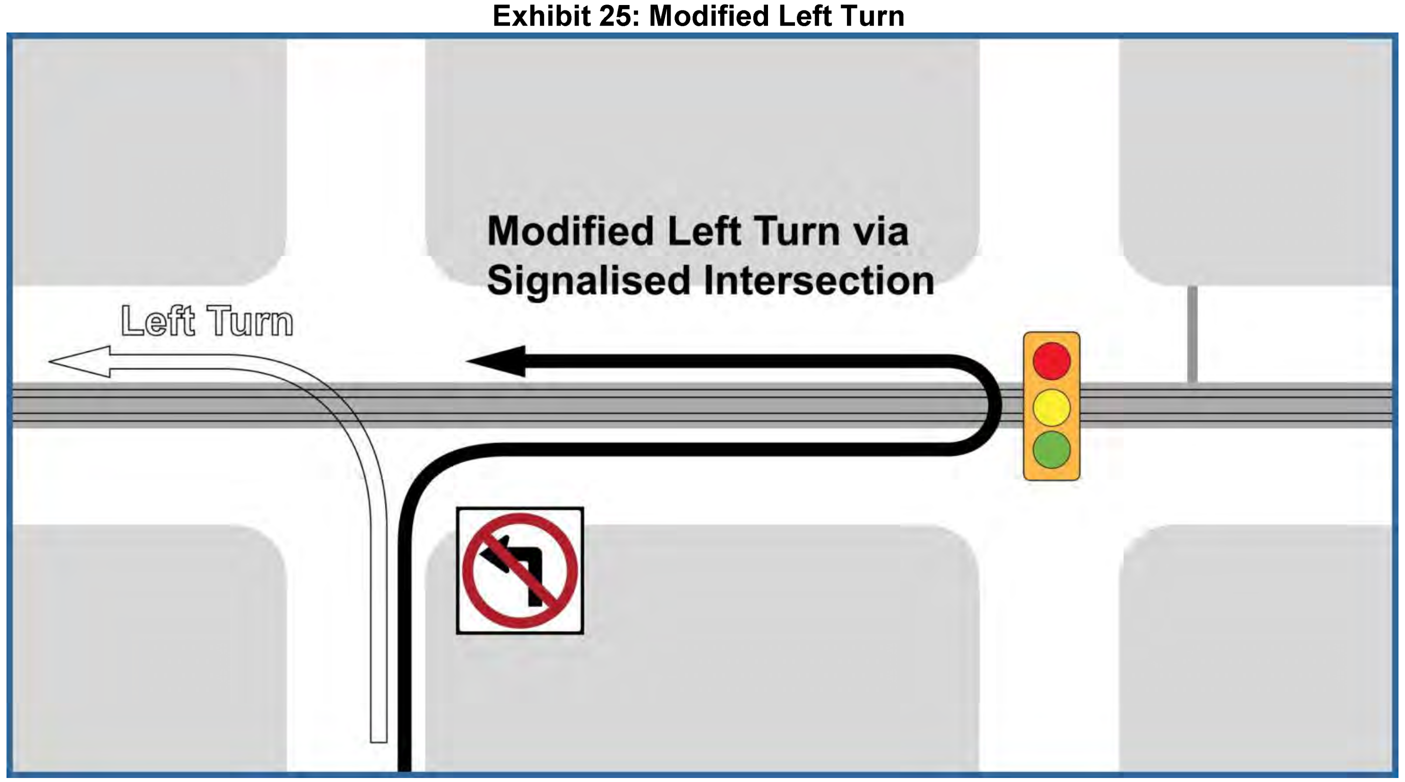


Exhibit 25: Modified Left Turn



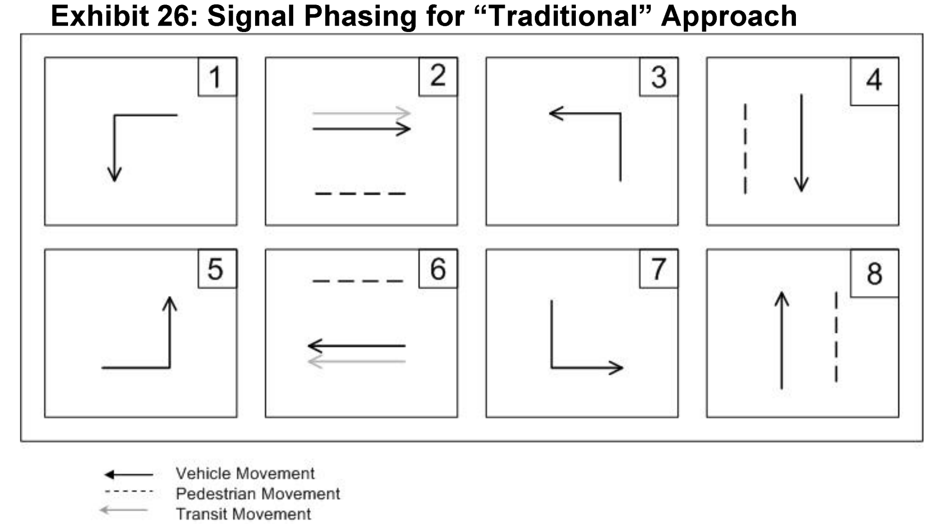
2.4.1 Key Challenges and Constraints

Currently, traffic is permitted to make left turns at most major intersections where major north-south roads cross Eglinton Avenue. Motorists can make left turns during a special phase for left-turning vehicles (left turn green arrow), and also during the green phases. However, the traffic signal timings must be changed with the addition of an LRT operating in the middle of the road on the surface. Left turning vehicles on Eglinton Avenue cannot be permitted to cross the transit right-of-way when LRT vehicles could potentially be traveling through the intersection. The implications on traffic and LRT operations are discussed herein.

The corridor was initially assessed under the assumption that transit, traffic and pedestrian movements would be managed at signalized intersections using the "traditional" approach, as shown in **Exhibit 26**, as follows:

- East-west left turns and U-turn traffic movements would operate at the same time (boxes 1 and 5 on **Exhibit 26**);
- East-west LRV, general traffic, and pedestrian movements would operate at the same time (boxes 2 and 6);
- North-south left turn traffic movements would operate at the same time (boxes 3 and 7); and
- North-south general traffic and pedestrian movements would operate at the same time (boxes 4 and 8).

Exhibit 26: Signal Phasing for "Traditional" Approach



Based on this approach to operations, the implementation of the Eglinton Crosstown LRT is projected to result in the following traffic impacts:

- Increased delays for vehicular traffic, particularly for left-turn movements, due to the introduction of separate left-turn and U-turn traffic signal phases in order to accommodate Eglinton Crosstown LRT service through the intersection; and
- Increased delays for pedestrians wishing to cross Eglinton, due to the need to operate high traffic signal cycle lengths to accommodate the distinct traffic, transit and pedestrian movements.

It should be noted that the assumptions used to generate these findings are conservative, since there were no adjustments made to the future traffic volumes based on an anticipated change in transportation modal split (shift from travelling by car to travelling on the Eglinton CLRT).

2.4.2 Options

The options to be considered were:

- Operate intersections using the "traditional" approach; or
- Operate some key intersections with re-routed left turns to downstream U-turn signals.

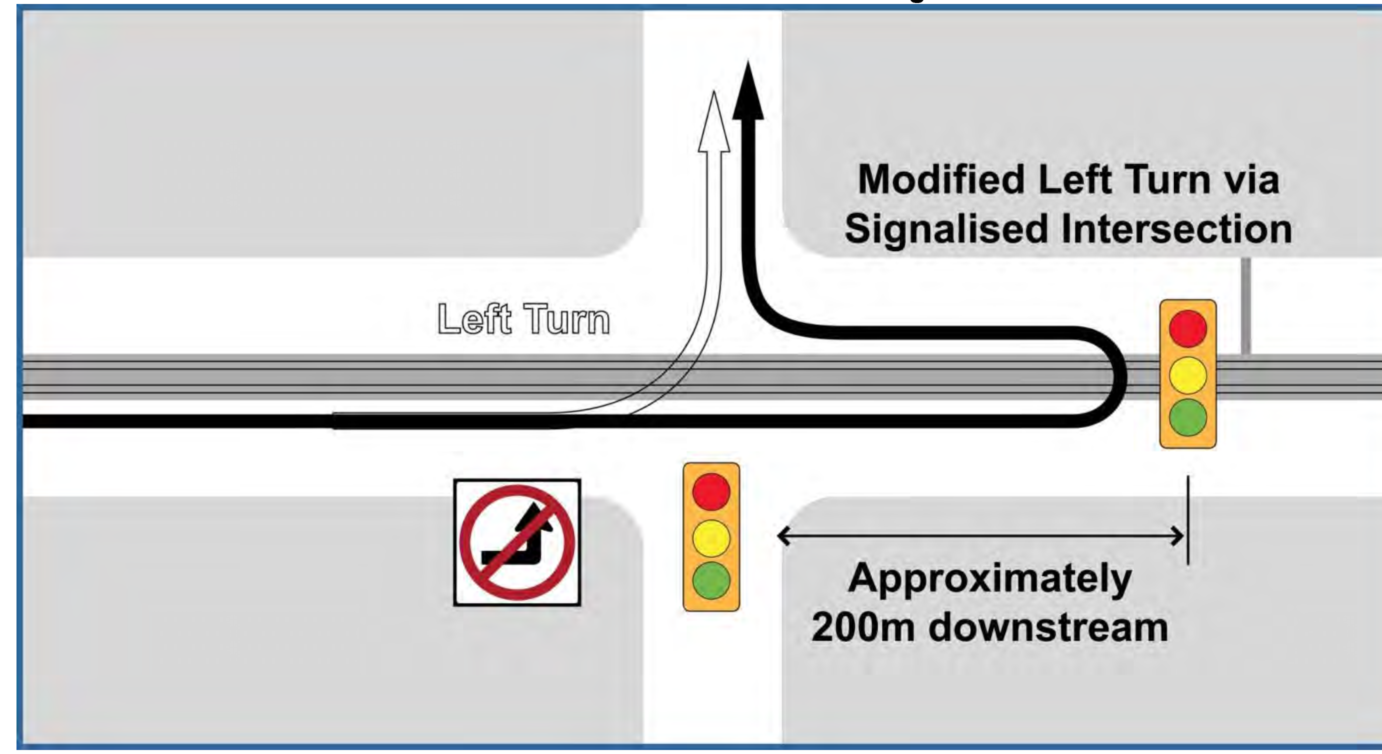
Ten signalized intersections were identified where traffic movements could cause potential Eglinton Crosstown LRT operational challenges (i.e. reduction in the speed and reliability for movement of transit vehicles, pedestrians, and vehicular traffic). These were locations where mitigating measures could potentially improve travel of the Eglinton Crosstown LRT, cross-transit vehicles, pedestrians, and vehicular traffic. The ten locations indentified for potential improvement were the intersections of Eglinton Avenue at:

- Martin Grove Rd.
- Kipling Ave.
- Islington Ave.
- Royal York Rd.
- Scarlett Rd.
- Jane St.
- Victoria Park Ave.
- Pharmacy Ave.
- Warden Ave.
- Birchmount Rd.

An alternative approach to the traffic operations was identified whereby the east-west and north-south left turn movements would be removed from the signalized intersections, and relocated to downstream "U-turn" signals. As shown in **Exhibit 27**, the operation is as follows:

- Drivers wanting to turn left from Eglinton Avenue onto an intersecting cross street must first travel through the intersection;
- Drivers will then make a U-turn at the traffic signals downstream of the intersection. The vehicles are stored in a separate turning lane. The drivers complete the U-turn when the traffic signals change to stop the traffic in the opposing direction;
- Drivers then turn right at the major intersecting street, using an exclusive right turn lane; and
- Through traffic in the same direction is not stopped by the U-turn traffic signal, and pedestrian crossings are not permitted at the U-turn traffic signal.

Exhibit 27: Left Turn at U-Turn Signal



2.4.3 Evaluation

A detailed traffic-traveller analysis was conducted at the ten locations comparing operations with traditional left turns to the left turn rerouting scenarios, with consideration for truck routing. The scenarios were compared based on the delays that would be experienced by the Eglinton Crosstown LRT, cross-street transit vehicles, general traffic, and pedestrians to determine which scenario was most beneficial to the spectrum of travellers.

To evaluate the traffic impacts of Light Rail Vehicle (LRV) operation in reserved right-of-ways within arterial roads, a priority scheme was developed and employed for traffic operations at signalized intersections. The priority scheme ensures that a safe transportation system is in place for all roadway users including pedestrians, cyclists, transit (bus and LRV) and traffic. The priority program consists of the following measures:

- Ensures high quality LRT operations (i.e. speed, reliability);
- Facilitates the movement of pedestrians;
- Facilitates bus operation and passenger transfer between bus and LRV, and
- Facilitates the movement of vehicles at the signalized intersections.

Increased Transit Reliability

Modifying left turns will greatly increase the chances of the LRV passing through a green signal – this will reduce the occurrence of bunching (when two or more transit vehicles arrive in quick succession.)

Other Successful Applications

This model has been implemented in other Canadian cities: Calgary, Vancouver and Edmonton. In the U.S. it is being used in Florida, Michigan, Maryland and New Jersey.

Existing intersection capacity analyses were undertaken using the Highway Capacity Manual (HCM) methodology, and specifically the Synchro 6.0 Traffic Signal Coordination Software package by Trafficware. The Synchro analysis consisted of two steps, namely:

- An analysis of existing and future conditions to identify problematic locations, or "Hot Spots" (the 10 locations); and
- A detailed analysis of Hot Spot locations to develop an effective LRT operation for the Hot Spot areas that will be refined during design.

From this evaluation, it was determined that implementing U-turns along Eglinton Avenue would provide significant benefits at most of the intersections and would result in:

- Reduced Travel Time;
- Shorter wait times for pedestrians (10 seconds less per location);
- Shorter wait times for left turning vehicles (10 seconds less per location);
- Faster, more reliable service for the LRT (3-5 minute reduction in schedule variability);
- Reduced delay and better progression for through traffic on the major arterial; and
- Shorter traffic cycle length (90 seconds instead of 120 seconds).

Based on the transit-traffic analysis conducted, specific design recommendations were made to ensure efficient and safe Eglinton Crosstown LRT operations. This resulted in the design recommendation to prohibit left-turns and re-route the movements at the identified intersections.

2.4.4 Recommendation

The analysis revealed that by restricting left turns at the majority of the intersections analyzed, more traffic signal green-time could be allotted to the Eglinton Crosstown LRT, cross-street transit, pedestrian, and vehicular traffic travelling through the intersections. Consequently, the majority of travellers, whether travelling on LRVs, on buses, as pedestrians, or in vehicles, experienced less delay when left turns were restricted at the intersections and rerouted.

This analysis resulted in the design recommendation to prohibit left-turns and re-route the movements at nine of the ten identified intersections. These are identified in **Section 3.4.5**.

2.5 Emmett Avenue Stop

In order to provide a surface stop every 400-600 metres, a LRT stop at Emmett Avenue between Scarlet Road was initially considered. The distance from Scarlett Road (next stop to the west) and Jane Street (next stop to the east) is approximately 1 kilometre. If the Emmett Stop were included, the distance between Scarlett Road and Emmett Avenue stops would be approximately 575 metres and the distance from Emmett Avenue to Jane Street approximately 450 metres.

2.5.1 Key Challenges and Constraints

The issue associated with designing for a stop platform at this location pertains to the curvilinear alignment of Eglinton Avenue between Scarlett Road and Jane Street. The horizontal alignment of the existing Eglinton Avenue in this location consists of back to back 300 metres radius curves with only a short tangent section between. In order to accommodate the TTC's design criteria for the platforms to be on a horizontal tangent, significant modifications of the existing alignment would be required to develop a minimum 100 metres of tangent section needed for the platform. However, the opportunities for modifying the alignment at this location are constrained by the Jane Street intersection located approximately 500 metres to the east and the existing Humber River bridge, with the east end located approximately 300 metres to the west. Due to the proximity of the west side platform at Jane Street, the desired location for a stop at Emmett Ave would be on the west side of the intersection. However, it is not possible to create the necessary 100 metres minimum tangent on the west side of the Emmett Ave intersection without deviating substantially from the existing Eglinton Avenue centreline.

2.5.2 Options

The two options considered were:

- Providing a stop at Emmett Avenue; or
- Do not provide a stop at Emmett Avenue.

2.5.3 Evaluation

2.5.3.1 Property Impacts

The existing alignment off of the east end of the Humber River bridge dictates that the alignment shift required to create a tangent section would be developed to the south side of Eglinton Avenue. The realignment needed will result in a centreline shift of approximately 35 metres to the south. Accounting for the differential elevation between Eglinton Avenue and the adjacent Scarlett Woods Golf course, significant impacts to the golf course would be expected.

2.5.3.2 Environmental Impacts

A centreline shift of approximately 35 metres to the south would result in the loss of two cultural vegetation communities (a meadow and a woodlot) and encroachment on a natural vegetation community (a fresh-moist poplar-sassafras deciduous forest). The cultural meadow and cultural woodlot are considered of low to moderate ecological value. The deciduous forest is considered of high ecological value due to its association with the Humber River valley lands. The loss of, or encroachment on these vegetation communities would require habitat restoration and enhancement measures to achieve TRCA's target of net gain for vegetation communities impacted.

In addition, this area lies within a flood plain. Work within this area would likely require flood plain mitigation.