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SCARBOROUGH RAPID TRANSIT BENEFITS CASE

January 2009

Scarborough RT Benefits Case

Final Report

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Executive Summary

In 2006 the Province of Ontario created the Greater Toronto Transportation Authority, renamed to Metrolinx in December 2007. The primary responsibility of the new organisation is to provide leadership in the planning, financing and development of the Greater Toronto and Hamilton Area's (GTHA) multi-modal transportation network and to conform to the objectives and vision set out in the *Places to Grow Act*, 2005.

Part of Metrolinx' mandate and one of its first deliverables is the development of the *Regional Transportation Plan* (RTP), a 25-year plan that presents the road map for the implementation of the Province's *MoveOntario 2020* vision of 52 new rapid transit projects in the GTHA by 2020.

As the rapid transit projects contemplated in the RTP move closer to implementation, a Benefits Case will be prepared for each project. The purpose of the Benefits Case is to undertake a comparative analysis of feasible options for a specific rapid transit project and present the results in such a way that it will assist decision makers to select a preferred option for implementation.

This Benefits Case report is about the Scarborough Rapid Transit project which is one of the rapid transit projects announced by the Premier as part of *MoveOntario 2020* and identified in the RTP. The project involves upgrading the existing SRT service between Kennedy and McCowan stations and replacing the aging fleet of vehicles to accommodate new, larger vehicles and examining the possibility of extending the service to Malvern Town Centre.

In consultation between Metrolinx and the Toronto Transit Commission (TTC) four options were identified. Each option is compared to the Base Case, which due to the urgent need to replace the aging vehicle fleet, is not assumed to be "Business as Usual", but rather include substantial investment to upgrade the existing system.

- **Base Case** is defined as the replacement of the aging MKI vehicles along with any infrastructure improvements to the existing line between Kennedy and McCowan stations that are required to accommodate the new vehicles. The anticipated improvements will increase capacity to 7,000 passengers per hour per direction by 2031 from today's 4,500 passengers per hour per direction.
- **Option 1** includes all the upgrades in the Base Case with a 5.4 km extension to the Malvern Town Centre utilizing the existing technology.
- **Option 2** includes all the upgrades assumed in the Base Case plus an extension of the SRT technology to a new terminus station at Markham/Sheppard. At Markham/Sheppard, the SRT will connect to the in-street Sheppard East LRT service running eastbound along Sheppard. The extension to Malvern Town Centre along Neilson Road from Sheppard Avenue has been included within this option.

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- **Option 3** has similar alignment to Option 1 (extension to Malvern Town Centre) but with light rail technology (LRT). The line would run in the existing right-of-way and, where possible, utilize the existing guideway between Kennedy and McCowan Stations, and then extend from McCowan to Malvern Town Centre along an exclusive right-of-way.
- **Option 4** has the same alignment and LRT technology as Option 3, but between McCowan and Malvern Town Center the LRT will operate in an at-grade, partially exclusive right-of-way.

The table below summarizes the characteristics of the options.

	Base Case	Option 1	Option 2	Option 3	Option 4
Year in Service	2015	2015	2015	2015	2015
Total Capital Costs[1] ($million)	$452	$1,612	$1,233	$1,404	$1,225
2031 Passenger Capacity Per Hour Per Direction	5,400	10,000	9,000	10,000	10,000
Frequency of Service in Peak	2’	1’48”	2’	2’19”	2’15” 4’30”
Number of SRT Vehicles	36	108	80	0	0
Number of LRT Vehicles	0	0	0	62	62
Length of Closure	At least 8 months	At least 8 months	At least 8 months	Up to 36 months	Up to 36 months

The options are evaluated using a Multiple Account Evaluation (MAE) methodology. The MAE is a framework that provides a systematic identification and analysis of broader implications and criteria of an option. The MAE framework includes a number of evaluation accounts that together address the most significant project performance and policy considerations for a specific project and include:

- Transportation User Benefits
- Financial Impacts
- Environmental Impacts

[1] The capital costs presented in this report should be considered indicative and represent point in time estimates, for the purpose of project evaluation and selection of an option. The costs will be refined as the project moves into design, procurement and implementation, and are not intended for budgeting purposes.

- Economic Impacts
- Socio-Community Impacts

The assessment is done by comparing each option to the Base Case and identifying the incremental impacts, negative and positive, caused by each option. The analysis is done over a 30-year period, from 2009 to end of 2038. In order to compare the options on a "like-to-like" basis and to reflect the time value of money the monetized values are discounted to today's value at a real discount rate of 5%.

The key results from the analysis show:

- All four options generate positive net present value as compared to the Base Case. Options 1, 3 and 4 generate user benefits that are approximately $2 billion while the user benefits for Option 2 are estimated at approximately $1.6 billion.
- Option 4 has the highest benefit-cost ratio (2.4) and highest net present benefit ($1,098 million). While the transportation user benefits for this option are not as high as for Options 1 and 3, the net costs are considerably lower showing that the incremental costs associated with the fully grade-separated systems as contemplated in Options 1 and 3 do not result in a corresponding increase of user benefits.
- Option 2 includes the Sheppard East LRT extension costs on Neilson Road but to capture all its benefits it assumes that the Sheppard East LRT will be operational at opening.
- Option 1 has the highest employment, income and GDP effects during construction (due to higher capital costs) and are estimated to generate approximately 10,500 person-years of employment. Options 1 and 3 have the highest long-term impacts on job access and productivity as measured in jobs and income with an estimated 240 new jobs in 2031.
- There is not a large difference among the Options in the potential for land value increases. Although Option 4 shows the greatest potential for land value uplift, estimated at between $140 million to $380 million, it is expected to be at the lower end due to the at-grade nature of the technology. Option 2, which has the lowest estimate of between $120-296 million, does not include the potential land value uplift in the section between Markham/Sheppard to Neilson/Sheppard as these benefits will accrue to Sheppard East LRT.
- From a socio-community perspective, Option 4 is preferred as it is less noisy and visually intrusive; and provides better access with closer spaced stations. The negative impacts of the elevated structure in Options 1, 2 and 3 are mitigated somewhat by the alignment traversing an industrial area.
- The retrofit under Options 3 and 4 will require the SRT system to be closed for up to 36 months during which time a replacement service will be offered. Options 1 and 2, as well as the Base Case, will have to be closed down for retrofit, for at least 8 months. While the cost of the replacement services is included in the capital cost estimates, the

inconvenience to passengers and the effect this may have on ridership has not been factored into the transportation user benefits.

The table below summarizes the key results from the analysis.

	Option 1	Option 2	Option 3	Option 4
Quantitative Assessment				
Net Cost (NPV $m)	1,273	819	1,111	784
Net Transportation User Benefits (NPV $m)	1,954	1,583	1,954	1,882
Overall Benefit (Cost)	681	765	843	**1,098**
Benefit Cost ratio	1.5	1.9	1.8	**2.4**
Emissions (NPV $m)	5.5	**5.7**	5.5	**5.7**
Land Value Uplift ($m)	166-370	120-296	166-370	**137-384**
Qualitative Assessment				
User Benefits				
Closure	✓✓✓	✓✓✓	✓	✓
Environmental				
Construction	✓	✓✓	✓✓	✓✓
Other	✓✓	✓✓	✓✓	✓✓
Economic Development				
Impacts	✓✓✓	✓	✓✓	✓
Temporary	✓✓✓	✓	✓✓✓	✓✓
Long-term				
Social Community Impacts				
Land use shaping	✓✓✓	✓✓	✓✓✓	✓
Accessibility	✓✓	✓✓	✓✓	✓✓✓
Other (noise, visual)	✓	✓✓✓	✓	✓✓✓

Note: Bold indicates preferred option/s for that specific criteria

Part A Project Rationale

Introduction

Purpose of Report

In 2006 the Province of Ontario created the Greater Toronto Transportation Authority, renamed to Metrolinx in December 2007. The primary responsibility of the new organisation is to provide leadership in the planning, financing and development of the Greater Toronto and Hamilton Area's (GTHA) multi-modal transportation network and to conform to the objectives and vision set out in the *Places to Grow Act*, 2005.

Part of Metrolinx' mandate and one of its first deliverables is the development of the *Regional Transportation Plan* (RTP), a 25-year plan that presents the road map for the implementation of the Province's *MoveOntario 2020* vision of 52 new rapid transit projects in the GTHA by 2020.

As the rapid transit projects contemplated in the RTP move closer to implementation, a Benefits Case will be prepared for each project. The Benefits Case will describe a range of feasible options including the business-as-usual scenario for each project, be it different technology, capacity or length of alignment, and will demonstrate the benefits and costs associated with each of the options.

The Scarborough Rapid Transit (SRT) project is one of the rapid transit projects contemplated in *MoveOntario 2020* and in the RTP. The project involves upgrading the existing SRT service between Kennedy and McCowan stations to replace the aging fleet of vehicles and to accommodate new, larger vehicles and examining the possibility of extending the service to Malvern Town Centre.

This document presents the comparison among four options against the Base Case. The assessment of the options compares the relative strengths and weaknesses of each option on people, the economy and the environment against the cost of implementing the option. The objective of the assessment is to clearly outline the trade-offs among the criteria to enable decision makers to make an informed decision.

Report Structure

This report is structured in three parts:

- **Part A - Project Rationale**: This section of the report describes the policy context, the broader regional and project objectives, the characteristics of the corridor and the issues and opportunities to be addressed by the proposed project.

- **Part B – Project Options**: This section of the report presents a summary of the options that are to be evaluated.
- **Part C – Project Assessment:** This section of the report presents the evaluation methodology, assessment for each evaluation account and the summary results of the analysis.

Project Rationale

Context and Need

Population and employment forecasts prepared by the City of Toronto[2] show that Scarborough will experience a faster growing population than the average growth for the City of Toronto, but that employment growth will be slower. Between 2001 and 2021 population in Scarborough is expected to increase by 17.1 percent compared to 14.2 percent in the City of Toronto while employment in Scarborough for the same time period is expected to grow 13.4 percent which is lower than the forecast employment growth rate of 18.2 percent for Toronto.

The majority of trips in the SRT corridor are for commuting to work with a large portion going to mid-town and downtown Toronto. With increasing population, it is expected that ridership in the corridor may double by 2031. The need for improvements to the SRT is primarily driven by two issues:

- The current vehicles are nearing the end of their economic lives and must be replaced no later than 2015 to avoid the inevitable reliability issues associated with operating older vehicles. Adding to this challenge, the current design of the vehicles is no longer in production. As a consequence, the TTC is considering replacing the existing fleet with larger vehicles that would also require upgrades to the existing infrastructure to accommodate the larger size.
- SRT is currently operating at capacity in the peak hour peak direction and more vehicles are required to meet the current and future demand. Ridership on SRT has grown steadily since the opening day from approximately 26,000 passengers per day in 1985 to almost 44,000 passengers in 2004. At present it is estimated that the service carries between 4,000 and 4,500 passengers per hour during peak in peak direction, well beyond its intended design, resulting in crowding and reduced quality of service.

Commensurate with the plans to upgrade the existing SRT system, consideration is also being given to extending the SRT line to Malvern Town Centre. There are a number of policy documents that support this project. These include:

[2] These numbers were used by Toronto Transit Commission to develop the *Scarborough RT Strategic Plan – Study Report, Final Report,* August 2006

- *Toronto's Official Plan* encourages transit-oriented development in intensive, mixed use, targeted growth areas, including Scarborough Centre which is to be promoted as the governmental, cultural, business, retail and transportation focus for the eastern City area.
- The *Scarborough Centre Secondary Plan* highlights the importance of transit infrastructure in the development of the Centre and recognizes the need to overcome the current capacity limitations of the SRT line and to extend this line further east.
- The City's *"Strong Neighbourhoods Strategy"* identifies thirteen Priority Neighbourhoods across the City for targeted investment and upgrading initiatives, including the Malvern community which will benefit from the SRT extension.
- The provincial *Growth Plan for the Greater Golden Horseshoe* designates Scarborough Centre as an Urban Growth Centre to be supported by major transit infrastructure at a targeted development density of 400 residents and jobs combined per hectare. The Scarborough Centre currently averages a gross density of approximately 230 residents and jobs per hectare and land use planning initiatives are underway to achieve the target figure by the 2031 deadline. The provincial Growth Plan also designates the SRT corridor for higher order transit up to Markham and Sheppard.
- The *Regional Transportation Plan* (RTP) identifies Scarborough Centre as an anchor hub and, in the longer term, designates Malvern as a gateway hub. The overall aim is to develop a system of these mobility hubs across the region that are connected by high order transit lines and supported by intensified development around the stations upon which they are based. The RTP further recognizes that the transportation system should be developed to enhance equity and social cohesion in the region by improving mobility options for people in "vulnerable and disadvantaged communities".

Any improvements to the SRT service must also be considered in the broader context of the transit network. In particular, this includes future connections and integration to the Eglinton Crosstown rapid transit line and Sheppard East LRT contemplated in TTC's Transit City Light Rail Plan and Metrolinx' Regional Transportation Plan.

Project Objectives

The primary project objectives for SRT are to provide an appropriate level of service and capacity to meet the current and future travel demand along the line at a reasonable cost. In addition, the project needs to reflect the broader policy objectives including people, environment and economy. Other objectives include:

- Minimize adverse environmental effects;
- Support local population and employment growth;
- Provide rapid transit into North East Scarborough;

- Connect SRT to proposed Sheppard LRT; and
- Provide rapid transit into Centennial College.

Project Overview

The SRT is a semi-automated rapid transit line that opened in 1985 and extends from Kennedy Station to McCowan Station east of Scarborough City Centre. The SRT is owned and operated by the TTC and although it utilizes a different technology and is physically separated from the rest of the TTC system it is fully integrated with the TTC fare structure.

The current SRT alignment includes six stations along a 6.4 km line. Service during peak hours is provided every 3 minutes and 30 seconds by six four-car trains. In total, the TTC manages a fleet of 28 vehicles, including 24 vehicles used for peak service and four spares. Maximum design capacity is approximately 3,800 passengers per hour per direction.

Replacement and Upgrade

The SRT line calls for immediate improvement driven by the need to replace the current vehicle fleet by no later than 2015 and because the system is at capacity in peak periods and needs more capacity to serve future demand.

The existing vehicle fleet consists of MKI vehicles that are no longer manufactured. Options for replacement include the MKII vehicles[3,4], a newer and larger version of MKI, or a different technology altogether, such as light rail vehicles. Regardless of the type of vehicle technology, significant upgrades to the existing guideway and stations would have to be undertaken to accommodate the new fleet.

The most significant one is the need to replace and straighten the sharp turn in the guideway just east of Kennedy Station. Other upgrades include:

- Improve the transfer between SRT and the subway at Kennedy Station which currently requires passengers to travel three levels between systems.
- Redesign of the station to include a centre platform two-track configuration is proposed, which would increase capacity.
- Integrate with Eglinton Crosstown rapid transit. The type of upgrade would depend on the technology chosen for the Eglinton line and how it is going to be integrated with SRT.

The retrofit would require closing down the system for at least 8 months.

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[3] A narrower and taller vehicle design used in Kuala Lumpur, Malaysia, is another feasible alternative. However, it is anticipated that the infrastructure improvements required to accommodate the Kuala Lumpur vehicle would be more costly than those required by the Vancouver design.

[4] Similar to the vehicles operated by TransLink in Vancouver

Extension

Extending the SRT to Malvern Town Centre is aimed at improving the accessibility for residents and businesses in an area that is currently underserved by transit. The 5.4 kilometre extension would serve a growing population and employment base in the area, supporting local land development initiatives and provide connections to:

- Sheppard East LRT line - proposed to run east from Don Mills along Sheppard Avenue; and
- Scarborough-Malvern LRT line – proposed service between Kennedy Station and Malvern Town Centre at a lower level of service and along a more southerly route than the proposed SRT extension.

Part B Options

Project Options

Four options have been identified for the SRT project that will be compared against the Base Case. A summary of each of these options is provided below. A more detailed description of each option is provided in the in the SRT Project Definition Report.[5]

Base Case

Due to the urgent need to replace the aging vehicle fleet, the Base Case for SRT is not assumed to be "Business as Usual", but rather include substantial investment to upgrade the existing system. As such the Base Case is defined as the replacement of aging MKI vehicles along with any infrastructure improvements to the existing line between Kennedy and McCowan stations that are required to accommodate the new vehicles. Under this Base Case scenario, it is assumed that the improvements to the current system will provide sufficient capacity to accommodate the anticipated future demand.

The Base Case includes:

- Replacement of the existing 28 MKI vehicles with 27 new MKII–type vehicles by 2015. This will provide the TTC with eight 3-car MKII trains plus three spare vehicles consistent with the current TTC standards.[6]
- Addition of extra 9 MKII-type vehicles (for a total fleet of 36 vehicles including spares) to provide sufficient capacity to accommodate the anticipated peak hour peak direction requirement of 5,400 passengers by 2031.
- Upgrades to the SRT infrastructure that are necessary to accommodate the new larger vehicles and provide the required capacities. These specific upgrades include:
  - All Stations - Cut back the platform edges
  - Kennedy Station – Replace the station to remove single track configuration and improve passenger transfer
  - McCowan Station – Implement a Variable Message Sign (VMS) system to direct passengers to the correct platform.
  - Midland Station – Strengthen the centre beam

[5] Metrolinx Benefits Case, Project Definition Report – SRT, September 5, 2008 prepared by Steer Davies Gleave

[6] The TTC standard for spares includes one train on stand-by ready for immediate service ('hot' train) and an additional 15 percent for spares rounded to the nearest train.

- Guideway – Realign the track as necessary
- Kennedy Curve – Replace the curved section of guideway
- Ellesmere Tunnel – Track re-alignment and structural upgrades
- McCowan Yard – Upgrade yard to accommodate more vehicles as well as the specific turning and storage requirements of the larger vehicles and longer trains.
- Upgrade ATC system (update required for compatibility with MKII type vehicles), LIM rail and other E&M equipment that might be close to end of life.

For the purpose of this comparative analysis, it is assumed that the current 60 meter station platforms are of sufficient length to accommodate a three-car MKII train and therefore will not be extended as part of the Base Case.

The Base Case assumes a 2 minute headway by 2031.

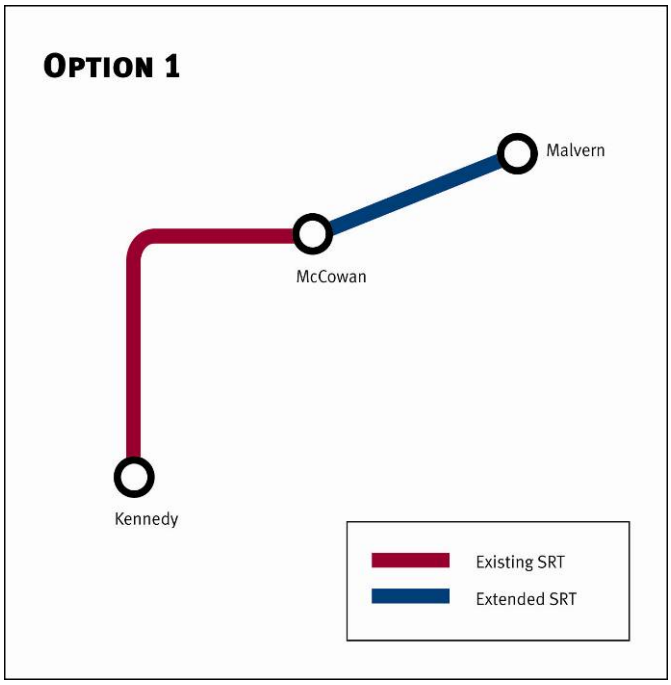
The proposed upgrades will require a temporary closure of the existing SRT service of at least 8 months thus requiring a replacement service along the corridor. The specific details regarding this temporary service are not known at this time, however, for the purpose of this analysis TTC's preliminary estimate for this replacement service is included in the capital cost estimate for the Base Case.

The estimated capital cost for the Base Case is $452 million.

Option 1 – Upgrade and Extend SRT to Malvern

As shown in Figure 1, this option includes all the upgrades in the Base Case plus the 5.4-km extension to the Malvern Town Centre with existing technology.

FIGURE 1 SRT UPGRADE AND EXTENSION TO MALVERN TOWN CENTRE



The extension includes three new stations including the terminus station at Malvern Town Centre[7].

In addition to the construction of the proposed extension to Malvern Town Centre and the upgrades to the current SRT system, the following improvements are required under Option 1:

- Extension of all station platforms (existing and new) to 80 meters to accommodate a 4-car MKII train; and
- A new operations and maintenance facility to accommodate the larger fleet (based on costs provided by TTC).[8]

The VMS system for the McCowan station is no longer required as the station would be operated as a through-station where the existing side platform station is fully adequate.

It is anticipated that the extended line will increase the demand for SRT to an estimated 10,000 passengers in the peak hour peak direction by 2031 between Kennedy Station and Malvern Town Centre. Based on this operating capacity and the TTC passenger loading standards, the TTC

[7] Since the submission of the Project Definition Report, TTC have recently confirmed that Bellamy is now proposed as an additional station location. The present work does not assume this.

[8] The cost of a Vancouver facility with comparable capacity was roughly $200m lower, although the yard alignment and maintenance practices differ from the TTC's.

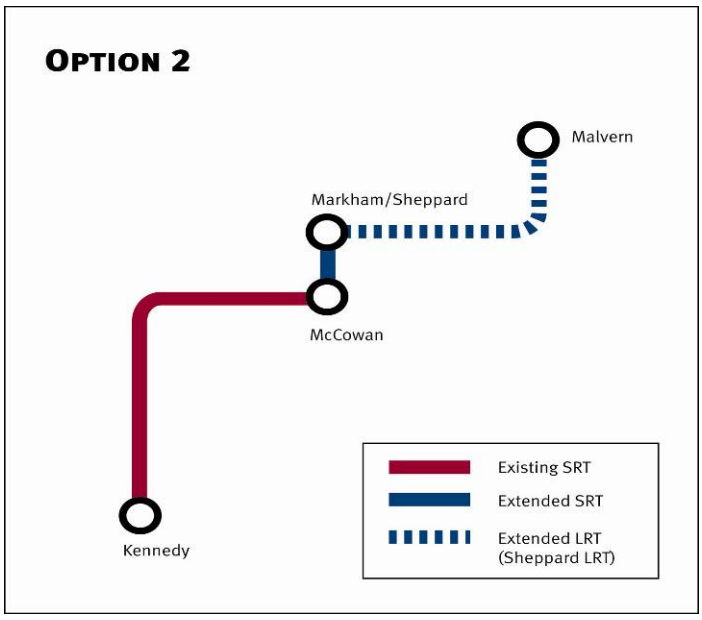
anticipates operating 22 4-car MKII trains at 1 minute and 48 second headway.[9] In total, this option requires 108 MKII-type vehicles including spares.

The capital cost for this option is estimated at $1,612 million.

Option 2 – Extend SRT and Connect with Sheppard East LRT

As shown in Figure 2, this option includes all the upgrades assumed in the Base Case plus an extension to a new terminus station at Markham/Sheppard. At Markham/Sheppard it is assumed that the SRT system would connect to the in-street Sheppard East LRT service travelling eastbound along Sheppard to Neilson with an extension to Malvern Town Centre.

FIGURE 2 SRT EXTENSION TO CONNECT TO SHEPPARD EAST LRT



A new elevated guideway, approximately 1.5 kilometres in length, will be built from McCowan Station to the new terminus station at Markham/Sheppard. Two new stations will be built along the corridor[10].

The terminus station will include appropriate design provisions for a transfer between the SRT and the Sheppard East LRT. Other required infrastructure improvements include:

9 Vehicle capacities are based on criteria established by the TTC and are less than the maximum capacities specified by the vehicle designer. If the capacity constraints applied by TTC were reduced such that more passengers could be assumed to be carried by each vehicle, it may be possible to reduce the frequency of service and/or the number of vehicles.

10 Since the submission of the Project Definition Report, TTC have recently confirmed that Bellamy is now proposed as an additional station location. The present work does not assume this.

- Extension of all station platforms (existing and new) to 80 meters to accommodate a 4-car MKII train.
- A new operations and maintenance facility to accommodate the larger fleet (based on costs provided by TTC).[11]

The VMS system for the McCowan station is no longer required as the station would be operated as a through-station where the existing side platform station is fully adequate.

The forecast demand for the section from Kennedy to Markham/Sheppard is estimated at 9,000 passengers in the peak hour peak direction by 2031. Based on this operating capacity and the TTC passenger loading standards, the TTC anticipates operating 16 4-car MKII trains at 2 minute headway.[12] In total, this option requires 80 MKII-type vehicles including spares.

The estimated capital cost for this option is $1,233 million. It includes the costs associated with extending the SRT system between Kennedy Station and Markham/Sheppard. While the extension to Malvern Town Centre would not be implemented unless the Sheppard East LRT was in place, the costs of the Sheppard East LRT from Sheppard East to Malvern Town Centre via Neilson Road have been included to ensure all costs associated with this option are considered.

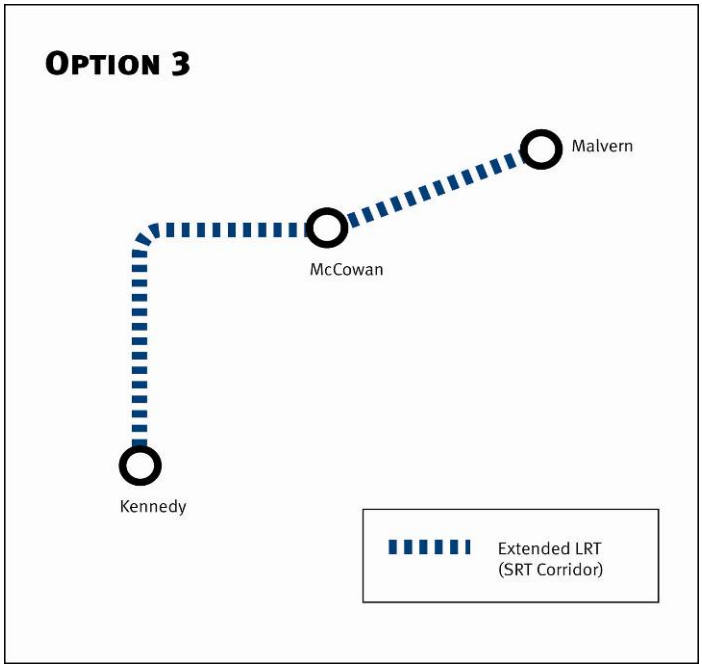
Option 3 – Segregated LRT Kennedy Station to Malvern Town Centre

As shown in Figure 3, this option has similar alignment as Option 1, but contemplates replacing the existing technology with light rail technology. The line would run in the existing right-of-way and, where possible, utilize the existing guideway between Kennedy and McCowan Stations, and then extend from McCowan to Malvern Town Centre along an exclusive right-of-way.

11 The cost of a Vancouver facility with comparable capacity was roughly $200m lower, although the yard alignment and maintenance practices differ from the TTC's.

12 TTC fleet requirements are based on average design loads over a maximum hour of passenger demand using observed passenger flow rates and behaviour in Toronto. These design capacities are less than the maximum capacities specified by the vehicle designer. If passenger behaviour changes to allow for more people to be carried by each vehicle, it may be possible to reduce the frequency of service and/or the number of vehicles.

FIGURE 3 REPLACE SRT WITH LRT TECHNOLOGY AND EXTEND TO MALVERN TOWN CENTRE



This option would avoid the expense associated with the proposed upgrades to the SRT required in the Base Case, but would carry the costs required to upgrade the existing SRT infrastructure to accommodate the larger and heavier LRT vehicles as well as the costs required to extend the LRT line from McCowan to Malvern station.

The retrofit of the existing SRT guideway to accommodate the LRT vehicles is estimated to require closure of the system for up to 36 months. The nature of the replacement service is not determined at this point. For the purposes of this analysis it is assumed that replacement service will be provided by buses.

In addition to the construction of the proposed LRT extension to Malvern Town Centre within an exclusive right-of-way and the upgrades to the current SRT system, the following changes to the existing infrastructure under Option 3 compared to the Base Case are:

- LRT vehicles will be used in place of the SRT vehicles.
- All existing SRT stations will be altered to accommodate the different vehicle technology.
- The existing guideway, signalling, SCADA, rail and power facilities will be replaced or upgraded as necessary to accommodate the requirements of the new LRT vehicles.
- The McCowan Station will not require the VMS system required under the Base Case.
- Operations and maintenance facilities to accommodate LRT vehicles (based on costs provided by TTC).

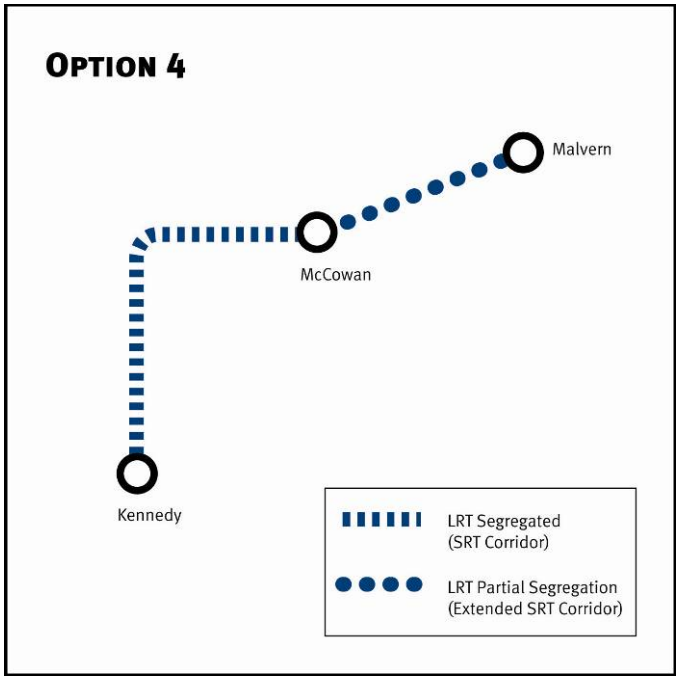
The forecast demand is the same as in Option 1, 10,000 passengers per hour per direction. The operating plan proposes that the line be served by 3-car trains running every 2 minute and 19 seconds with each 3-car train carrying an average of 390 passengers over the maximum hour.[13] In total, it is assumed that this option will require 62 light rail vehicles including spares.

The estimated capital cost for this option is $1,404 million.

Option 4 – Segregated LRT Kennedy Station to McCowan, At-Grade LRT to Malvern Town Centre

This option is different from Option 3 in that it contemplates using an at-grade partially segregated LRT section between McCowan station and Malvern Town Centre, as shown in Figure 4.

FIGURE 4 MODIFIED OPTION 3 WITH PARTIALLY EXCLUSIVE LRT TO MALVERN TOWN CENTRE



As with Option 3, the section between Kennedy and McCowan Stations would operate LRT vehicles along the existing exclusive right-of-way currently utilized by SRT. It is contemplated that between McCowan and Malvern the LRT alignment would operate in a segregated right-of-way in the middle of Progress Avenue. This configuration needs more detailed analysis to confirm the exact alignment. Option 4 would provide a slower service than that proposed under Option 3

[13] Based on estimates provided by TTC assuming a maximum vehicle capacity of 130 passengers

as the semi-exclusive alignment would require at-grade crossings at intersections with signal priority for the LRT vehicles where possible. Work is currently underway regarding the operational feasibility of this option on Sheppard Avenue due to its combined operation with Sheppard LRT.

The retrofit of the existing SRT guideway to accommodate the LRT vehicles is estimated to require closure of the system for up to 36 months. Replacement service would be provided by buses.

The additional changes to the infrastructure required under Option 4 relative to the Base Case include:

- LRT vehicles will be used in place of the SRT vehicles.
- All existing SRT stations will be altered to accommodate the different vehicle technology.
- The existing guideway, signalling, SCADA, rail and power facilities will be replaced or upgraded as necessary to accommodate the requirements of the new LRT vehicles.
- The McCowan Station will not require the VMS system required under the Base Case.
- Construction of an in-street LRT alignment on Progress Avenue between McCowan Station and Malvern Town Centre
- Operations and maintenance facilities to accommodate LRT vehicles (based on costs provide by TTC).

The segregated LRT between Kennedy and McCowan will serve the same peak demand as in Options 1 and 3 of 10,000 passengers per hour. Based on this requirement, it would require 12 three-car trains running every 2 minute and 15 seconds with each three-car train carrying up to 390 passengers.[14]

The partially exclusive operations between McCowan Station and Malvern Town Centre is assumed to have a capacity of 4,500 passengers per hour per direction served by 5 three-car trains operating every 4 minutes and 30 seconds, or half as frequent as the operations along the existing SRT corridor.

This option will require 62 light rail vehicles including spares of which 44 will serve the exclusive corridor while the remaining 18 vehicles will serve the partially exclusive right-of-way between McCowan and Malvern Town Centre. It is further assumed that the system will operate as one integrated system with every other outbound vehicle short-turning at McCowan.

The estimated capital cost for this option is $1,225 million.

[14] Based on estimates provided by TTC assuming a maximum vehicle capacity of 130 passengers

Summary of Options

Table 1 provides a summary of the estimated capital costs for each of the options described above including the Base Case. The table also provides a summary of operational characteristics, including the number of vehicles, frequency of service and capacity.

TABLE 1 GENERAL CHARACTERISTICS OF SRT OPTIONS

	Base Case	Option 1	Option 2	Option 3	Option 4
Year in Service	2015	2015	2015	2015	2015
Total Capital Costs[15] ($million)	$452	$1,612	$1,233	$1,404	$1,225
2031 Passenger Capacity Per Hour Per Direction	5,400	10,000	9,000	10,000	10,000[16]
Frequency of Service in Peak	2’	1’48”	2’	2’19”	2’15” 4’30”
Number of SRT Vehicles	36	108	80	0	0
Number of LRT Vehicles	0	0	0	62	62
Length of Closure	At least 8 months	At least 8 months	At least 8 months	Up to 36 months	Up to 36 months

15 The capital costs presented in this report should be considered indicative and represent point in time estimates, for the purpose of project evaluation and selection of an option. The costs will be refined as the project moves into design, procurement and implementation, and are not intended for budgeting purposes.

16 This capacity applies to the segment between Kennedy and McCowan Stations. The new segment proposed under this option will operate a slower frequency of service providing approximately half the capacity.

Part C Assessment

Evaluation Framework

The comparative analysis uses a Multiple Account Evaluation (MAE) methodology. The MAE is a framework that provides a systematic identification and analysis of broader implications and criteria of an option. It systematically compares the impacts on costs, users, environment, economy and community and shows the trade-offs among the often conflicting criteria.

The MAE framework includes a number of evaluation accounts that together address the most significant project performance and policy considerations for a specific project. The criteria and the accounts can be tailored for a project. The relevant accounts for the analysis of the SRT project are:

- Transportation User Benefits
- Financial Impacts
- Environmental Impacts
- Economic Impacts
- Socio-Community Impacts

It is important to note that the options defined in this report have only been developed to a level of technical detail sufficient to enable a comparative analysis for the purpose of selecting a preferred option. Project scope, costs and service plans need to be developed in more detail for funding and implementation.

The assessment is done by comparing each option to the Base Case and identifying any incremental costs or benefits that are generated by each option. Hence, the results should not be interpreted as "total" values, but as the incremental impact compared to the Base Case.

The analysis is done over a 30-year period (2009-2038). Where possible the impacts are monetized and quantified. In order to compare the options on a "like-to-like" basis and to reflect time value of money the monetized values are discounted to today's value at a real discount rate of 5%. These values, and other input variables used in this analysis are shown in Appendix A.

Transportation User Benefits

This account considers the incremental benefits to the transportation users as a result of the SRT improvements. The monetized benefits are measured in travel time savings for both transit users and road users; automobile operating cost savings achieved by individuals as their trip times or overall automobile usage declines; and reduction in accidents as a result of declining automobile usage.

In addition to the monetized benefits, there are qualitative user impacts that are not easily quantified. In most instances they are captured in the ridership and travel time savings, but in some instances they can be isolated and identified separately, especially where there are large differences among the options. Those considerations include passenger comfort, accessibility and reliability.

All transportation user benefits are incremental to the Base Case.

Travel Time Benefits

Travel time benefits are measured for both transit and non-transit users. With the upgrade of the existing SRT corridor, the replacement of the aging fleet, the additional capacity, and improved service frequencies, it is anticipated that the journey time and reliability of service will improve for both existing and new transit users. The proposed extension of the line to Malvern Town Centre will also improve the journey time for those patrons that currently access SRT by bus. Non-transit users, primarily existing car users, will experience time savings as a result of reduced road congestion.

The analysis shows that passengers and car drivers would experience substantial time savings as a result of the improvements in SRT over current service. The time savings for road users grow over time which is a reflection on worsening road congestion.

The value of this "saved" time is estimated at $13 per hour[17] and is expected to grow, in real terms, by 1.6% per year over the evaluation period to 2038.

The value of the incremental combined time savings for transit users and motorists over the period compared to the Base Case is estimated at $1,458 for Options 1 and 3, $1,362 million for Option 4 and $1,067 million for Option 2.

The higher travel time savings for Options 1 and 3 reflect the faster travel time by these two fully grade separated options while Options 2 and 4 have lower time savings due to the slower service in the at-grade LRT sections. The reason Option 4 has higher travel time savings than Option 2 is a result of the requirement for passengers to transfer to LRT at Markham/Sheppard under Option 2 while Option 4 passengers enjoy a direct ride.

[17] See Appendix A for details.

Automobile Operating Cost Savings

Automobile operating costs savings are derived from a reduction in kilometres driven as a result of the transit investment. The analysis shows that the reduction in automobile usage is very similar among the options and it is estimated that by 2031 there will be a reduction of more than 60 million km annually.

With an assumed automobile operating cost of 60 cents per km, the annual reduction in automobile operating costs is estimated at approximately $60 million in 2031.

The net present value of the automobile operating cost savings over the period is $457 million for Options 1 and 3, $476 million for Option 2 and $480 million for Option 4.

Safety Benefits

The reduction in accidents follows from the fewer kilometres driven. The average saving of an accident is assumed to be 7 cents per km. The incremental net present value of safety benefits over the period is estimated at approximately $40 million for all options compared to the Base Case.

Other Qualitative Transportation User Benefits

The upgrades and enhancements proposed under each of the options will also result in a series of qualitative improvements from a transit user's perspective. These improvements include:

- Enhanced comfort offered by the new vehicles, upgraded infrastructure and greater train capacity;
- More frequent and reliable service; and
- Improved station functionality, passenger connections and network accessibility.

Each of the proposed options provides additional enhancements over and above what is offered by the Base Case. All of the options, for example, expand the network access by providing a connection to the proposed Sheppard East LRT line. Similarly, all of the options improve the operations at McCowan Station by extending the system beyond the current terminus and enabling a more efficient and convenient side platform operation.

The frequency and reliability of service is enhanced under all of the options, but more so under Options 1 and 3 which operate in an exclusive right-of-way. Both options have much more frequent service between Markham/Sheppard and Malvern than either Option 2 or 4. However Option 4, with increased number of stations, provides the largest walk-in catchment. Option 1 also has slightly more frequent service than Option 3, which is an added convenience to the passengers.

All options, except for Option 2, provide a direct connection for passengers travelling from Malvern to Kennedy while Option 2 requires a transfer at Markham/Sheppard onto the Sheppard East LRT line. Further, Option 2 is dependent on the Sheppard East LRT being implemented and connected to SRT at Markham/Sheppard.

The improvements under all options (including the Base Case) will require a closure of the current SRT system in order to do the necessary improvements. Under the Base Case, Options 1 and 2 the estimated time is at least 8 months, while Options 3 and 4 will require up to 36 months in order to retrofit the guideway and stations to accommodate the larger light rail vehicles. While SRT is closed down replacement service would be provided by buses. The direct cost of this service has been included in the capital costs ($15 million for Base Case, Options 1 and 2; $45 million for Options 3 and 4). The inconvenience to passengers and the effect this might have on ridership has not been factored into the ridership analysis.

In the event that it is decided that the Eglinton Crosstown rapid transit will be built using a fully segregated ALRT/LRT technology, all options will have the potential to provide a direct and better (i.e. faster) connection to points along Eglinton Avenue from Scarborough Centre.

Summary

Options 1, 3 and 4 generate user benefits that are approximately $2 billion while the user benefits for Option 2 are estimated at approximately $1.6 billion. Table 2 summarizes the incremental transportation user benefits relative to Base Case.

TABLE 2 INCREMENTAL TRANSPORTATION USER BENEFITS (NPV)

All Values in NPV $m	Option 1	Option 2	Option 3	Option 4
Travel Time Savings	1,458	1,067	1,458	1,362
Automobile Cost Savings	457	476	457	480
Accident Reductions	38	40	38	40
Transportation User Benefits	**1,954**	**1,583**	**1,954**	**1,882**

Financial Account

This account includes the assessment of the direct incremental "cash" items, primarily costs and revenues, from the owner's perspective, for each option over the assessment period. Costs include the incremental capital and operating costs incurred by each option compared to the Base Case. Incremental revenues, such as fare revenues, advertising, and proceeds from disposal of assets are also shown in this account. Any savings resulting from the implementation of the options are also included.

Capital and Operating Costs

The capital costs include all costs associated with the construction and acquisition of the infrastructure, revenue collection, vehicles, and maintenance centre. The estimates also include, design, management & administration, insurance, environmental permitting, property, contingencies and interest during construction. An estimate for the cost of the closure of the system has also been included based on TTC's estimated annual bus service replacement cost of $15 million.

The operating costs are based on TTC's 2005 data broken down into kilometres, hours, number of vehicles, stations and route kilometres, and inflated to 2008 dollars.

As a result of the improvements in SRT, the current bus service is expected to be reconfigured to avoid duplication of services. The details of the service plan have not been developed at this time, but for the purposes of this analysis and to give recognition to the fact that there will be some bus savings, it is assumed that the costs associated with the 131 bus service (Nugget Express), estimated at $1.8 million per year, are saved.

Table 3 shows the total capital costs expressed in today's dollars[18] for each option, including the Base Case. The annual operating costs are based on the assumption that the described service level is reached in 2021. The operating costs are expressed in today's dollars.

[18] The capital costs presented in this report should be considered indicative and represent point in time estimates, for the purpose of project evaluation and selection of an option. The costs will be refined as the project moves into design, procurement and implementation, and are not intended for budgeting purposes.

TABLE 3 CAPITAL AND OPERATING COSTS

All Values in 2008 $m	Base Case	Option 1	Option 2	Option 3	Option 4
Design and Construction Period	2009-15	2009-15	2009-15	2009-15	2009-15
Capital Costs	452	$1,612	$1,233	$1,404	$1,225
Annual operating costs 2021	27	55	42	55	41
Bus Savings	-	1.8	1.8	1.8	1.8

In comparing the costs for each option on a like-to-like basis independent of the varied construction schedules among the options, the cash flows for both capital and operating costs and bus savings are discounted over a period of 30 years. Further, the costs for each option are compared relative to the Base Case, and expressed in incremental net present values in Table 4.

TABLE 4 INCREMENTAL CAPITAL AND OPERATING COSTS (NPV)

All Values in NPV $m	Option 1	Option 2	Option 3	Option 4
Capital Costs	913	614	751	605
Operating Costs	378	223	378	198
Bus Savings	(19)	(19)	(19)	(19)
Total Incremental Costs	**1,273**	**819**	**1,111**	**784**

As shown, incremental costs for Options 1 and 3 are estimated at more than $1 billion. These high costs are largely driven by the more expensive infrastructure between McCowan and Malvern Town Centre.

The estimated present value of costs for Option 2 is approximately $820 million. The lower cost is due to the shorter guideway that ends at Markham/Sheppard to connect to the Sheppard LRT. Note that the cost of extending to Malvern Town Centre only includes the section between Neilson/Sheppard to Malvern (less than 1.5 km), as the reminder of the section is included in the Sheppard East LRT project.

The lowest cost among the options is Option 4, estimated at approximately $780 million. Compared to options 1 and 3 this is caused by the lower cost of infrastructure from McCowan to Malvern where the LRT will run at-grade. Compared to option 2, LRT has lower cost to Markham/Sheppard (compared to ALRT) and option 4 also has considerably lower maintenance yard costs ($160m lower).

Ridership and Revenues

Annual ridership under each option has been projected using Greater Golden Horseshoe Travel Forecasting Model[19]. Total projected transit demand under the Base Case in the Scarborough area is estimated at 109.6 million trips in 2021 and 112.7 million trips in 2031. The small increase from 2021 to 2031 is due to expected slow population and employment growth within the project alignment during this period e.g. population only grows by 4% and employment by 3% in those ten years.

As shown in Table 5, the improvements in SRT will not result in a large increase in additional ridership i.e. increase in total transit trips between what is projected in the Base Case versus the options. New ridership under Option 1 and 3 are identical - some 800,000 new trips are expected in 2021 as compared to the Base Case. Even though the technology differs between options 1 and 3, the travel time is assumed to be the same, and therefore the ridership is expected to be similar.

Options 2 and 4 generate fewer additional trips - 300,000 and 400,000 trips in 2021 respectively – due to slower travel time (and for Option 2 the requirement for a transfer at Markham/Sheppard to access the LRT to Malvern).

TABLE 5 INCREMENTAL ANNUAL RIDERSHIP (NEW RIDERS)

Million Trips	Option 1	Option 2	Option 3	Option 4
Annual Ridership in 2021	0.8	0.3	0.8	0.4
Annual Ridership in 2031	0.8	0.5	0.8	0.6

While the number of new riders is limited, the increase in SRT ridership is considerable for existing transit users as result of the high frequency and higher order of transit service provided

[19] This model has been used for the development of the Regional Transportation Plan (RTP) and ensures consistency with that work. The model is strategic in nature and the effect of small projects can be minimal. However the main purpose of the benefits case work is of a comparative nature and we consider the model adequate for this purpose.

e.g. the peak passenger hour per direction (pphpd) in 2021 in the Base Case is under 6,800 passengers while for the various options it ranges between 9,000 and 9,200 passengers.

Due to the low incremental ridership, projected additional fare revenues are low. The net present value of the incremental fare revenues compared to the Base Case for Option 1 and Option 3 is estimated at $20 million; and for Options 2 and 4, $11 million and $10 million respectively.

Summary

Table 6 shows the summary of the incremental costs and fare revenues for each option relative to the Base Case.

TABLE 6 INCREMENTAL COSTS AND REVENUES (NPV)

All Values in NPV $m	Option 1	Option 2	Option 3	Option 4
Capital Costs	913	614	751	605
Operating Costs	378	223	378	198
Bus Savings	(19)	(19)	(19)	(19)
Incremental Costs	**1,273**	**819**	**1,111**	**784**
Incremental Fare Revenues	20	10	20	10

Comparing Benefits and Costs

Comparing the results from the Financial and Transportation User Benefits accounts shows that all options generate substantially more benefits than it costs to do the improvements.

The benefit-cost ratios range from 1.5 to 2.4 with option 4 having the highest ratio. Option 4 also has the lowest costs. Note that Option 2 includes the Sheppard East LRT extension costs on Neilson Road but to capture all its benefits it assumes that the Sheppard East LRT will be operational at opening.

As shown in Table 7, the net overall benefit expressed in present value is more than $1 billion for Option 4 and between $680 and $840 million for the remaining options.

TABLE 7 COMPARISON BENEFITS AND COSTS (NPV)

All Values in NPV $m	Option 1	Option 2	Option 3	Option 4
Transportation User Benefits	1,954	1,583	1,954	1,882
Incremental Costs	1,273	819	1,111	784
Net Benefit (Cost)	**681**	**765**	**843**	**1,098**
Benefit-Cost Ratio	1.5	1.9	1.8	2.4

Environmental Impacts

This account examines the environmental impacts of the SRT options. The major environmental impact with respect to urban transit projects is the ability of the project to reduce greenhouse gas emissions from automobile usage and as such is the primary focus of this comparison. In addition to the reduced emissions associated with the reduced auto travel under each option, there are also environmental impacts associated with the construction of each option.

Greenhouse Gas Emissions

It is estimated that the improvements to the SRT will cause a reduction in auto usage by more than 60 million kilometres annually in 2031 relative to the Base Case.

As shown in Table 8, this translates into an annual reduction of CO_2 emissions by 10,000 tonnes in 2021 increasing to 13,000 tonnes in 2031. The value of the incremental emission reduction over the 30-year period is estimated at between $5.5 million and $5.7 million.

TABLE 8 REDUCTION IN CO_2 EMISSIONS

	Option 1	Option 2	Option 3	Option 4
2021 Reduction in CO_2 kilotonnes	10.0	10.6	10.0	10.3
2031 Reduction in CO_2 kilotonnes	12.4	12.6	12.4	13.6
NPV Value ($m)	5.5	5.7	5.5	5.7

Unlike the greenhouse gas reductions for auto use, the harmful emissions associated with construction have not been quantified for the purpose of this comparison. Intuitively, it is reasonable to assume that the construction impacts associated with those options that require longer extensions will be incrementally greater than for those options that do not. The extent to which these negative impacts are outweighed by the positive benefits from reduced auto use will depend on the specific option selected as well as the construction materials and method used for implementation. It is anticipated that this environmental analysis will be undertaken for the preferred option as part of the mandatory environmental assessment process.

Other Environmental Issues

As is the case with the construction related emissions, it is also reasonable to assume that the potential negative impacts of the upgraded SRT line are also greater for the extended lines which will require consideration for any potential impacts on existing green space or water courses. Consistent with the planning and environmental assessment activities being undertaken by TTC in support a proposed extension to Malvern Town Centre, it is assumed for the purpose of this comparison that regardless of the preferred option selected, that the specific alignment design will satisfactorily address any specific environmental issues related to the implementation of a new rapid transit line in the corridor. As a consequence, these additional environmental considerations are not considered to be relevant to the relative comparison of options.

Economic Impacts

This account measures the broader economic impacts of the project, including employment, income and GDP effects as well as the impact on land values. The results reflect both the *direct* impacts the SRT project will have on households and businesses in the region as well as the *indirect* impacts on employment, wages and GDP, estimated by applying Ontario specific multipliers. This account also includes an assessment of the incremental impacts the options will have on land values and development in the corridor.

Improvements to SRT will also generate social benefits that can be monetized, including valuing time savings and emission benefits. These have already been discussed above under transportation user benefits and environmental impacts.

Temporary Economic Impacts Generated by Construction

The improvements in SRT will generate direct and indirect economic benefits during construction. As shown in Table 9, it is estimated that construction will generate between $435 million to $653 million in direct GDP incremental to the Base Case and between 4,500 and 6,800 person years of employment. Including indirect impacts, construction of Option 1 will total over $1 billion more than for the Base Case with an estimated employment of 10,500 person years. Impacts for Option 3 are $200m less while options 2 and 4 produce similar results (4,500 person years and $435 million for direct impacts).

Table 9 summarizes the direct and indirect impacts of construction in terms of employment by person years, wages earned and GDP.

TABLE 9 EMPLOYMENT AND INCOME IMPACTS DURING CONSTRUCTION

	Direct Impacts			Total (Direct+Indirect) Impacts [20]		
	Employment (person years)	Wages ($m)	GDP ($m)	Employment (person years)	Wages ($m)	GDP ($m)
Option 1	6,800[21]	$250	$653	10,500	$390	$1,015
Option 2	4,600	$170	$439	7,100	$270	$682
Option 3	5,600	$210	$535	8,600	$320	$832
Option 4	4,500	$170	$435	7,000	$260	$675

[20] Based on Province of Ontario Multipliers, 2004.

[21] Rounded to nearest hundred.

Long-term Economic Impacts

There will also be ongoing direct economic benefits stemming from the SRT improvements which reflect both households' freed up vehicle operating expenditures and transportation cost savings to area businesses. The former effect is simply a redirected consumption demand by households away from purchases of gas, parking, automotive parts and services and into other consumer goods/services.

The latter reflects improved regional competitiveness for metro-area businesses that now have lower costs of doing businesses, including access to a larger labour market and encountering less congestion on roadways because people are choosing to use the improved SRT system instead of driving. The impact of the improved SRT will be different for each business.

As shown in Table 10, the incremental long-term direct and indirect impacts compared to the Base Case are considerable under all options. The annual incremental direct and indirect employment in 2031 is estimated at 105 jobs for Option 2 with $4.0 million in wages, and up to 240 jobs for Options 1 and 3 with $9.1 million in annual wages. Option 4 is estimated to generate 180 jobs with $6.7 million in wages.

TABLE 10 LONG-TERM EMPLOYMENT AND INCOME IMPACTS

	Direct Annual Impacts in 2031			Direct and Indirect Annual Impacts in 2031		
	Employm. (Jobs)	Wages ($m)	GDP ($m)	Employm. (Jobs)	Wages ($m)	GDP ($m)
Option 1	170	$6.3	$16.3	240	$9.1	$23.4
Option 2	75	$2.8	$7.2	105	$4.0	$10.3
Option 3	170	$6.3	$16.3	240	$9.1	$23.4
Option 4	125	$4.7	$12.0	180	$6.7	$17.3

Land Value Changes

There is evidence from a number of different jurisdictions around the world that investment in rapid transit can have a positive impact on property values in the general area and particularly within close proximity to station areas. The evidence also shows however, that the same investments may have a negative impact on some properties located along the transit right-of-way between the stations.

The area considered to be within a rapid transit stations range of influence varies depending on the type of rapid transit technology. More permanent, rail-based, higher capacity technologies

typically capture a larger area of property within their area of influence than lower capacity bus-based transit facilities. As shown in Table 11, the catchment area around LRT stations is estimated to be between 500 to 600 metres.

TABLE 11 TRANSIT INFLUENCE ON PROPERTY VALUES

Technology		Bus	BRT	LRT: at-grade	LRT: grade separated	Subway	GO Rail
Station impact Area (m)		100	400	500	600	800	800
Premium %							
Residential	Low	1%	2%	10%	15%	20%	20%
	High	2%	4%	25%	30%	50%	50%
Office	Low	1%	2%	10%	15%	20%	20%
	High	2%	4%	50%	50%	50%	50%
Retail	Low	1%	1%	10%	10%	7%	7%
	High	2%	2%	50%	50%	15%	15%
Industrial	Low	0	0	1%	1%	5%	5%
	High	1%	2%	2%	2%	5%	5%

Technology		Bus	BRT	LRT: at-grade	LRT: grade separated	Subway	GO Rail
Right of way impact Area (m)		0	0	200	200	0	300
Premium %							
Residential	Low			0	-5		-5
	High			-10	-15		-15
Office	Low			0	0		0
	High			-10	-15		-10
Retail	Low			5	5		0
	High			10	10		-10
Industrial	Low			0	0		0
	High			1	1		0
		(1)	(1)			(2)	(3)

Notes:

(1) no impact for bus right of way impact areas, given that the short distance between bus stops creates situation where station impact areas are almost adjoining each other. Note that BRT could cause negative impact along right of way due to factors including congestion and noise

(2) no impact for underground subway since right of way impact area is underground.

(3) Ref Landis et al (1994) found negative externalities from being too near commuter rail (within 300 m)

Table 11 shows the range of premium in property value that can be associated with various transit technologies[22] and for various land uses. The range of premiums for residential property

22 The estimates are based on a 2002 comprehensive review of land value and public transport literature that references approximately 150 studies. The studies show that the premium placed on property values fluctuates widely for different transit projects with the same technology. The estimates included above represent the mid-range of the premiums found in the reference material.

values shows a higher value for grade separated LRT (a premium of 15% to 30%) compared to partially exclusive or at-grade LRT (10% to 25%). The premium for commercial properties has a wider range - 10% to 50% - and is similar for both technologies.

The land value uplift has been estimated around the new stations for SRT, which are located at Progress Av/Markham Rd, Markham Rd/Sheppard Av and at Malvern Town Centre[23]. A detailed description of the land use including a map within each station impact area is shown in Appendix B.

- The new station at Progress Avenue/Markham Road includes a mix of commercial and residential land uses, some high-rise residential development and is also designated for industrial and institutional uses. It is expected that a new station would have a positive impact on land values and accelerate development.
- The station contemplated at Markham Road/Sheppard Avenue includes a high proportion of residential development, some industrial development, and some local commercial uses. In particular, the impact of the station on residential subdivisions in the area depends on a variety of factors (such as the workplace destinations of residents, income levels, and the proportion of car ridership versus transit ridership). It is expected that the proximity to the station will have a positive impact on rents and occupancy in the high-rise residential areas. The mall located on Markham Road is also likely to see positive benefits from the transit accessibility. There is a natural node for transit-oriented development at Markham and Sheppard.
- The Malvern Town Centre station is contemplated to be located at McLevin Avenue/Neilson Road. The area is characterized by single-detached residential development, apartment buildings, a shopping mall and other commercial uses. It is expected that land values in the area, particularly the high density residential and retail, will see positive impacts due to the new transit station.

Based on the estimated property values for each of the station areas, the potential land value uplift for each option was calculated and is shown in Table 12.[24] The results show that the land value uplift is the highest for Options 1 and 3 and ranges from $166 million to $370 million.

The land value uplift for Option 2 ranges from $120 to $296 million. This estimate includes the impact at Malvern Town Centre, but does not include the land value uplift for stations along the Sheppard LRT alignment. Those will be included in the Sheppard LRT Benefits Case.

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[23] Since the submission of the Project Definition Report, TTC have recently confirmed that Bellamy is now proposed as an additional station location. The present work does not assume this.

[24] In calculating land values, the designated land use in each of the three station impact areas was identified (e.g., 500m radius of the proposed station). The area of each designated land use within the impact radius is then multiplied by an average land price per acre and the percentage impact is then applied to the assumed land value for the subject area. Appendix B shows a detailed table with calculations.

For Option 4, the estimates are between $137 million and $384 million – the highest total upside. However due to the at-grade nature of the technology the uplift is likely to be closer to the lower end of the range.

These estimates exclude any potential negative impacts on land values along the right of way of the extension.

These values are incremental to Base Case and do not reflect the potential for land uplift and re-zoning along the existing SRT alignment. The current stations along SRT, with the exception of Kennedy Station and Scarborough Centre, have the potential for higher density development.

TABLE 12 POTENTIAL PROPERTY VALUE UPLIFT BY OPTION

	Tech.	Station	Low Impact ($m)	High Impact ($m)
Option 1	ALRT	Malvern	85	189
	ALRT	Markham/Sheppard	64	130
	ALRT	Progress	17	51
			166	**370**
Option 2	LRT (Street)	Malvern	39	115
	ALRT	Markham/Sheppard	64	130
	ALRT	Progress	17	51
			120	**296**
Option 3	LRT (Segr.)	Malvern	85	189
	LRT (Segr.)	Markham/Sheppard	64	130
	LRT (Segr.)	Progress	17	51
			166	**370**
Option 4	LRT (Street)	Malvern	39	115
	LRT (Street)	Greenspire	24	60
	LRT (Street)	McLevin	18	46
	LRT (Street)	Markham/Sheppard	30	76
	LRT (Street)	Markham/Milner	13	31
	LRT (Street)	Progress	8	35
	LRT (Street)	Bellamy	4	21
			137	**384**

Summary

As shown in Table 13, the incremental economic impacts as compared to Base Case are substantial as they reflect the capital costs associated with the four options. The direct and indirect impacts during construction are the highest for Option 1 and the lowest for Options 2 and 4, which reflects the ranking of capital costs.

The long-term economic benefits are considerable for all options. Options 1 and 3 have the same level of impact as both provide the same level of accessibility and travel time. Option 2, which has the slower travel time, has also the lowest economic impact.

The extension to Malvern Town Centre will generate increases in property values, primarily around the stations. Option 1 and 3 will have a significant impact with an estimated increase in land values more than twice that of Option 2. Option 4 shows the highest total upside but the at-grade nature of the technology means the uplift is likely to be closer to the lower end of the range. These values are incremental to Base Case and do not reflect the potential for land uplift and re-zoning along the existing SRT alignment.

TABLE 13 SUMMARY OF BROADER ECONOMIC IMPACTS

	Option 1	Option 2	Option 3	Option 4
Impacts During Construction:				
GDP ($m)	$1,015	$682	$832	$675
Employment (Person-years)	10,500	7,100	8,600	7,000
Income ($m)	$394	$265	$323	$262
Long-term Annual Impacts:				
Employment (FTE)	240	105	240	180
Wages ($m)	$9.1	$4.0	$9.1	$6.7
Land value increase	$166-370m	$120–296m	$166-370m	$137-384m

Social Community Impacts

This account examines each option from the community perspective with specific consideration given to the ability of each option to enhance the quality of life within a local community. This may result from land use changes or developments that can occur in response to the introduction of a new rapid transit line, as well as the improvements brought about by the enhanced accessibility, both locally and regionally, offered by the new transit alternative. This account also considers the ability of each option to positively affect the overall health of the local community and its residents through reduced auto congestion on local streets as well as the ability of transit to support a more balanced lifestyle for local residents and enhance personal safety. Visual impacts and noise are also assessed as part of this account.

Land Use Changes

Experience in other jurisdictions demonstrates that when combined with complementary local planning initiatives both LRT and ALRT can influence development, particularly around stations, and promote more compact, mixed use communities. The type and magnitude of the development is dependent upon a number of factors including the general nature of the transit corridor and the surrounding neighbourhoods.

It is likely that the larger and more dispersed stations envisioned for SRT and LRT in Options 1, 2, and 3 will lead to higher density developments around stations as compared to the eastern section of Option 4 where the LRT stations are in-street stops as opposed to station structures. These stops are more closely spaced than the stations proposed for the other options and therefore the Option 4 stops likely encourage pedestrian activity along the corridor that will be attractive to both residential and commercial development.

All options are capable of promoting the appropriate land use changes provided that the local planning and resultant zoning is consistent with the desired outcome from the community perspective. The significance of the stations proposed under Options 1 and 3 is likely to give them a slight advantage over the other options with Option 2 also slightly outweighing Option 4 with its ALRT extension to Markham and Sheppard.

Health

The extent to which a rapid transit line can influence and encourage mixed use densities, the greater the potential to reduce auto dependency and promote more liveable communities. This is turn will increase walking generally, including walking to access transit, consequently leading to health benefits. As indicated above, both ALRT and LRT have been proven to support mixed use communities. In addition, the extent to which the rapid transit line can address traffic congestion within a community, the greater the health benefit to that community in terms of reduced environmental impacts of car pollution.

The close proximity of station stops on the at-grade section of Option 4 east of McCowan Station may encourage relatively more pedestrian activity along that section of the corridor between stops. On the other hand, the relatively faster travel times provided by the options operating within an exclusive right-of-way can attract riders from with a larger area many of whom may elect to walk to the station. From a health perspective therefore it is difficult to differentiate between the technologies.

Accessibility

The more closely spaced at-grade stations proposed under Option 4 between McCowan and Malvern are the most convenient for pedestrians and provide the highest walking catchment to the new service.

However the larger scale and higher number of elevated stations for Options 1 and 3 provide better opportunities to become local nodes where integrated development could provide direct and convenient connections between various transport modes and nearby activity centres.

Visual Impacts

Elevated ALRT and LRT options have the greatest impact from a visual perspective as it is generally more difficult to visually integrate an elevated structure such as that proposed for Options 1, 2 and 3 than an at-grade in-street alignment as described for the segment east of McCowan under Option 4 (although it is possible to encourage integrated station developments to restrict the negative visual impacts to the elevated guideway between stations). However the significance of the visual impact in this corridor is likely to be limited as existing and future land uses along the corridor, particularly in the southern section, are largely industrial and therefore there will be limited visual impact.

Noise Impacts

The significance of the noise and vibration generated by either technology is dependent on the land use activities immediately adjacent to the line and the relative contribution of each technology to the existing conditions.

In residential areas, noise attenuation can be used in the design of the elevated structures to mitigate where necessary the excessive noise generated by the rapid transit vehicles. In more industrial areas or adjacent to active transportation corridors noise considerations are less significant as the electrically powered rapid transit vehicles do not contribute measurable to the existing conditions.

In this case, Options 1 and 3 are located in existing rail right of way corridor which is adjacent to residential properties and therefore the introduction of services will result in noise increases compared to Options 2 and 4. Options 2 and 4 are in established corridors with higher levels of noise and the new services will not increase these to such an extent.

The noise associated with an at-grade LRT can be mitigated with landscape and other corridor treatments. Provided that the at-grade system does not require any additional pedestrian and vehicular warning devices, the noise generated by the at-grade system is limited.

Overall, the alignment chosen suggests that Options 1 and 3 will result in greater noise increases in the transit corridor compared to Options 2 and 4. For all options, including the Base Case, the removal of the Kennedy curve and system upgrades lead to improvements compared to the existing system.

Summary

TABLE 14 INCREMENTAL SOCIAL COMMUNITY IMPACTS

	Option 1	Option 2	Option 3	Option 4
Land Use Impacts	Land changes primarily around stations	Land changes primarily around stations	Land changes primarily around stations	Promotes pedestrian friendly, community based development
Health	Modest improvement	Modest improvement	Modest improvement	Modest improvement
Accessibility	New stations provide improved accessibility	New stations provide improved accessibility connection	New stations provide improved accessibility	Highest number of stations provides most improved access
Visual	Visually intrusive, particularly for section north of Sheppard	Elevated section visually intrusive but short and industrial nature of corridor lessens the effect	Visually intrusive, particularly for section north of Sheppard	Less visually intrusive as it is on roadway
Noise	Increased noise for residential properties along alignment	Modest noise, community and design specific	Increased noise for residential properties along alignment	Modest noise, community and design specific

Sensitivity Analysis

Since the analysis is based on discounted cash flow and subject to changes as the discount rate changes, the robustness of the ranking of the options with respect to the benefit-cost ratio was tested under two alternative discount rates – 3% and 7%. As shown in Table 15, the relative ranking among the options does not change and more importantly, even with a 7% discount rate, the results are still positive for all options.

TABLE 15 SENSITIVITY ANALYSIS

Discount Rate	3%		5%		7%	
	NPV ($m)	BCR	NPV ($m)	BCR	NPV ($m)	BCR
Option 1	1,233	1.8	681	1.5	326	1.3
Option 2	1,263	2.3	765	1.9	442	1.6
Option 3	1,411	2.1	843	1.8	474	1.5
Option 4	**1,761**	**2.9**	**1,098**	**2.4**	**670**	**2.0**

The relatively high benefit-cost ratio is influenced by the costs that are assumed to already have been spent in the Base Case to upgrade the existing system. However, if the present value of the Base Case costs were excluded ($350 million), the benefit-cost ratios would still be positive but considerably lower, ranging between 1.2 and 1.7. The ranking among the options would not change.

Summary Results

The analysis shows that all four options generate positive net present value as compared to the Base Case. Options 1, 3 and 4 generate user benefits that are approximately $2 billion while the user benefits for Option 2 are estimated at approximately $1.6 billion.

Option 4 has the highest benefit-cost ratio and net present value. While the transportation user benefits for this option is not as high as for Options 1 and 3, the net costs are considerably lower showing that the incremental costs associated with the fully grade-separated systems as contemplated in Options 1 and 3, do not result in a corresponding increase of user benefits.

Note that work is currently underway regarding the operational feasibility of Option 4 on Sheppard Avenue due to its combined operation with Sheppard LRT. Option 2 includes the Sheppard East LRT extension costs on Neilson Road but to capture all its benefits it assumes that the Sheppard East LRT will be operational at opening.

Option 1 has the highest economic development impacts due to the high capital costs.

Option 4 has the greatest impact on potential land value uplift, but the at-grade nature of the technology means the uplift is likely to be closer to the lower end of the estimated value range.

The elevated structures tend to be more visually intruding than at-grade or below grade structures making Options 1 to 3 less desirable, but Option 2 has shorter elevated structure length and the area affected is industrial in nature. Noise level increases will be highest for Options 1 and 3 as they are located along a rail right-of-way corridor with existing residents to consider.

Options 3 and 4 require the SRT system to be closed down for up to 36 months to do the retrofit to the existing guideway, compared to at least 8 months for Options 1 and 2. While the cost of the replacement services has been included in these estimates, the inconvenience to passengers and the effect this may have on ridership has not been factored into the analysis.

TABLE 16 MAE SUMMARY

	Option 1	Option 2	Option 3	Option 4
Quantitative Assessment				
Net Cost (NPV $m)	1,273	819	1,111	784
Net Transportation User Benefits (NPV $m)	1,954	1,583	1,954	1,882
Overall Benefit (Cost)	681	765	843	**1,098**
Benefit Cost ratio	1.5	1.9	1.8	**2.4**
Emissions (NPV $m)	5.5	**5.7**	5.5	**5.7**
Land Value Uplift ($m)	166-370	120-296	166-370	**137-384**
Qualitative Assessment				
User Benefits				
Closure	✓✓✓	✓✓✓	✓	✓
Environmental				
Construction	✓	✓✓	✓✓	✓✓
Other	✓✓	✓✓	✓✓	✓✓
Economic Development				
Impacts	✓✓✓	✓	✓✓	✓
Temporary	✓✓✓	✓	✓✓✓	✓✓
Long-term				
Social Community Impacts				
Land use shaping	✓✓✓	✓✓	✓✓✓	✓
Accessibility	✓✓	✓✓	✓✓	✓✓✓
Other (noise, visual)	✓	✓✓✓	✓	✓✓✓

Note: Bold indicates preferred option/s for that specific criteria

APPENDIX

A

INPUT VARIABLES AND ASSUMPTIONS

Factor	Value	Source
Analysis Period	30 years (2009-2038)	
Discount Rate Sensitivity Analysis	5% (real terms) 3% and 7%	Province of Ontario
Value of Time Business Other Weighted Average	(2008$) $35.16 (9%) $10.82 (92%) $13.02	Transport Canada, Greater Golden Horseshoe Model
Value of Time Growth (real growth in GDP/capita))	1.6% per annum	www.greatertoronto.org; and 2007 Province of Ontario Budget
Average Accident Cost	Accident cost per km $2008: $0.07	Collision Statistics: 2004 Canadian Motor Vehicle Traffic Collision Statistics, TP3322. Vehicle Kilometers: Statistics Canada, Catalogue No. 53–223–XIE, "Canadian Vehicle Survey"
GHG Emissions 2006 2021 2031	 2.39 kg /l or 0.23 kg per km 2.35 kg /l or 0.21 kg per km 2.35 kg /l or 0.20 kg per km	Urban Transportation Emissions Calculator, Transport Canada
Average Cost of CO_2	Cost per km in $2008: $0.01	Several literature sources, Transport and Environment Canada, Greater Golden Horseshoe Model and http://envirovaluation.org/index.php/2007/09/06/university_of_hamburg_forschungsstelle_n_1
Auto Operating Costs 2007 2021 2031	In 2008$ + 2% p.a. incr. $0.60/km $0.78/km $0.95/km	Data in 2007 based on CAA calculation of average driving costs and includes operating and ownership costs (long-term costs). Increase based on Greater Golden Horseshoe Model
Annualisation Factors: Metro / LRT Road	Peak-daily/Daily-Annual 3 / 300 10 / 300	Greater Golden Horseshoe Model

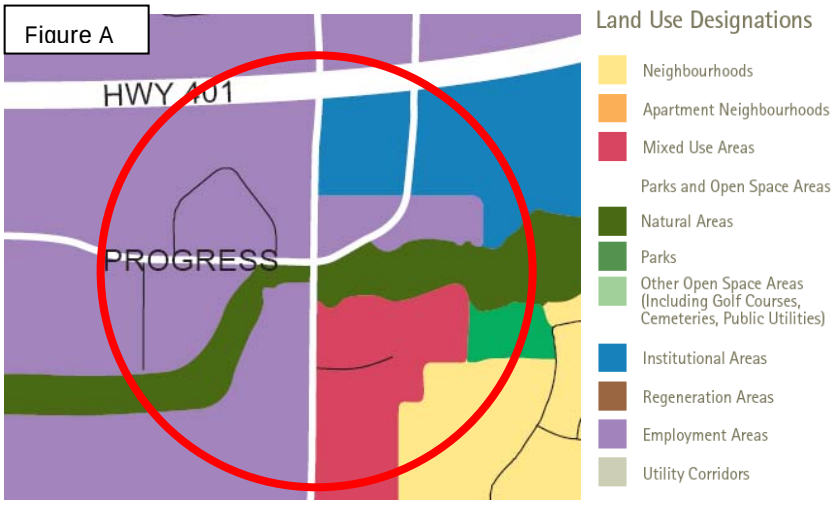
APPENDIX

B

LAND VALUE ANALYSIS

1. **The Progress Avenue and Markham Road SIA** is depicted in *Figure A*. This SIA is located south of Highway 401 and near Scarborough Town Centre. It includes Centennial College, commercial land uses and some high-rise residential development. Based on the research, since the land value uplift ranges for LRT and ICTS have been assessed to be similar and the area is designated for a high proportion of industrial and institutional uses, the impact of a new station on land values in the area would likely be positive (and potentially linked to the development of higher order permitted uses in the SIA), but lower than in an area with a high proportion of residential or office uses.

Figure A



Land Use Breakdown

Roads - 15%

Mixed Use - 15%

Residential

Low Density – 5%

High Density – 0%

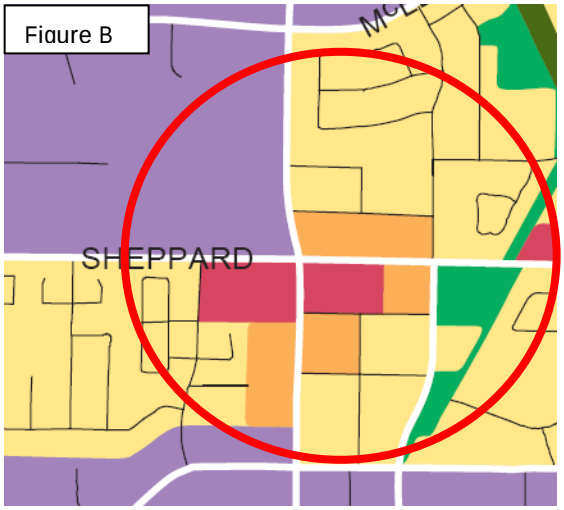
Institutional – 15%

Industrial – 40%

Parks/Open Space – 10%

2. The **Markham Road and Sheppard Avenue SIA** is depicted in *Figure B*. Land use designations for this SIA include a high proportion of low-rise residential development (and some high-rise residential development), some industrial development, and local commercial uses. In particular, the impact of the station on residential subdivisions in the area depends on a variety of factors (such as the workplace destinations of residents, income levels, and the proportion of car ridership versus transit ridership). On the other hand, the research indicates broadly that high-rise residential development in proximity to higher order transit sees benefits in terms of rent and occupancy increases. Similarly, the mall located on Markham Road is likely to see positive benefits from the transit accessibility. There is a natural node for transit-oriented development at Markham and Sheppard.

Figure B



Land Use Breakdown

Roads - 15%

Commercial - 5%

Residential

Low Density – 40%

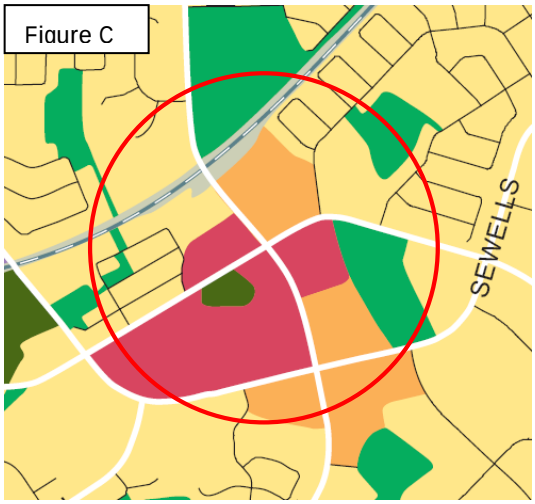
High Density – 10%

Industrial – 20%

Parks/Open Space – 10%

3. The Malvern Town Centre, i.e., the **McLevin Avenue and Neilson Road** SIA is depicted in *Figure C*. The area is characterized by single-detached residential development, apartment buildings, a shopping mall and other commercial uses. Research indicates that the land uses in the area (primarily high density residential and retail) will see strongly positive impacts due to the introduction of a new transit station.

Figure C



Land Use Breakdown

Roads - 15%

Commercial - 25%

Residential

Low Density – 30%

High Density – 15%

Industrial – 0%

Parks/Open Space – 15%

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Calculation of Land Value Uplift

Area Impact / Station Area Impact		Land Value Assumption	LRT 500 Area	LRT 500 Value	LRT 500 Low impact	LRT 500 High impact	ICTS 600 Area	ICTS 600 Value	ICTS 600 Low impact	ICTS 600 High impact
Markham & Sheppard										
Residential Highrise	10%	$ 4,500,000.00	19.95	$ 89,770,000	$ 8,980,000	$ 22,440,000	28.73	$ 129,270,000	$ 19,390,000	$ 38,780,000
Residential Low	40%	$ 2,500,000.00	79.80	$ 199,490,000	$ 19,950,000	$ 49,870,000	114.91	$ 287,270,000	$ 43,090,000	$ 86,180,000
Commercial	5%	$ 550,000.00	9.97	$ 5,490,000	$ 550,000	$ 2,750,000	14.36	$ 7,900,000	$ 1,190,000	$ 3,950,000
Industrial	25%	$ 550,000.00	49.87	$ 27,430,000	$ 270,000	$ 550,000	71.82	$ 39,500,000	$ 400,000	$ 790,000
Institutional	0%									
Malvern										
Residential Highrise	15%	$ 5,000,000.00	29.92	$ 149,620,000	$ 14,960,000	$ 37,410,000	43.09	$ 215,450,000	$ 32,320,000	$ 64,640,000
Residential Low	30%	$ 3,000,000.00	59.85	$ 179,540,000	$ 17,950,000	$ 44,890,000	86.18	$ 258,540,000	$ 38,780,000	$ 77,560,000
Commercial	25%	$ 1,300,000.00	49.87	$ 64,830,000	$ 6,480,000	$ 32,420,000	71.82	$ 93,360,000	$ 14,000,000	$ 46,680,000
Industrial	0%									
Institutional	0%									
Progress & Markham										
Residential Highrise	0%									
Residential Low	5%	$ 1,200,000.00	9.97	$ 11,970,000	$ 1,200,000	$ 2,990,000	14.36	$ 17,240,000	$ 2,590,000	$ 5,170,000
Commercial	15%	$ 2,000,000.00	29.92	$ 59,850,000	$ 5,990,000	$ 29,930,000	43.09	$ 86,180,000	$ 12,930,000	$ 43,090,000
Industrial	40%	$ 1,400,000.00	79.80	$ 111,710,000	$ 1,120,000	$ 2,230,000	114.91	$ 160,870,000	$ 1,610,000	$ 3,220,000
Institutional	15%		29.92	$ -			43.09	$ -		
BASE VALUE					**$ 77,450,000**	**$ 225,480,000**			**$ 166,300,000**	**$ 370,060,000**

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