Ontario Line
Initial Business Case

July 2019

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Executive Summary

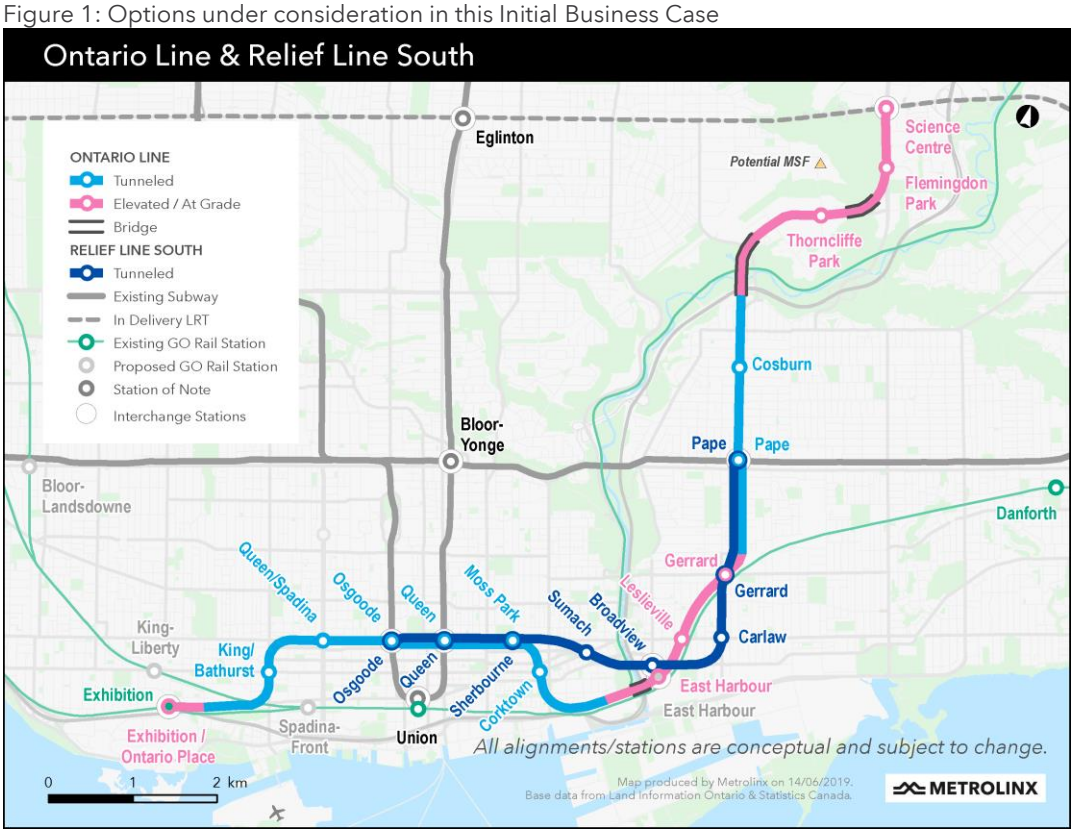
Scope

Recognizing the pressing need to serve the fast growing Greater Toronto and Hamilton Area (GTHA), Metrolinx and Infrastructure Ontario have developed an option for a new rapid transit line – the Ontario Line - based on the existing plans for the Relief Line South subway and initial analysis for the Relief Line North extension, to better expand the transportation network as well as allow for faster delivery and cost-optimization.

This Initial Business Case evaluates the performance of the Ontario Line and Relief Line South compared to a Business as Usual (BAU) scenario as the basis for an investment decision. The BAU assumes that "In Delivery" projects from the *2041 Regional Transportation Plan* are in service, as modified by Ontario's Transit Plan[1], and that reasonable improvements to existing surface transit as well as signalling improvements to Line 1 are delivered.

For reference, see Figure 1 and Table 1, which provide a summary of the options considered.

Figure 1: Options under consideration in this Initial Business Case



[1] Ontario Government, 2019

Table 1: Summary of options under consideration in this Initial Business Case

Option	Length	Stations	Vertical Alignment	Vehicle and Automation
Relief Line South	7.5 km	8 stations Osgoode, Queen, Sherbourne, Sumach, Broadview, Carlaw, Gerrard, Pape.	Tunnel	Toronto Rocket (Semi-Automated)
Ontario Line	15.5 km	15 stations Exhibition, King/Bathurst, Queen/Spadina, Osgoode, Queen, Moss Park, Corktown, proposed East Harbour, Leslieville, Gerrard, Pape, Cosburn, Thorncliffe Park, Flemingdon Park, Science Centre.	Tunnel + Elevated Guideway + At Grade	Modern Standard Metro Rail (Fully Automated)

Method of Analysis

A Business Case is a comprehensive collection of evidence and analysis that sets out the rationale for why an investment should be implemented to solve a problem or address an opportunity. Business cases are required by Metrolinx's Capital Projects Approval Policy for all capital infrastructure investments. The Ontario Line Initial Business Case (IBC) follows the methodology from the Metrolinx Business Case Guidance[2].

The Ontario Line Initial Business Case falls under the Options Analysis stage of Metrolinx's Project Lifecycle (see Figure 2 on page 16), compares the "Relief Line South" and "Ontario Line" investment options against a Business As Usual scenario, and identifies a representative alignment and station locations for further refinement and design. As with all Metrolinx Business Cases, the Ontario Line IBC is structured around four cases:

- The Strategic Case, which determines the value of addressing a problem or opportunity based on regional development goals, plans and policies.
- The Economic Case, which uses standard economic analysis to detail benefits and costs of the options to individuals and society as a whole, in economic terms.
- The Financial Case, which assesses the overall financial impact of the options, its funding arrangements and technical accounting issues and financial value for money.
- The Deliverability and Operations Case, which considers procurement strategies, deliverability risks, and operating plans and risks.

[2] http://www.metrolinx.com/en/regionalplanning/projectevaluation/benefitscases/benefits_case_analyses.aspx

Findings

Both Relief Line South and Ontario Line offer significant improvements compared to a Business As Usual scenario, generating $3.4 billion and $7.4 billion worth of economic benefits respectively. Because it generates twice the economic benefits for a proportionally smaller cost increase, the Ontario Line provides better value for money than the Relief Line South, with a Benefit-to-Cost Ratio between 0.90 an 0.96 when delivered under a Public – Private Partnership (P3) delivery model. Findings are summarized inTable 2.

Table 2: High-Level Summary of Ontario Line IBC Findings

	Relief Line South	Ontario Line
Strategic Case		
Strong Connections	• 206,000 daily boardings • +25,000 jobs accessible within a 45 minute transit commute to Toronto residents compared to Business As Usual (BAU) • Brings rapid transit to new areas in Toronto's east end • Opportunities for transit-oriented development	• 389,000 daily boardings • +53,000 jobs accessible within a 45 minute transit commute to Toronto residents compared to BAU • Brings rapid transit to new areas in the east end, as well as north of Danforth and west to Exhibition/Ontario Place • Access to employment within 45 minutes is increased significantly for low-income residents • Additional opportunities for transit-oriented development
Complete Travel Experiences	• 212,000 person-minutes transit travel time savings compared to BAU • 7% reduction in crowding on Line 1 compared to BAU • 4 interchange stations connecting to 4 rapid transit lines	• 355,000 person-minutes transit travel time savings compared to BAU • 14% reduction in crowding on Line 1 compared to BAU • 6 interchange stations connecting to 6 rapid transit lines • Cross-platform interchanges with GO Rail create attractive and accessible transfers for passengers.

	Relief Line South	Ontario Line
Sustainable and Healthy Communities	• 10,000 net new transit users in the morning peak hour[3] compared to BAU • 28,000km decrease in VKT[4] compared to BAU • Reduction in auto-related GHG emissions of 825,000 tonnes annually (2.6% reduction) compared to BAU • The tunneled alignment helps with limiting impacts to the natural environment, public realm and quality of life.	• 18,000 net new transit users in the morning peak hour compared to BAU • 83,000km decrease in VKT compared to BAU • Reduction in auto-related GHG emissions of 1,012,000 tonnes annually (3.2% reduction) compared to BAU • The elevated/at-grade portions of the line may present visual and environmental impacts that will need to be mitigated.
Economic Case		
Total Economic Benefits ($2019, Net Present Value (NPV))	$3.4 billion	$7.4 billion
Total Costs ($2019 NPV)	$8 to $9.2 billion	$10.4 to $12 billion
Fare Revenue Adjustment ($2019 NPV)	$993 million	$1,761 million
Benefit-Cost Ratio (NPV)	0.48 to 0.55	0.76 to 0.88 with a standard delivery model; 0.90 to 0.96 with P3 delivery.
Financial Case		
Capital Costs ($2019)	$6.2 - $7.5 billion	$9.5 to $11.4 billion
Capital Costs ($2019), adjusted for P3 Delivery	N/A	$8.7 to $10.5 billion
Operations Costs (NPV, $2019)	$1.7 billion	$1.9 billion
Deliverability and Operations Case		
Procurement and Delivery	• Designed as a fully compatible expansion of the existing subway network, building on current system assets, which limits the range of options for delivery	• Developed with the potential to be a freestanding line from a systems and standards perspective, which opens up the possibility of Public-Private Partnership (P3) delivery and driving cost and schedule adherence

[3] TTC defines peak hour as 8:15 am to 9:14 am on weekdays
[4] Vehicle Kilometres Travelled

	Relief Line South	Ontario Line
Delivery Timeline	• Currently at approximately 15% design with an approved Environmental Assessment • Target in-service date of 2029	• Design on shared sections with Relief Line South will be carried forward, with further design. • Environmental approvals are required on the west and north segments • Target in-service date of 2027
Operations	• Semi-automated operation • Use of compatible TTC fleet allows for flexible operation between lines and use of TTC yards	• Fully automated operation allows for higher service frequencies • Standard gauge vehicles are not inter-operable with the rest of the TTC subway system

Recommendation

This Initial Business Case recommends advancing design of the Ontario Line option over the Relief Line South. Next steps will include refining design and engineering to maximize benefits and address risks, developing a Preliminary Design Business Case, seeking environmental approvals through a Transit Project Assessment Process and proceeding towards delivery. Though the Ontario Line would expand mobility and opportunities for people in the GTHA, as well as provide relief to the existing transit network, it is also recommended that overall expansion of the transit system, beyond current plans for 2041, be pursued at pace in order to anticipate and support future growth of the region.

1 Introduction

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Initial Business Case Scope and Objectives

This Initial Business Case has two objectives:

- Document the Ontario Line project concept, including scope, cost estimates, benefits, and potential implementation challenges
- Compare Ontario Line and Relief Line South with a Business As Usual (BAU) scenario

Background

The Greater Toronto and Hamilton Area (GTHA) is one of North America's fastest growing regions, projected to grow by over 40% between 2016 and 2041[5]. While population and employment growth continue across the region, key activities, in particular office growth, continue to be concentrated in Toronto's downtown core and periphery. This growth will further the need for increased transit capacity and access to downtown from across the region.

Metrolinx is now investing more than $20 billion in the GO Expansion program to expand the rail system[6], with faster and more frequent trains and the capacity to carry three times as many passengers by 2041. GO Rail will continue to serve primarily longer-distance trips, and is being developed in existing corridors with all trains running to or from Union Station. However, the GO Rail system does not serve all parts of Toronto, nor does it serve many shorter distance trips. In particular, crowding on Line 1 Yonge, specifically at Bloor-Yonge Station, constrains transit ridership growth into downtown from north and northeast Toronto. This constraint directly affects the ability to accommodate future growth in the region.

Accordingly, Relief Line South has for many years been recognized by Metrolinx, the City of Toronto, the Toronto Transit Commission (TTC) and members of the public as a local and regional transit priority. Given the significance of the project, all three organizations have dedicated resources to Relief Line planning studies. More recently Metrolinx and Infrastructure Ontario have optimized plans for the new line in order to facilitate and expedite its delivery and maximize its benefits to both the city and the region. Previous studies have found that improvements and optimizations to the existing system designed to provide additional transit capacity would not, on their own, be sufficient to address capacity issues during peak periods. As the City's population continues to grow, new transit infrastructure is required to relieve congestion in downtown Toronto.

In 2009, Toronto City Council approved an Environmental Assessment Study for an extension of Line 1 Yonge from Finch Avenue, in Toronto, to Highway 7 in the Regional Municipality of York.[7] With its approval,

[5] Statistics Canada 2016 Census; *Growth Plan for the Greater Golden Horseshoe*, 2017
[6] http://www.metrolinx.com/en/greaterregion/projects/go-expansion.aspx
[7] Yonge Subway Extension–Finch Station to Richmond Hill Centre: Environmental Project Report (January, 2009)

Toronto City Council also requested that Metrolinx prioritize Relief Line South within its 15-year plan in advance of the Yonge North Subway Extension[8]. This was intended to accommodate capacity issues.

In 2012, the Downtown Rapid Transit Expansion Study[9] (DRTES), commissioned by TTC and City of Toronto, assessed future rapid transit needs to support anticipated growth in Toronto. DRTES recommended Relief Line South to provide capacity relief to Line 1 Yonge and Bloor-Yonge Station. In 2013, Relief Line South was identified as one of Metrolinx's Next Wave of priority transit projects within The Big Move Regional Transportation Plan (RTP). In 2015, Metrolinx completed the Yonge Relief Network Study[10] (YRNS) which recommended that Metrolinx, in partnership with the City of Toronto and TTC, advance Relief Line project planning and development in order to further assess the extension of the Relief Line north from Danforth Avenue to Sheppard Avenue East. In 2018, the Relief Line North was recognized in Metrolinx's *2041 Regional Transportation Plan* as a key rapid transit project that is "In Development."[11]

Now in 2019, the Ontario Line Initial Business Case builds upon the Relief Line South Project Assessment (Downtown to Danforth) completed in early 2018, the Relief Line South preliminary design and engineering and the Relief Line North Project Assessment to make a recommendation on the most efficient way to deliver the new line to Toronto.

Business Case Overview

Business Case analyses are mandated by Metrolinx for all capital projects. As projects develop in scope and construction, business cases are completed to define the rationale and requirements for delivering said investment. As shown in Figure 2, the Initial Business Case is the first of four business cases completed in an investment's lifecycle. The IBC compares options against Business As Usual. It reviews options to address the problem statement and selects a preferred option for further design and analysis.

8 Toronto City Council, 2009.EX28.1 (January 27 and 28, 2019)
9 TTC and City of Toronto Downtown Rapid Transit Expansion Study (October, 2012)
10 Metrolinx Yonge Relief Network Study (July, 2015)
11 Metrolinx 2041 Regional Transportation Plan for the Greater Toronto and Hamilton Area (March, 2018)

Figure 2: Metrolinx Business Case Development Process

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Problem Statement

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Introduction

This chapter defines the case for change, which is used to guide the evaluation of investment options considered within this business case.

Case for Change

Problem and Opportunity Statement:

The Greater Toronto and Hamilton Area (GTHA) is experiencing unprecedented growth calling for corresponding expansion of its transportation network. Expanding the transit system is essential to connect people to schools, jobs and their communities.

Symptoms of the region's accelerated growth are visible and make evident the potential risks of a Business As Usual approach. Line 1 Yonge, the primary north-south spine of Toronto's rapid transit system, which serves both local and regional trips, is currently operating at capacity, with impacts to passenger comfort. Even with improvements now underway, such as upgraded signalling on Line 1, it is projected to remain overcrowded in the near future. Road traffic congestion is expected to worsen and commute times to become longer, with negative impacts to Ontario's quality of life, environment and economy.

Increasing the transit network's capacity into downtown Toronto, other major employment areas and neighbourhoods throughout the City, is critical to unlocking the GTHA's potential as a leading international metropolitan region and maintaining the GTHA's appeal to people and major employers. Expansion of the transit network will shape growth in the region, encourage transit-oriented development and improve overall mobility and quality of life.

Under such pressure, a quick and efficient delivery of an expansion of the rapid transit network is critical.

Table 3: Problem or Opportunity Drivers

	Driver	How does this Driver influence the problem/opportunity?	What is the impact of not addressing the problem/opportunity?
Internal to the Transport Network	Travel Behaviour	• High travel demand into Downtown Toronto results in auto congestion and transit overcrowding. • Transit users generally rely on the bus and streetcar network as a first mile solution to access the subway.	• Lack of confidence in transit may result in mode shift to auto and further road congestion, resulting in longer commute times, loss of productivity, and a decrease in air quality.
	Transport Service Provision	• The current practical capacity of Line 1 is 26,400 passengers per hour per direction, assuming a 2.5-minute headway and 1,100 passenger-per-train capacity. This hourly capacity however is largely dependent on consistent short dwell times at stations. • The geographic coverage of rapid transit is limited.	• Failure to increase rapid transit coverage limits access throughout the region, especially to economic, cultural, and social opportunities, for large sections of the population. • Inadequate capacity provision increases levels of crowding at stations and on trains, which results in longer dwell times or service disruptions, further reducing transit capacity.
	Transport Infrastructure and Technology	• In 2011, Line 1's rolling stock switched to 6-car Toronto Rocket trains to deliver increased capacity. • The block signal system is currently being replaced with Automatic Train Control, set to be fully in service by 2022. This will allow higher frequency and passenger capacity. • TTC is studying station expansion and other infrastructure improvements to Line 1 to address overcrowding issues that are not resolved by above-mentioned improvements.	• The current infrastructure limits the system's ability to provide higher levels of services, increased capacity, and safety to riders. Ultimately, it limits the system's ability to keep up with demand.
External to the Transport Network	Government Policy and Planning	• The Province and City of Toronto have both recognized the project as a high priority.	• Without funding for these initiatives, the situation will be exacerbated, with the risk of paralysing the region's economy and contributing to environmental concerns.
	Economic Activity, Land Use, and Demographics	• Population and Employment growth in Downtown Toronto has accelerated, and has already exceeded 2031 forecasts. Population growth is also very high in the Downtown; however population density itself is more diffused, with pockets generally along existing subway lines as well as in neighbourhoods with lower average household incomes.	• Focus of growth in certain areas, along with spatial mismatch, requires a significant increase in transit capacity in order to support economic activity.

Business as Usual

A Business As Usual scenario is used as a base case in this IBC to give us a comparator for the options under consideration.

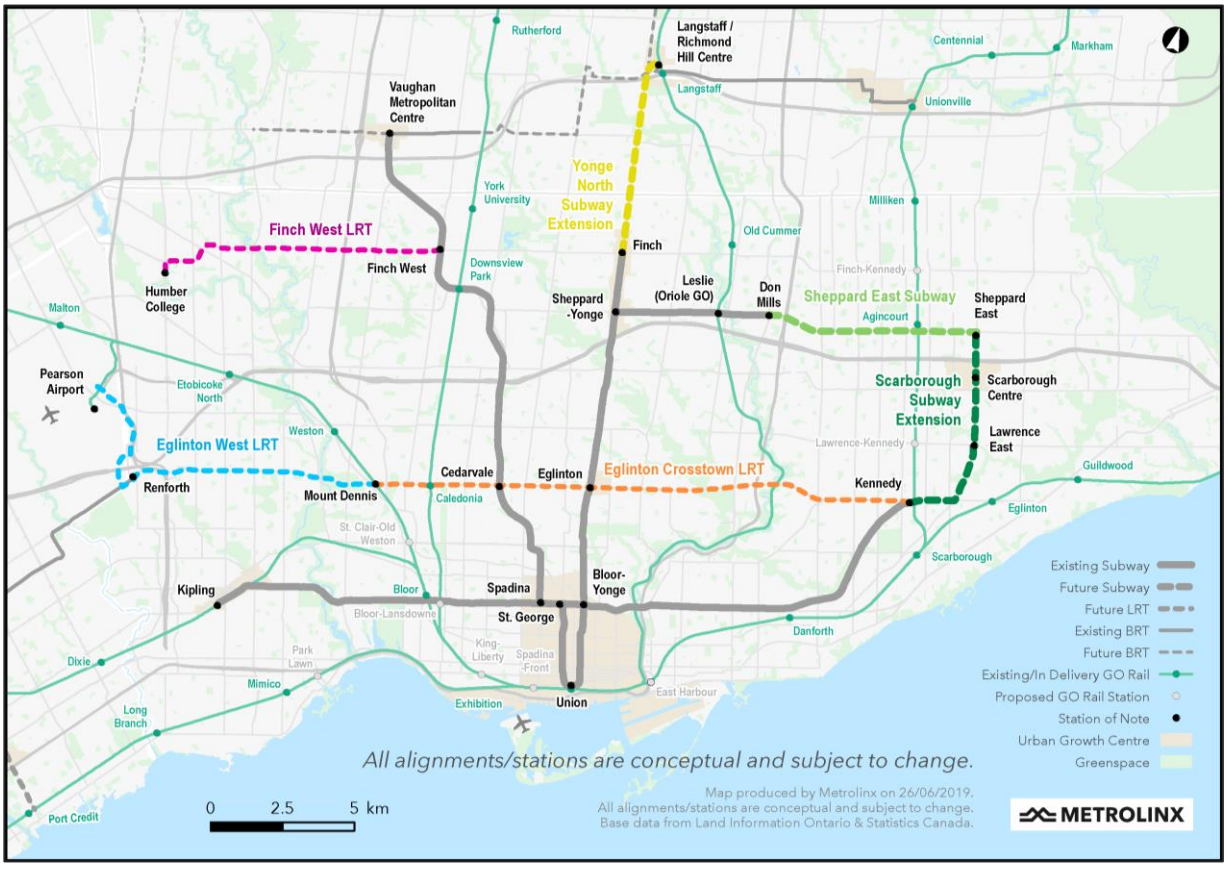
The *2041 Regional Transportation Plan*, adopted by the Metrolinx Board of Directors in 2018, identifies as Priority Action 1.1 the delivery of 14 transit projects by 2025. These projects are known as "In Delivery," meaning they are currently in advanced stages of design or under construction, and include the GO Expansion Program, Eglinton Crosstown, Finch West LRT, Sheppard East LRT, Scarborough Subway Extension, Highway 7 BRT and Yonge BRT.

The 2041 "In Delivery Network" is included in the Business As Usual (BAU) scenario, with a few modifications reflecting recent decisions:

- Scarborough Subway Extension is included in the BAU with three stops rather than one, in accordance with commitments from the current provincial government;
- Eglinton West LRT is included as an underground extension of the Eglinton Crosstown;
- Sheppard East is included as a subway extension of Line 4 Sheppard, with six stations.

The Business As Usual scenario also assumes reasonable improvements to existing surface transit, as well as capacity improvements currently underway on Line 1.

Figure 3: Business As Usual Network



Strategic Value

The *2041 Regional Transportation Plan* (RTP) presents a common vision for the region:

"The GTHA will have a sustainable transportation system that is aligned with land use, and supports healthy and complete communities. The system will provide safe, convenient and reliable connections, and support a high quality of life, a prosperous and competitive economy, and a protected environment."

The goals of the 2041 RTP are to achieve:

- *Strong Connections* – this IBC will recommend an option that will connect more people to more places and opportunities
- *Complete Travel Experiences* – this IBC willrecommend a solution to improve reliability, comfort and safety
- *Sustainable and Healthy Communities* – this IBC will evaluate transit investments to provide more environmental-friendly travel options

Strategic Outcomes

The proposed investment to be recommended through this Initial Business Case should support the realization of the three 2041 RTP goals as follows:

Strong Connections:

The recommended investment will improve transit coverage by offering rapid transit access to more communities and serving key destinations, increase access to economic opportunities for people in the region by better connecting them to jobs and support transit-oriented development, thus creating a synergy between transit and places.

Complete Travel Experiences:

The recommended investment will improve travel time and reliability for riders on currently congested routes, such as Line 1, and for riders shifting to rapid transit by adding capacity to the transit system. It will also improve their comfort and safety by relieving crowding and integrate into the future transit network to allow for convenient and seamless trips.

Sustainable and Healthy Communities:

The recommended investment will move more people more quickly using less energy by shifting trips to more sustainable modes and reducing auto congestion. The recommended investment will also strive to

reduce the overall negative impact of travel on the natural environment and quality of life. This will be realized through the reduction of greenhouse-gas emissions, the preservation of green spaces and limited noise and vibration impacts.

Strategic Objectives

To support the strategic outcomes, the recommended investment should achieve the objectives listed in Table 4. These objectives were developed to support the realization of the three Strategic Outcomes and tailored to the Problem and Opportunity Statement (see page 18).

Table 4: Strategic Objectives

Goals	Objectives
Strong Connections	Improve access to transit
	Increase access to economic opportunities
	Support a synergistic relationship between transit and city-building
Complete Travel Experiences	Improve travel time and reliability
	Improve comfort and safety
	Build an integrated transportation network
Sustainable and Healthy Communities	Move people with less energy and pollution
	Improve quality of life and public health

3

Investment Options

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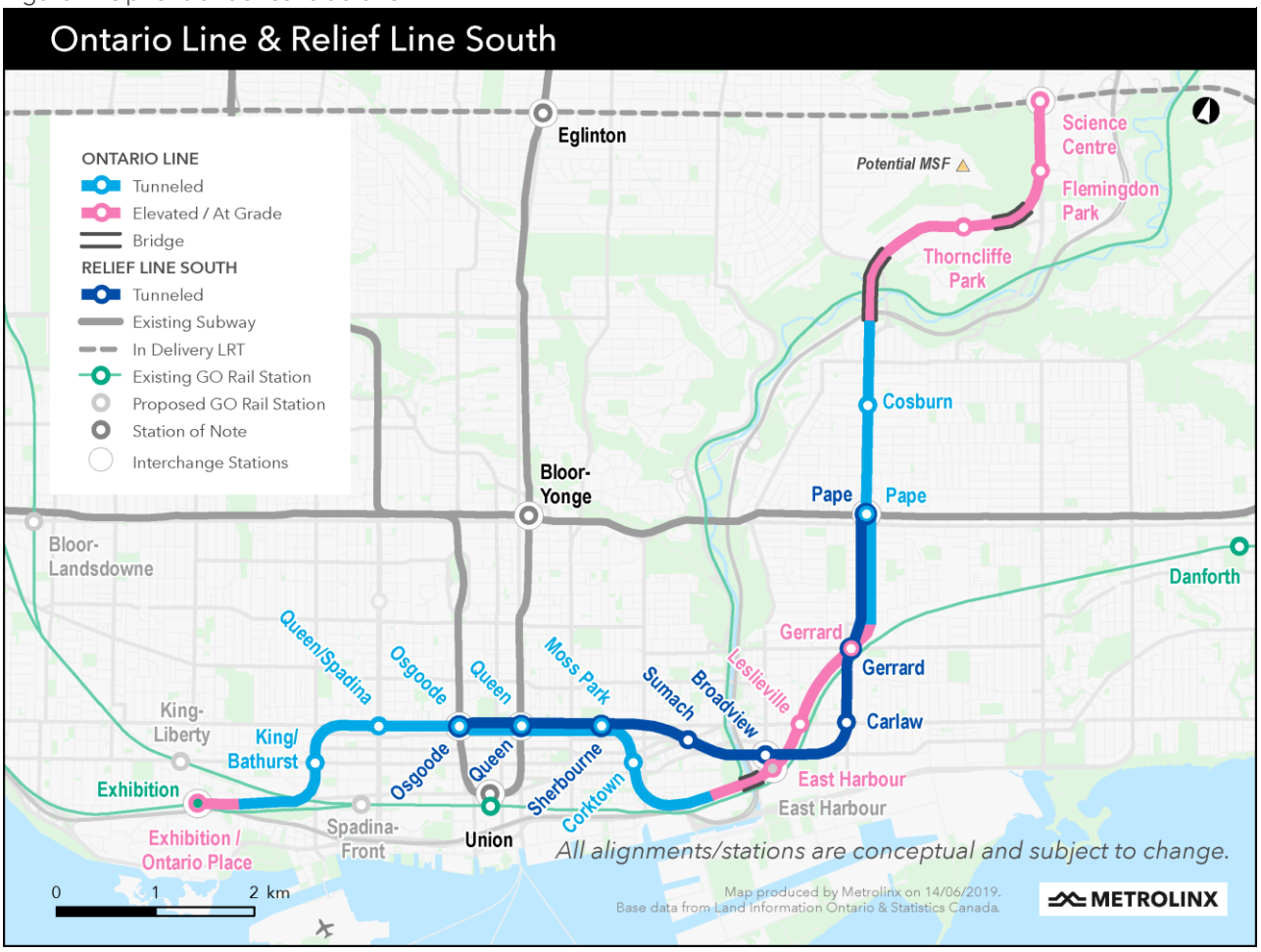
Introduction

This chapter introduces the options to be evaluated and compared through the four cases that constitute the Initial Business Case. Two options will be considered here, within a similar north-south corridor, connecting downtown Toronto to its east end. As a key differentiator however these options, though following comparable routes, rely on different technologies and infrastructure detailed below.

Options Development

Figure 4: Options under consideration



Business As Usual for the horizon year 2041 assumes the delivery of fourteen transit projects identified as "In Delivery" in the *2041 Regional Transportation Plan* with modifications from Ontario's Transit Plan, announced in April 2019. The Business As Usual scenario also assumes reasonable improvements to existing surface transit, as well as capacity improvements currently underway on Line 1 Yonge-University.

Relief Line South is the result of planning and engineering work carried out under the umbrella of the Relief Line South Project Assessment, led by City of Toronto and TTC. The Relief Line South concept and design was developed in compliance with the subway design standards in use in Toronto by the TTC. An extension of Relief Line to the north had been under development but is not being considered through this IBC.

Ontario Line was developed with the intent to accelerate delivery of new transit, serve additional markets and reduce costs per kilometre while building on plans developed by City of Toronto, TTC and Metrolinx under the umbrella of the Relief Line South Project Assessment and Relief Line North Project Assessment. The Ontario Line concept was developed iteratively and with flexibility to allow for implementation using a public-private partnership, transferring risks to a Project Company that would also have the freedom to determine the exact design and technology within set parameters. These key drivers led to decisions to

- use modern standard technology,
- look at a standalone maintenance and storage facility for Ontario Line,
- and consider at-grade or elevated alignments, and other variations.

Leading up to this IBC, a variety of variations for the Ontario Line alignment were developed and considered. The alternatives were refined and narrowed down through continuous analysis and screening that focused on major community impacts, cost, constructability, and operability. The alignment evaluated in this document is a representative alignment and variations may be explored further through preliminary design.

Options Overview, Including Sensitivities

1. Relief Line South

The first option is the Relief Line South concept as shown in the *2041 Regional Transportation Plan*, the Relief Line South Environmental Assessment and as further detailed in 15% design.

Figure 5: Relief Line South

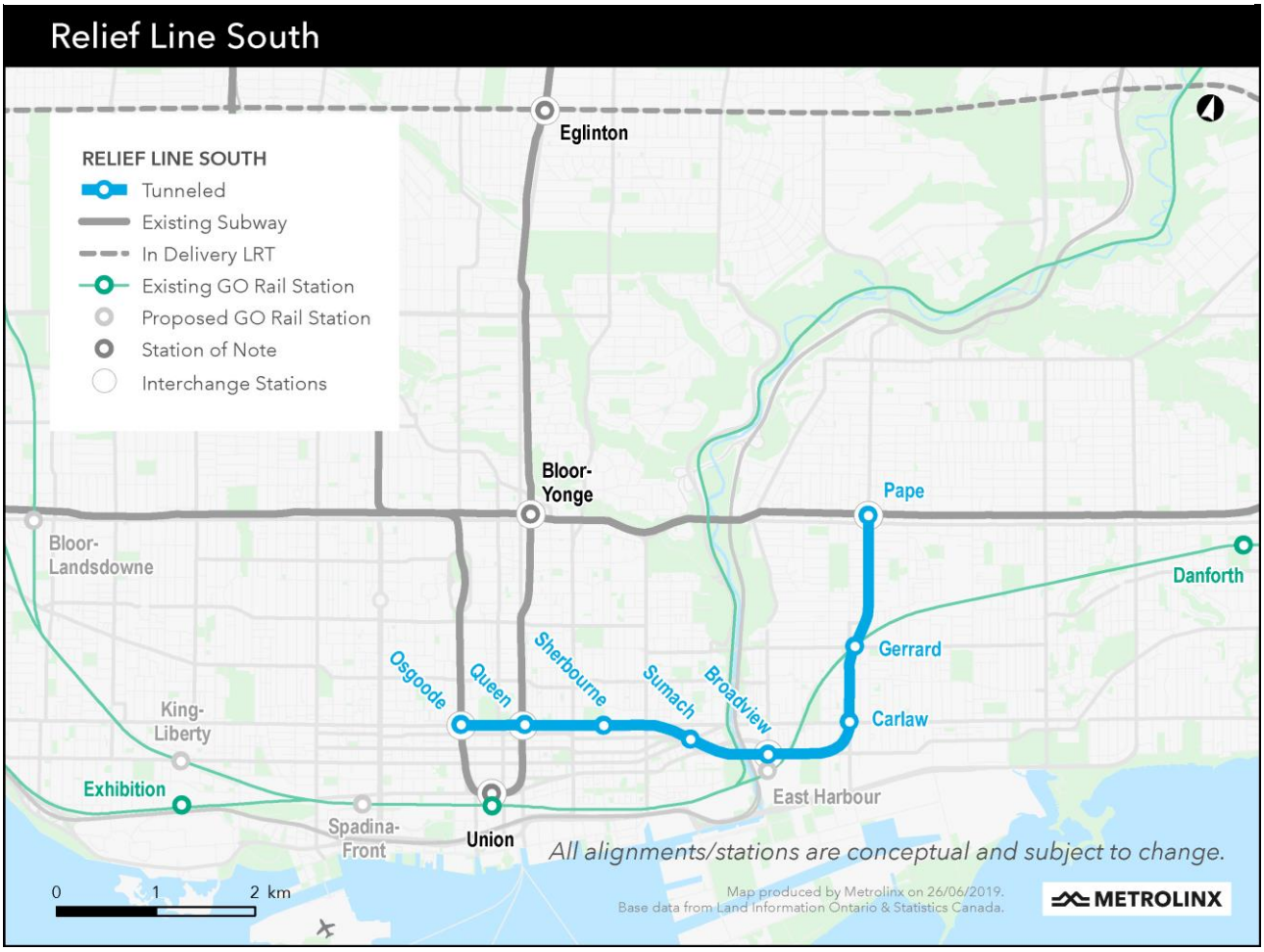


Table 5: Relief Line South Characteristics

Option	Length	Rolling Stock	Number of Stations
Relief Line South	7.5 km	TR-Series Train (existing fleet)	8 (incl. 4 interchanges with subway and GO Rail)

Alignment

As shown in Figure 5, the line extends from Osgoode Station along Queen Street eastward to the Sherbourne Street intersection before veering south to the King Street and Sumach Street intersection and continuing east along Eastern Avenue, and north along Carlaw Avenue up to Gerrard Street. Its last leg follows Pape Avenue to the existing Pape Station (Pape Avenue and Danforth Avenue intersection). There are a total of eight stations, three of which are interchange stations with existing subway lines (Queen, Osgoode, Pape) and one of which is a potential interchange station with the proposed East Harbour GO Station.

Relief Line South was designed with an underground alignment (up to ~40 m deep due to multiple constraints such as utilities and natural environment), and twin single bore tunnels, with seven emergency exit buildings every 800m or less. Ongoing engineering work recommends usage of four Tunnel Boring Machines (TBM) launching at the proposed East Harbour site and an additional TBM to create a new direct connection to Greenwood Yard. Station designs follow TTC Design Standards and assume mostly mined station construction.

Technology

Relief Line South was designed assuming the use of existing TTC subway technology (see Table 6). The rolling stock is consistent with the rest of the TTC subway system, with Toronto Rocket trains and Automatic Train Control and one-person train operation, similar to what is being implemented on Line 1 Yonge-University. It is assumed that the existing Greenwood Yard would become Relief Line South's dedicated maintenance facility with overnight storage on the tail tracks.

Table 6: Relief Line South Technology and Rolling Stock

Vehicle	Track Gauge	Train Length	Train Capacity (Crowding Standards)	Max. Axle Load	Train Control system	Operation
Toronto Rocket	1,495 mm (Almost Standard)	138m	1,100 passengers	15 tonnes	Communications-Based Train Control	Semi-Automatic

* Passengers per hour per direction

Capacity

Capacity is a function of train length, vehicle width, passenger loading, frequency, and seating configuration. The use of Communications-Based Train Control would allow Relief Line South's Toronto

Rocket trains to run every 90 to 120 seconds, thus providing an hourly capacity between 33,000 and 44,000 passengers per direction, based on TTC's crowding standards[12].

Table 7: Relief Line South Capacity

Vehicle	Train Capacity (Crowding Standards)	Headway	Practical Capacity
Toronto Rocket	1,100 passengers	90 seconds to 2 minutes	33,000 to 44,000 pphpd*

* Passengers per hour per direction

[12] TTc, Update to TTC Service Standards (May 2017)

2. Ontario Line

The second option is the Ontario Line concept:

- a western terminus at Exhibition/Ontario Place
- northern terminus at Ontario Science Centre
- changes to the alignment across the Lower Don River

Figure 6: Map of Ontario Line

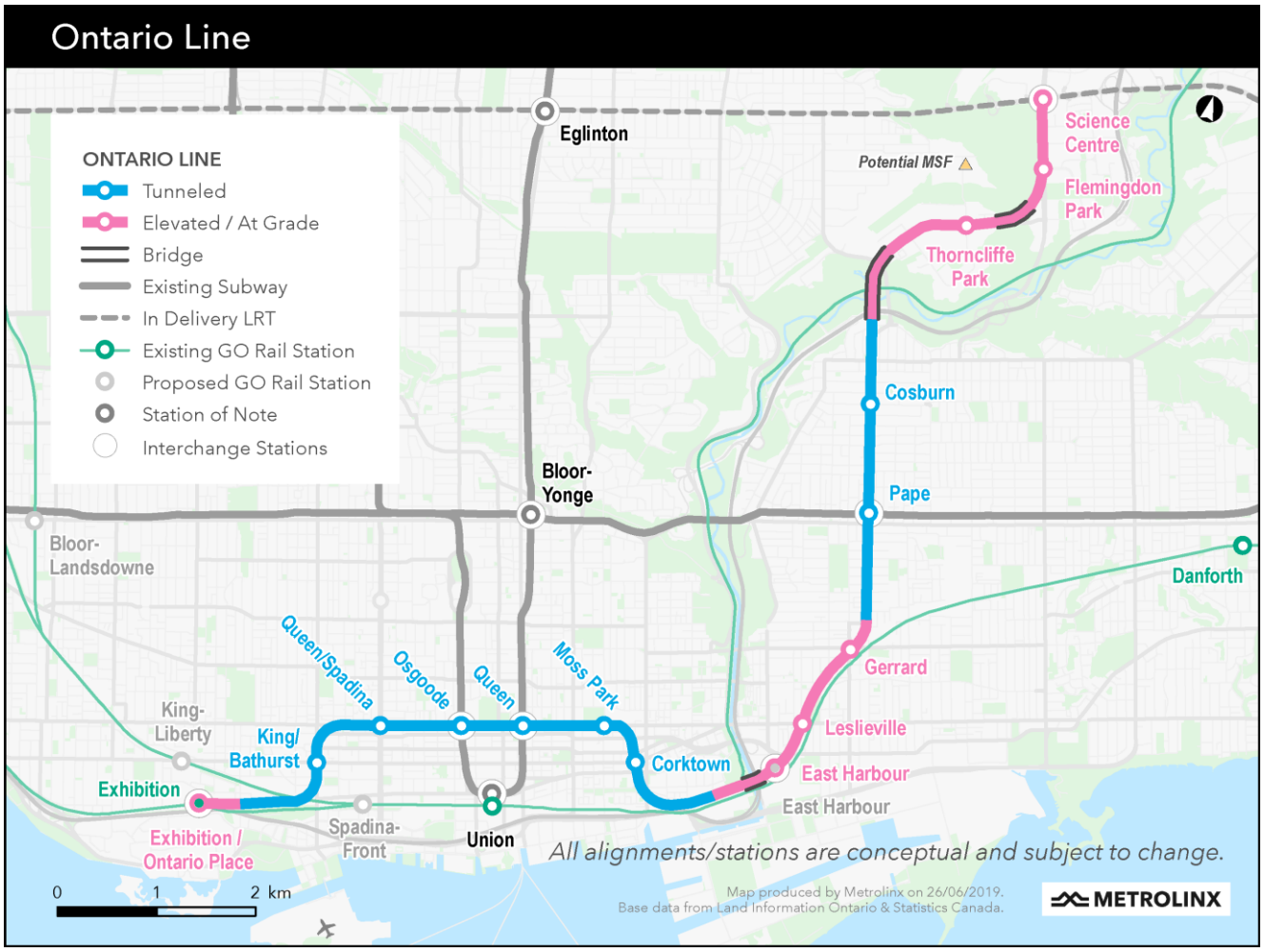


Table 8: Ontario Line Characteristics

Option	Length	Rolling Stock	Number of Stations
Ontario Line	15.5 km	Modern Standard Metro Rail Vehicles	15 stations (incl. 6 interchanges)

Alignment

This section sets out the assumed alignment for the Ontario Line. It is the "representative alignment," for purposes of this Initial Business Case. The alignment will evolve throughout design development and procurement, as more information is known about geotechnical conditions, built and natural environmental impacts, potential development integration, and other factors.

The Ontario Line starts at Exhibition Station with platforms at grade to allow for a cross-platform interchange with GO. It goes underground just west of Strachan Avenue and continues east, turning north under Bathurst Street to a station at King Street. It continues north turning east under Queen Street West with stations at Spadina Avenue, University Avenue, Yonge Street and Sherbourne Street. At Berkeley Street/Parliament Street, the line turns south, with a station at the intersection of King Street, then turning east under the GO Corridor.
The line rises within the rail corridor, with a portal east of Cherry Street. The Ontario Line crosses over the Don River and continues along the GO Rail corridor, along a widened embankment or elevated structure. There is a station with cross-platform interchange to GO at the proposed East Harbour, with stations along the rail embankment also at Queen and Gerrard.

North of Gerrard, the Ontario Line drops into tunnel, with an interchange station with Line 2 Bloor-Danforth at Pape Avenue and Danforth. It continues north under Pape Avenue with a station at Cosburn Avenue. The line emerges in a portal on the cliff side above the Don Valley Parkway, west of the existing Leaside (Millwood) Bridge, approximately under Minton Place. The line crosses the Don Valley on a new bridge, and then continues on elevated guideway along Overlea Boulevard, to a station at Thorncliffe Park Drive. The line continues along Overlea Boulevard, turning north at Don Mills Road with an additional station at Flemingdon Park. An alternative route would follow the CP Rail corridor and then run along the south side of Eglinton Avenue and would serve the Flemingdon Park neighbourhood through the station at Ontario Science Centre/Eglinton Avenue.

A train Maintenance and Storage Facility is assumed to be located alongside the CP Rail corridor, in the area of Wicksteed Avenue and Beth Nealson Drive. If the line is routed via Flemingdon Park, a connecting track would be required to the line at Overlea Boulevard.
All of the stations interconnect with existing and planned TTC bus, streetcar, LRT and subway and with GO Transit rail.

Technology

It is assumed that the Ontario Line, though fully integrated with the TTC network for passengers, will be operated independently from the rest of the system (see Table 9).

Table 9: Ontario Line Assumed Technology and Rolling Stock

Vehicle	Track Gauge	Train Length	Train Capacity (Crowding Standards)	Max. Axle Load	Train Control system	Operation	Headway	Practical Capacity
To be finalized by bidder	1,435mm (Standard)	100m *	730-850	12 Tonnes	Communications-Based Train Control	Automatic	90 seconds	29,300-34,000 pphpd**

* exact length and number of cars to be finalized at financial close by winning proponent
** Passengers per hour per direction

The following technological assumptions were made to develop a cost-efficient concept:

- Generic standard gauge technology, which enables competitive procurement and protects for possible future extensions onto GO rail tracks.
- Fully automated operation , which enables higher frequencies (up to 40 trains per hour) and allows for shorter trains to provide high capacity, with smaller and thus less expensive stations.

  Lighter vehicles with the ability to climb steeper gradients, which enables the use of elevated alignments, with potential for substantial reductions in the costs and construction time.

Capacity

The Ontario Line has been designed to deliver capacity to match projected future ridership for 50+ years beyond opening day, with room for network expansion as well. In order to understand the appropriate capacity required for Ontario Line, projected peak hour, peak direction ridership was analyzed in the context of international best practice crowding standards and station construction costs.

Metrolinx concluded that the Ontario Line should be built with provision for trains of up to approximately 100 metres length and assuming a 3.0 metre car width. This compares with 80 metre stations being built for the Montréal Express Metro, and 90 metre stations and trains with 2.4 metre car widths on the Grand Paris Express. See Table 10 for other examples.

Table 10: Sample Characteristics of Rapid Transit Lines

	Train size (L x W) (m)	Passengers per square meter	Passengers per train	Passengers per direction per hour (pphpd)
Toronto Rocket	138 x 3.2	3.29 (design) 2.44 (observed)	1,458 (design) 1,100 (observed)	26,400 with 24 trains per hour (tph) 39,600 with 36 tph
Vancouver Expo Line	68 x 2.65	2.95	532	19,152 with 36 tph
Vancouver Canada Line	41 x 3.0	2.78	342	10,260 with 30 tph
Ontario Line [Assumed]	100 x 3.0	2.44-2.85*	730-850	29,300-34,000 with 40 tph

*2.85 passengers/sq. m reflects Transit Cooperative Research Program (TCRP)'s guidance on tolerable loading

Connection to Ontario Place

A station at the Exhibition Place site will bring subway service to the doorstep of Ontario Place, and will serve any future large-scale destination attraction contemplated as part the of the Ontario Place Development process. This development process is currently in market (2019) and is seeking submissions to transform the site into a major waterfront destination that could include sport, entertainment, public spaces, parks, recreational facilities, and retail. In 2018, an estimated two million people visited Ontario Place. Visits are expected to significantly increase as the site continues to revitalize.

Due to the scale of the immediate area (192 acres at Exhibition Place and up to 155 acres at Ontario Place), future local transit solutions could be integrated into development. Such solutions could be phased, as redevelopment occurs on surrounding property (at either Exhibition Place or Ontario Place).

There are a multitude of options to provide a high-quality connection directly to Ontario Place. Many cities, including Singapore, London, Dubai and Tokyo, have waterfront destinations linked to subways by automated people mover, cable cars, or other mode. Besides providing an effective transport link, the system can be a feature, or potentially an attraction in its own right. Planning for this connection creates an

opportunity to enhance the public realm, support new retail and commercial uses and extend transit-oriented development opportunities.

The Ontario Place/Exhibition Station is located at a reasonable distance from large event venues, BMO Field (31,000 capacity), Budweiser Stage (16,000 capacity) and Coca-Cola Coliseum (7,800 capacity) as well as conference and trade show centres, including the Enercare Centre and Beanfield Centre. Sports, entertainment and trade shows attract nearly six million visitors a year to the area. Good practice is to locate rail stations some distance from large event venues, to enable crowd-management and mitigating unsafe crowding on platforms.

The assumed western terminus at Exhibition Station has been chosen for several reasons:

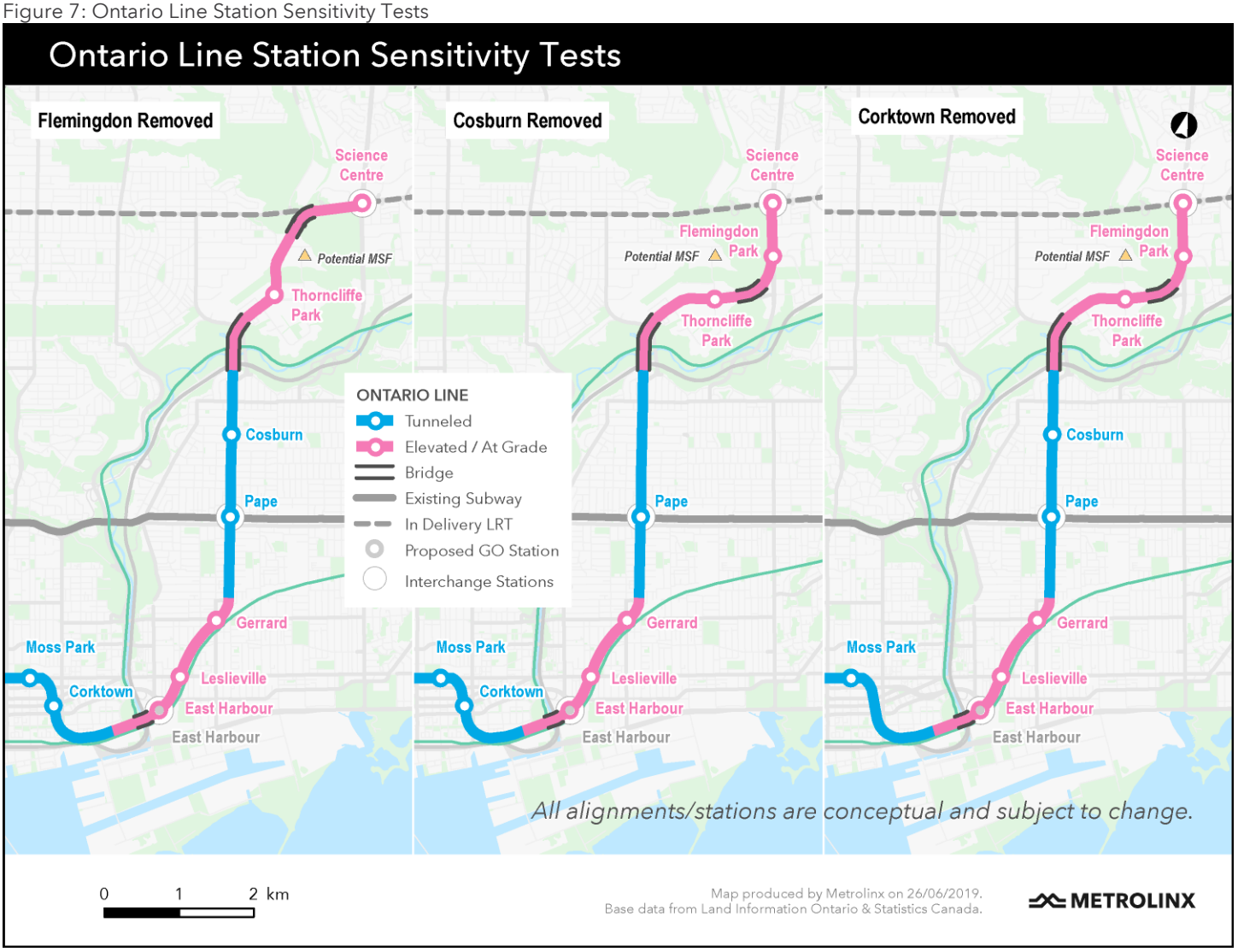
- It will serve the dense Liberty Village residential and employment area.
- The cross-platform interchange with the Lakeshore West GO Rail line GO Rail will allow easy transfers between GO and the subway and can relieve crowding at Union Station, shortening journeys for thousands of regional commuters to the north part of downtown, to Ryerson University, University of Toronto, and for destinations further north on Line 1.
- By terminating at the Ontario Place/Exhibition Station the Ontario Line is protected for future potential western extensions.
- The Exhibition Place site provides space for tunnel construction, potentially using rail access to limit road haulage of excavated material, tunnel liners and rails. This can reduce costs and impacts while actually speeding construction of the line.

Station Sensitivity Tests

In considering a full range of options for optimizing the Ontario Line, analysis has been conducted on several stations to determine how construction costs for the station compare with ridership and benefits. Several stations serve primarily local traffic, much of which would still use transit even if it requires a short trip on a feeder bus or streetcar. This IBC includes an initial assessment of the benefits and costs of these stations. These stations are:

- Flemingdon Park: Analysis assumes this station is elevated along Don Mills Road, near the Flemingdon Park Shopping Centre. Its absence would allow for a change in alignment (see Figure 7).
- Cosburn Station: Analysis assumes this station is underground, under Pape Avenue.
- Corktown Station: Analysis assumes this station is underground near the King and Parliament intersection.

Figure 7: Ontario Line Station Sensitivity Tests



Summary of Assumptions Used in this Business Case for Analysis and Travel Demand Modelling

In order to develop the business case evaluation and undertake the modelling and analysis that support it, a number of assumptions were made with respect to future conditions (see

Table 11). These are consistent with the standard assumptions generally applied to Metrolinx studies and are inferred from both policy and observed trends.

Table 11: Summary of Assumptions

	2041 Assumption (Source)
City of Toronto Urban Structure	City of Toronto Official Plan, Maps 2,13-20
Population and Employment	Expanded Market Land Use based on 2011 Census (Statistics Canada) and existing development applications
Base Rapid Transit Network	2041 Regional Transportation Plan "In-Delivery Network" with updates from Ontario's Transit Plan (Ontario Government, 2019)
Fare Structure	2018 TTC-level fare at all GO stations within City of Toronto Boundaries 2018 Double-Discounted Fare GO/TTC 2018 TTC fare on all TTC routes (including the projects herein evaluated) 2018 Distance-Based GO fare structure, except within City of Toronto 2018 Ride To GO fare discount YRT/GO
GO Network	GO Expansion Full Business Case, 2019
Surface Transit Network	Surface transit network assumptions were provided by TTC
Travel Behaviour Model	Greater Golden Horseshoe Model v4
Line 1 hourly capacity	36,000 (provided by TTC)

4

Strategic Case

Infrastructure ONTARIO

METROLINX

Introduction

The Strategic Case summarizes the performance of the options against the identified strategic objectives to indicate if the investment addresses the Problem Statement and the goals of the *2041 Regional Transportation Plan*. Criteria were developed and selected to evaluate each option's ability to meet the objectives and support the realization of the strategic outcomes.

This chapter will be structured around the 3 outcomes defined in the Problem Statement chapter, as follows:

1 **STRONG CONNECTIONS**

Assessment of how the options would improve people's mobility and access to opportunities and destinations.

2 **COMPLETE TRAVEL EXPERIENCES**

Review of how the options would allow people to travel faster, more comfortably, more conveniently and more reliably.

3 **SUSTAINABLE AND HEALTHY COMMUNITIES**

Examination of how the options would support sustainable travel patterns and public health.

Outcome 1: STRONG CONNECTIONS

Adding a new rapid transit line will improve the connections between people and the places where they live, work and play. The service will improve access to jobs and other services by transit, and in particular, strengthen connections between people and jobs within Toronto and the surrounding region. Improving the quality of, and access to, transit services is essential to support the continued economic development of the Greater Toronto and Hamilton Area.

This section will compare the options' ability to deliver three benefits that support the realization of Outcome 1 "Strong Connections."

1

Improve Access to Transit

Do the options go where people are and where they go?

2

Increase Access to Economic Opportunities

Do the options connect more people to more jobs?

3

Support a Synergistic Relationship between Transit and City-Building

Do the options support planned growth and development opportunities?

OUTCOME 1: STRONG CONNECTIONS

BENEFIT 1: Improve Access to Transit

Both Relief Line South and Ontario Line will improve access to transit through the provision of new rapid transit infrastructure compared to the BAU scenario. The Ontario Line is approximately twice as long as the Relief Line South and serves nearly 50% more residents (west of University Avenue and north of Danforth Avenue). It is projected to generate 389,000 daily boardings, compared to 206,000 with Relief Line South. The Ontario Line would provide walking-distance access (800 metres or ten minute walk)[13] to rapid transit for 154,000 new people, compared to BAU, almost twice the number of people who would gain access to rapid transit with the Relief Line South in place (see Figure 8). The Ontario Line station locations are within walking distance for 34,000 low-income people as opposed to 19,000 for the Relief Line South (see Figure 10, 2016 Census numbers).

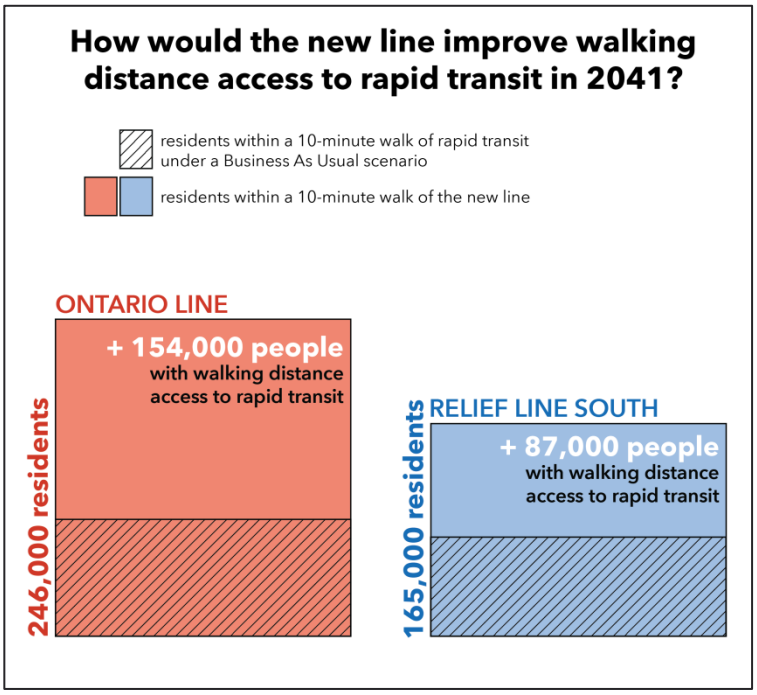


Figure 8: 2041 Residents within 10-minute walkshed of Options. Source: GGHm v4.

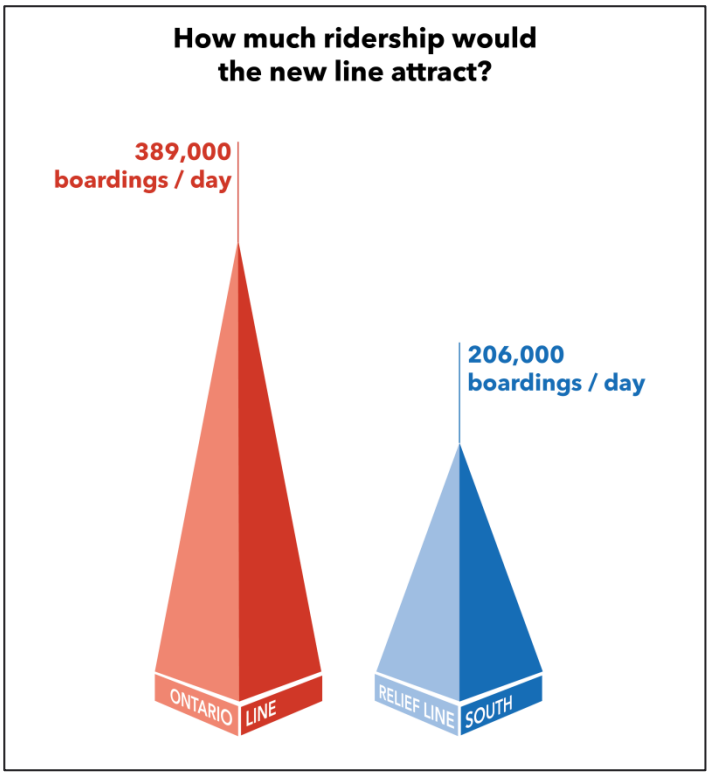


Figure 9: Projected number of daily boardings. Source: GGHm v4.

[13] All metrics related to walking distance access were calculated using an 800-metre walkshed around stations, based on an assumed 2041 street network, where an 800m walk is considered to take on average ten minutes. Where a catchment area is mentioned, the study area considered is an 800m radius buffer (as the crow flies distance) around stations.

Both Relief Line South and Ontario Line serve dense older neighbourhoods including Moss Park and Leslieville, and newer development at Corktown. The Ontario Line also serves dense residential areas west of University Avenue, including Chinatown, Alexandra Park, Liberty Village, and older, relatively dense suburban neighbourhoods including Cosburn and Thorncliffe Park (see Figure 11).

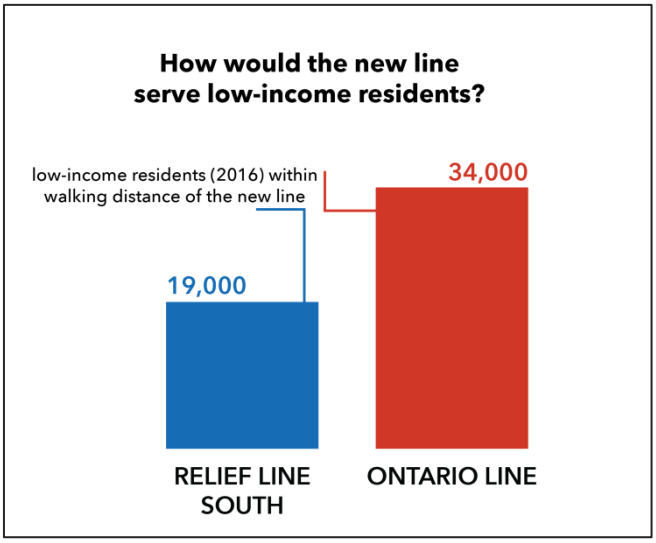


Figure 10: 2016 low-income residents within 10-minute walkshed of options. Source: Statistics Canada, 2016 Census.

Figure 11: 2041 Population Density Forecast. Source: 2041 Market Expanded Land use.

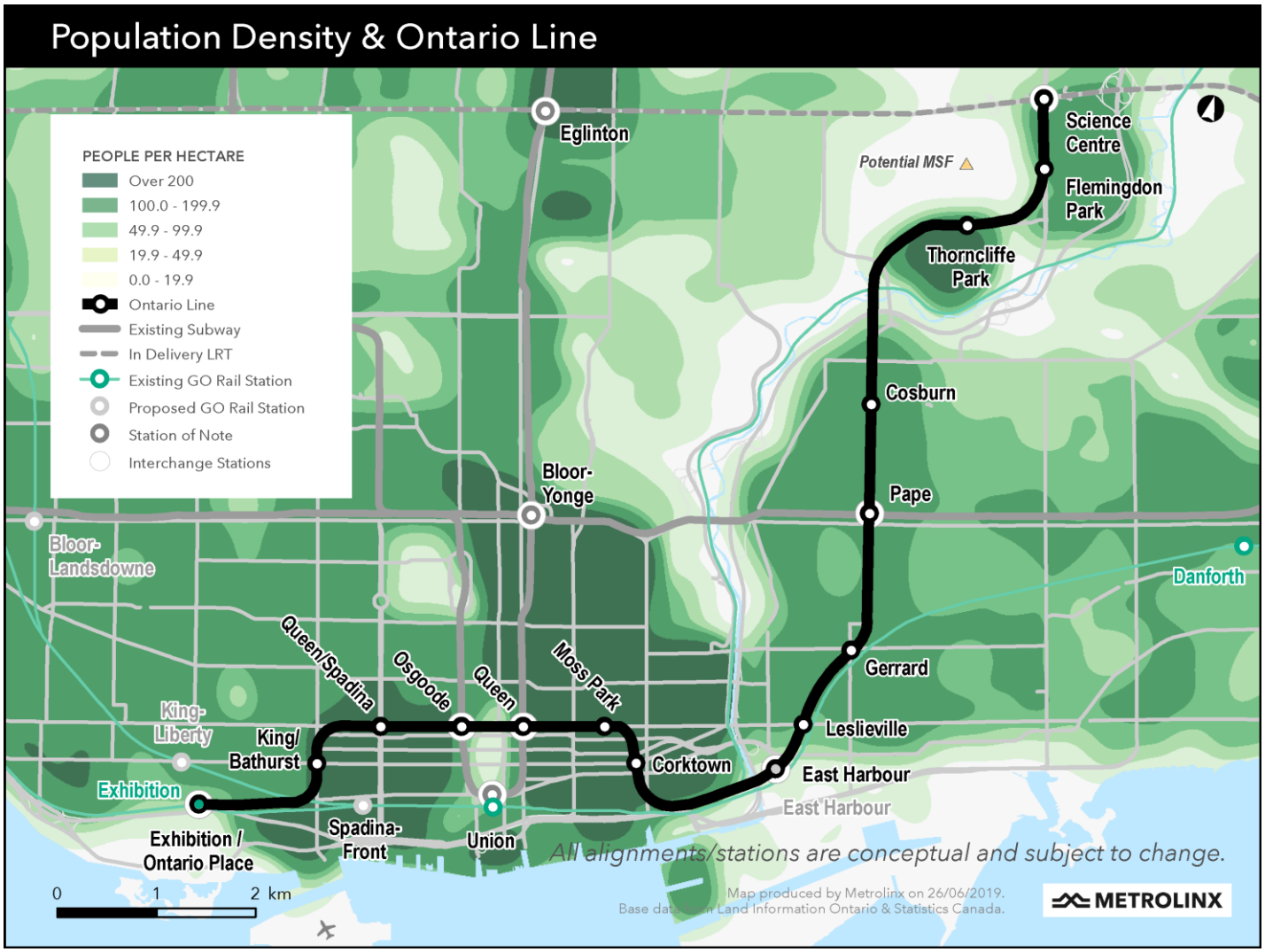


Table 12: "Improve Access to Transit" Summary

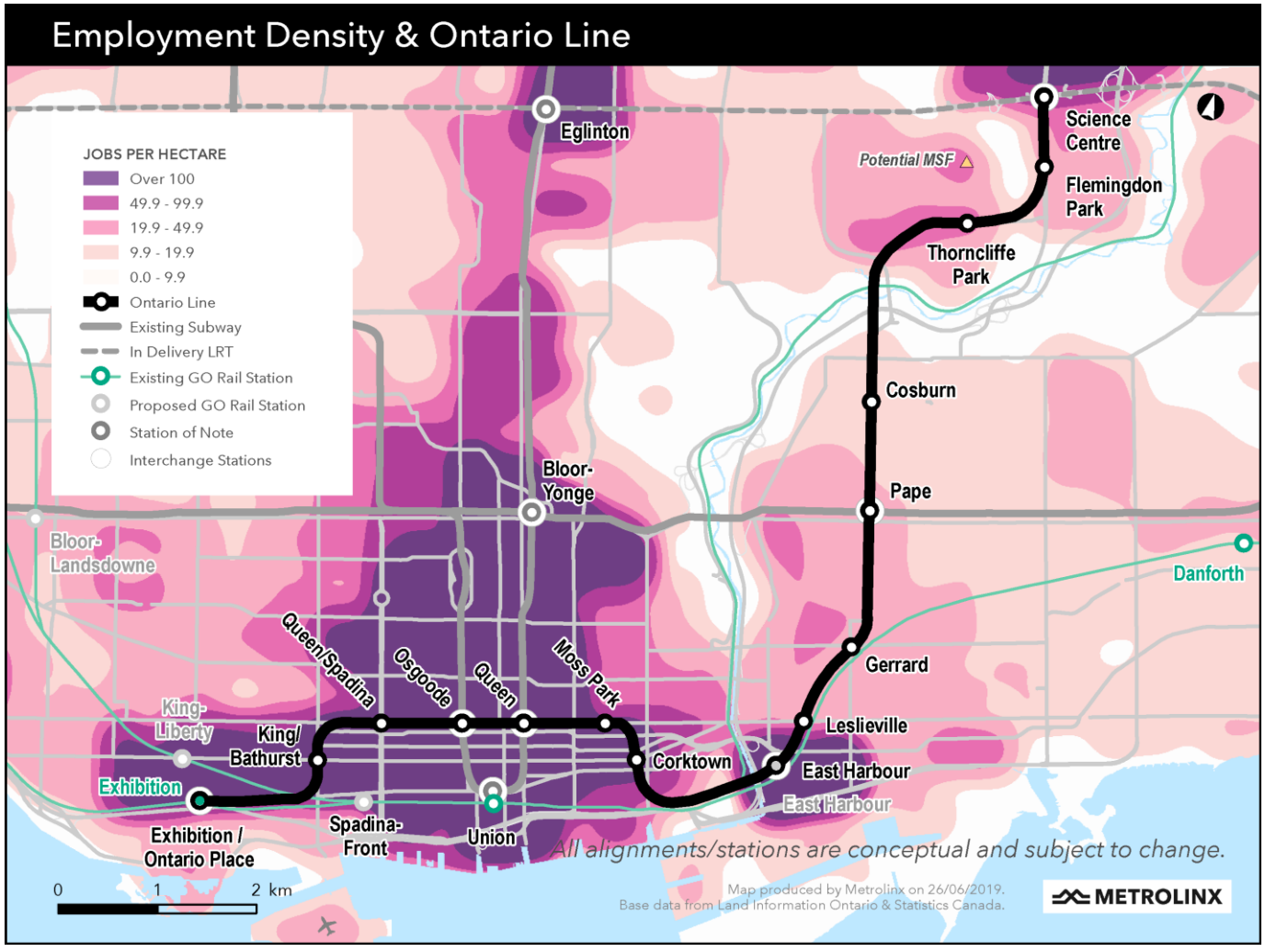
Criteria	Relief Line South	Ontario Line
How many people would gain walking distance access to rapid transit? *Projected 2041 residents within a 10-minute walk of the line who wouldn't have walking distance access to Rapid Transit under the Business As Usual scenario	+87,000 people (out of a total of 165,000 projected residents within a 10-minute walk of the line)	+154,000 people (out of a total of 246,000 projected residents within a 10-minute walk of the line)
How would the option impact the mobility of low-income residents? * 2016 Census, Statistics Canada	19,000 low-income residents within a 10-minute walk of the line (2016)	34,000 low-income residents within a 10-minute walk of the line (2016)
How many people will use the new transit line?* *2041 GGHm v4 outputs	206,000 daily boardings	389,000 daily boardings

OUTCOME 1: STRONG CONNECTIONS

BENEFIT 2: Increase Access to Economic Opportunities

Both Ontario Line and Relief Line South increase access to the Toronto Financial District compared to BAU, and can serve proposed employment development at the proposed East Harbour. The Ontario Line also serves significant employment in the western part of downtown Toronto. Due to its length, Ontario Line is able to provide walking distance access to more jobs than Relief Line South, with the majority of the new access located in downtown Toronto, west of University Avenue (see Figure 12), and at Don Mills and Eglinton.

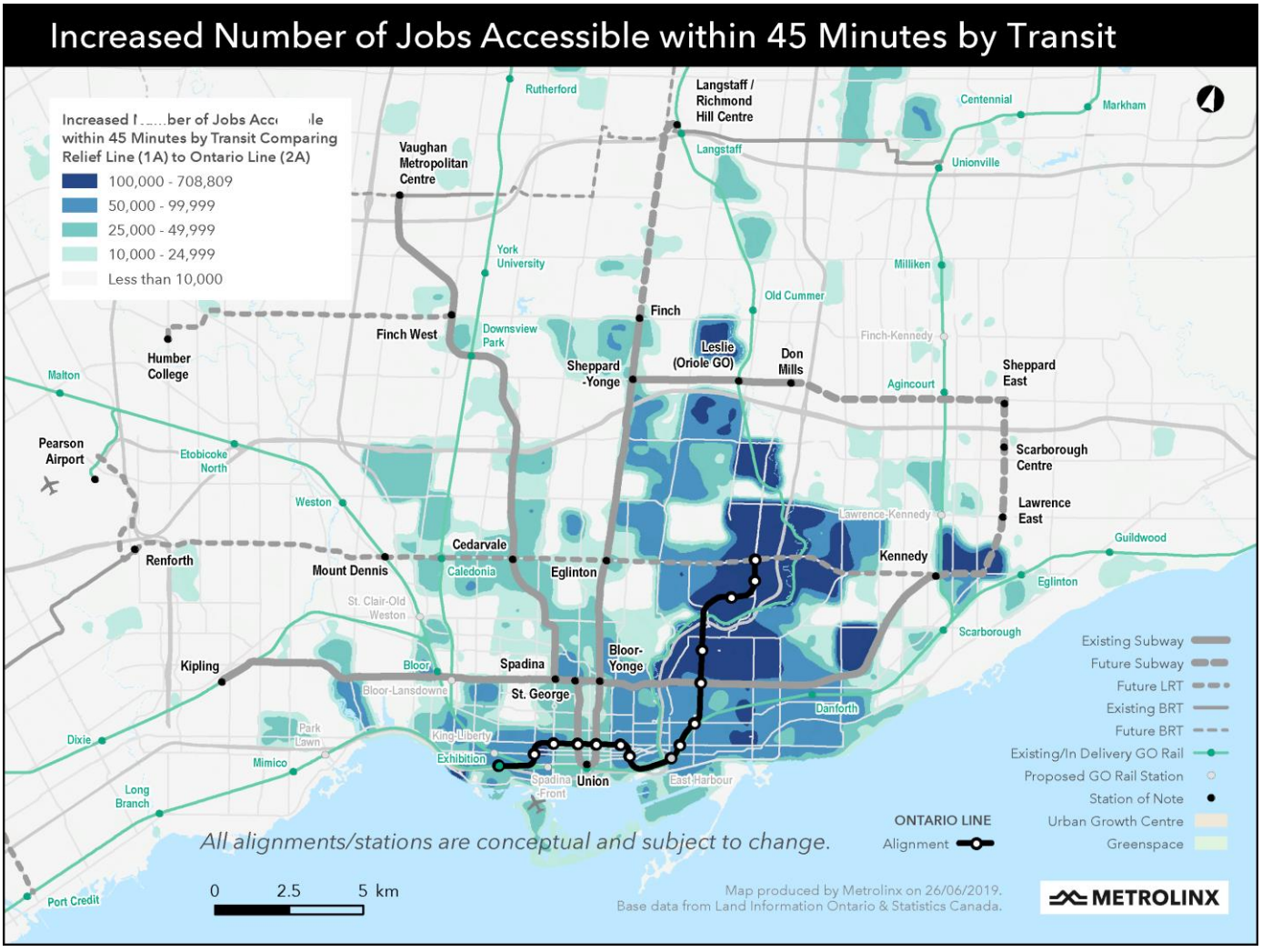
Figure 12: 2041 Employment Density Forecast. Source: 2041 Market Expanded Land Use.



The difference in performance between the options is further demonstrated when considering the number of Toronto jobs accessible in 45 minutes or under by transit. Ontario Line more than doubles the number of additional jobs accessible to Toronto residents compared to Relief Line South (53,000 additional jobs with implementation of Ontario Line, compared to BAU, and 25,000 additional jobs with Relief Line South).

Compared to BAU, the Ontario Line also provides employers an advantage by increasing the number of people, and therefore potential employees, within a 45-minute transit trip of Toronto jobs by 91,000. The Relief Line South would result in an increase of 42,000 people within 45 minutes of Toronto jobs compared to BAU.

Figure 13: Difference in number of jobs accessible within 45 minutes by transit between the Relief Line South and Ontario Line scenarios by zone of origin



A closer look at low-income residents[14] in Toronto shows that the Ontario Line would increase the number of jobs accessible in a 45 minutes or shorter transit journey for low-income residents by 66,000 compared to BAU. Relief Line South would increase the same number by 26,000[15] (see Figure 15).

[14] LICO, Statistics Canada, 2016
[15] These numbers were calculated using 2016 low-income distribution levels.

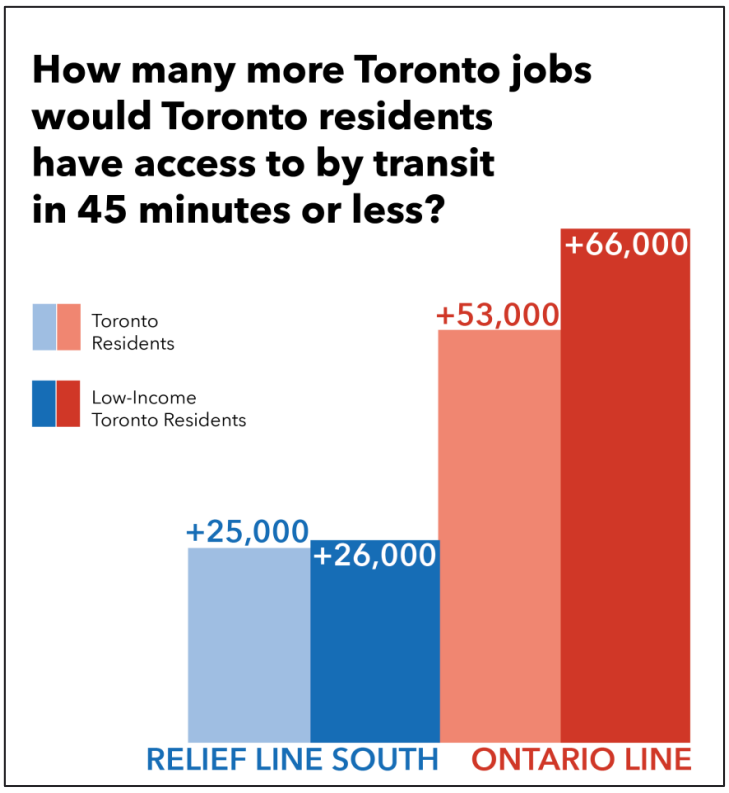


Figure 15: Number of net new jobs accessible within a 45-minute transit trip to Toronto residents, compared to Business As Usual.

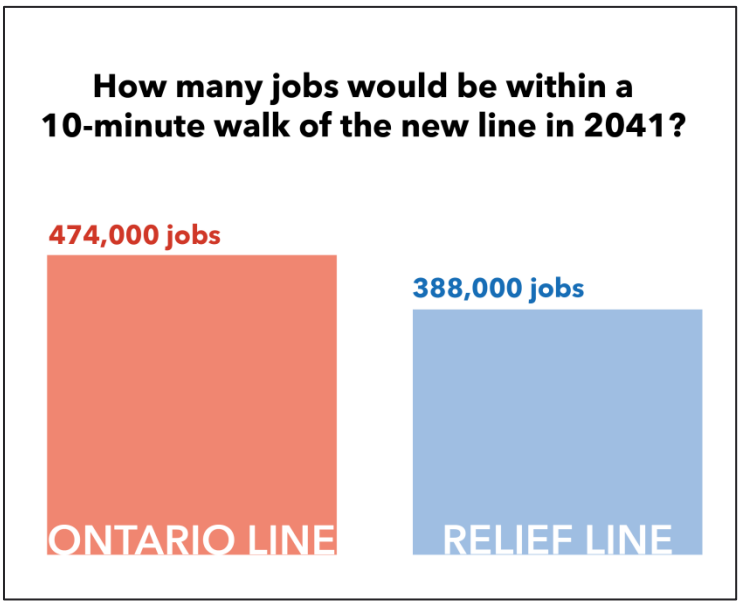


Figure 14: Number of future jobs within a 10-minute walk from the new line's stations.

Table 13: "Increase Access to Economic Opportunities" Summary

Criteria	Relief Line South	Ontario Line
How will the option serve areas of planned employment growth?* * GGHm v4 outputs	388,000 projected jobs within a 10-minute walk of the line	474,000 projected jobs within a 10-minute walk of the line
How many more employment opportunities will people have access to within a 45-minute transit commute compared to BAU?* * GGHm v4 outputs	+ 25,000 jobs accessible in 45 minutes or less to Toronto residents	+53,000 jobs accessible in 45 minutes or less to Toronto residents
Does the option serve key destinations? *Transportation Tomorrow Survey, 2016	524,000 trips (2016) destined to locations within a 10-minute walk from the line	692,000 trips (2016) destined to locations within a 10-minute walk from the line
How will the option impact access to opportunities of low-income residents? * * GGHm v4 outputs and LICO, Statistics Canada, 2016	+26,000 jobs accessible in 45 minutes or less to low-income residents in Toronto	+66,000 jobs accessible in 45 minutes or less to low-income residents in Toronto

OUTCOME 1: STRONG CONNECTIONS

BENEFIT 3: Support a Synergistic Relationship between Transit and City-Building

To maximize current and future ridership, new rapid transit should be built where people reside and jobs are located today, and where there is potential for growth in the future. Transit infrastructure has been found to encourage development activities in all categories of use, generating further economic benefits for communities and the region. This growth and development, in turn, generates more transit ridership.

Two major policies guide development in the City of Toronto: the provincial *Growth Plan for the Greater Golden Horseshoe (*the *"Growth Plan")*, and the *City of Toronto Official Plan (*the *"Official Plan")*. These policies generally work to direct growth in areas that have been identified as "Urban Growth Centres" (UGC) in the *Growth Plan* and in Toronto's Downtown and Central Waterfront, "Avenues", and "Centres" as identified in the *Official Plan*.

Both Relief Line South and Ontario Line have similar station locations from Osgoode Station to Pape Station, in areas designated for growth in the *Official Plan-*, and both serve the areas that are planned to accommodate the largest percentage of future growth, the Downtown and Central Waterfront[16].

With its Carlaw alignment, Relief Line South serves the "Employment Area" at Dundas-Carlaw more directly, but all of the stations located along Carlaw and/or Pape, both on Ontario Line and Relief Line South, are mostly surrounded by "Neighbourhoods", which are considered stable residential areas (traditionally low-density). The alignment bisects several "Avenues", which are generally mixed-use in nature and expected to intensify with mid-rise style development.

The longer Ontario Line serves more growth-focused areas than the alternative under consideration. It intersects major "Employment Areas" at Exhibition GO Station, Don Mills/Eglinton Avenue and in Leaside, thus offsetting the large "Natural Areas" within the line's catchment area in the Don Valley, which are not designated for intensification. Flemingdon Park and Thorncliffe Park are designated as "Apartment Neighbourhoods", meaning they have significantly higher residential densities, and are currently underserved by rapid transit. The introduction of new rapid transit may unlock intensication of underutilized sites in these neighbourhoods, futher benefitting ridership. Moreover, Ontario Line's Science Centre Station would serve transit-oriented development sites around the Eglinton Crosstown station currently proposed to host close to 5,000 residential units as well as office and retail uses.

[16] *City of Toronto Official Plan*, Map 2 Urban Structure

Figure 16:800m Catchment Areas and Land Use Plan (Toronto Official Plan, 2015)

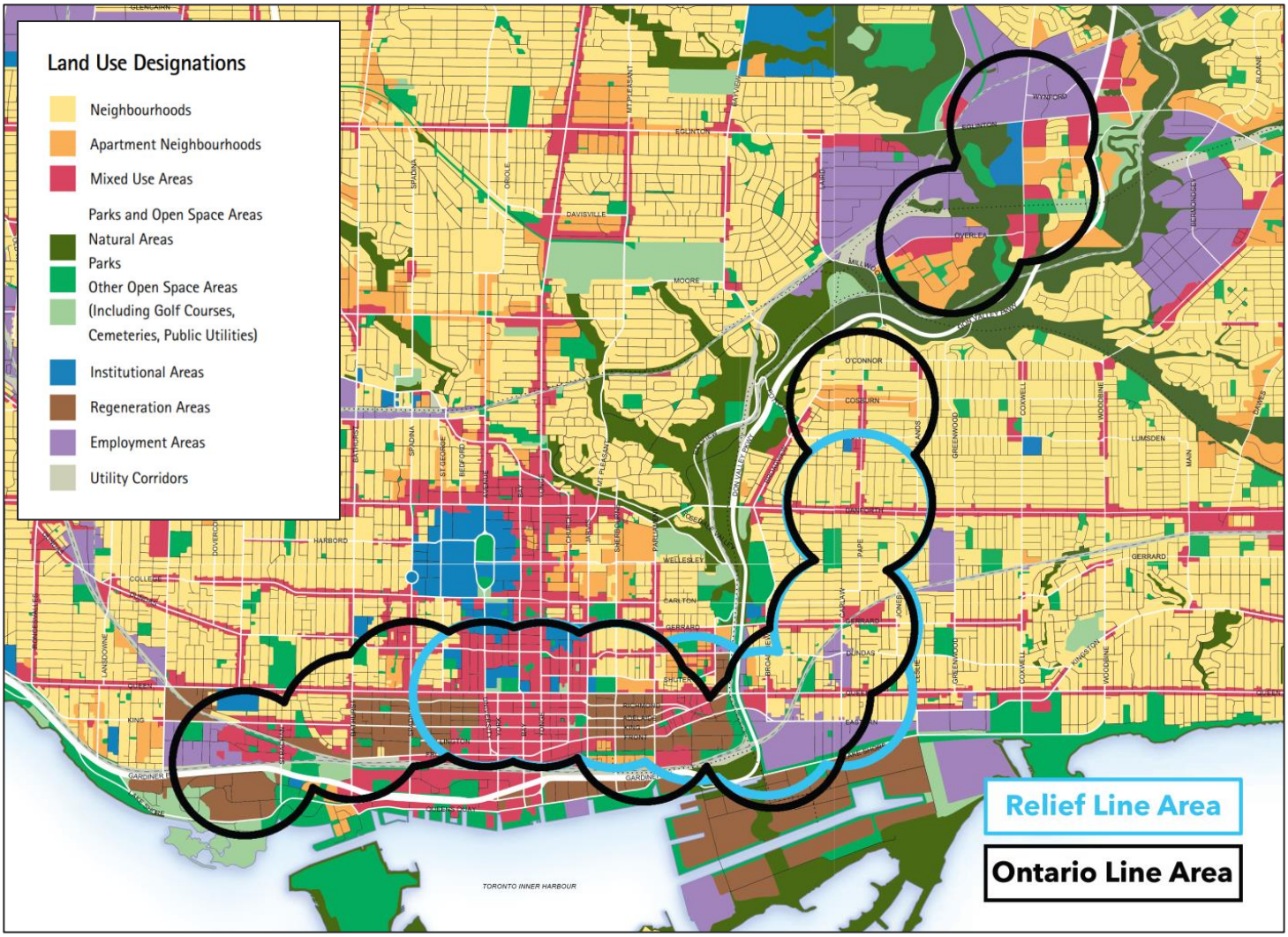


Table 14: "Support a Synergistic Relationship between Transit and City-Building" Summary

Criteria	Relief Line South	Ontario Line
How would transit-oriented development (TOD) affect ridership of the line?* *Based on analysis of potential TOD opportunities	+7,400 daily riders	+ 20,600 daily riders
How does the option align with planned/future development?	Sites and areas with in-progress/future major development served by the line include: Financial District, Moss Park, proposed East Harbour, Lower Don Lands, Regent Park and Canary District.	The line serves: all in/progress future development served by Relief Line South as well as Ontario Place, Liberty Village, King/Portland and Don Mills/Eglinton.
Does the option improve the connectivity of Urban Growth Centres (UGC)?	Yes, the option directly serves the Downtown Toronto UGC.	Yes, the option directly serves the Downtown Toronto UGC and increases options to access the Yonge-Eglinton UGC due to a connection with Eglinton Crosstown.
Does the option support areas with land uses compatible with rapid transit as identified in City of Toronto's *Official Plan*?	Yes, generally, stations are located in areas designated for mixed-use, regeneration, and employment land uses.	Yes, generally, stations are located in areas designated for mixed-use, regeneration, employment, and higher-density residential use.

Outcome 2: COMPLETE TRAVEL EXPERIENCES

The addition of a new rapid transit line will improve the speed, frequency and reliability of transit service in the study area. Combined, these will enhance the overall travel experience for customers and make transit a more attractive travel mode.

This section will compare the options' performance on three objectives that support the realization of Outcome 2 "Complete Travel Experiences":

4 **Improve Travel Time and Reliability**

Do the options make transit travel faster and more dependable?

5 **Improve Comfort and Safety**

Do the options make transit trips safer and more comfortable?

6 **Build an Integrated Transit Network**

Do the options provide a seamless travel experience?

OUTCOME 2: COMPLETE TRAVEL EXPERIENCES

BENEFIT 4: Improve Travel Time and Reliability

Moving people quicker and offering reliable travel is at the heart of the *2041 Regional Transportation Plan*. The new rapid transit line should reduce travel times for people travelling in Toronto, not only for those located near the new stations, and create favourable conditions for a smooth-running transit network.

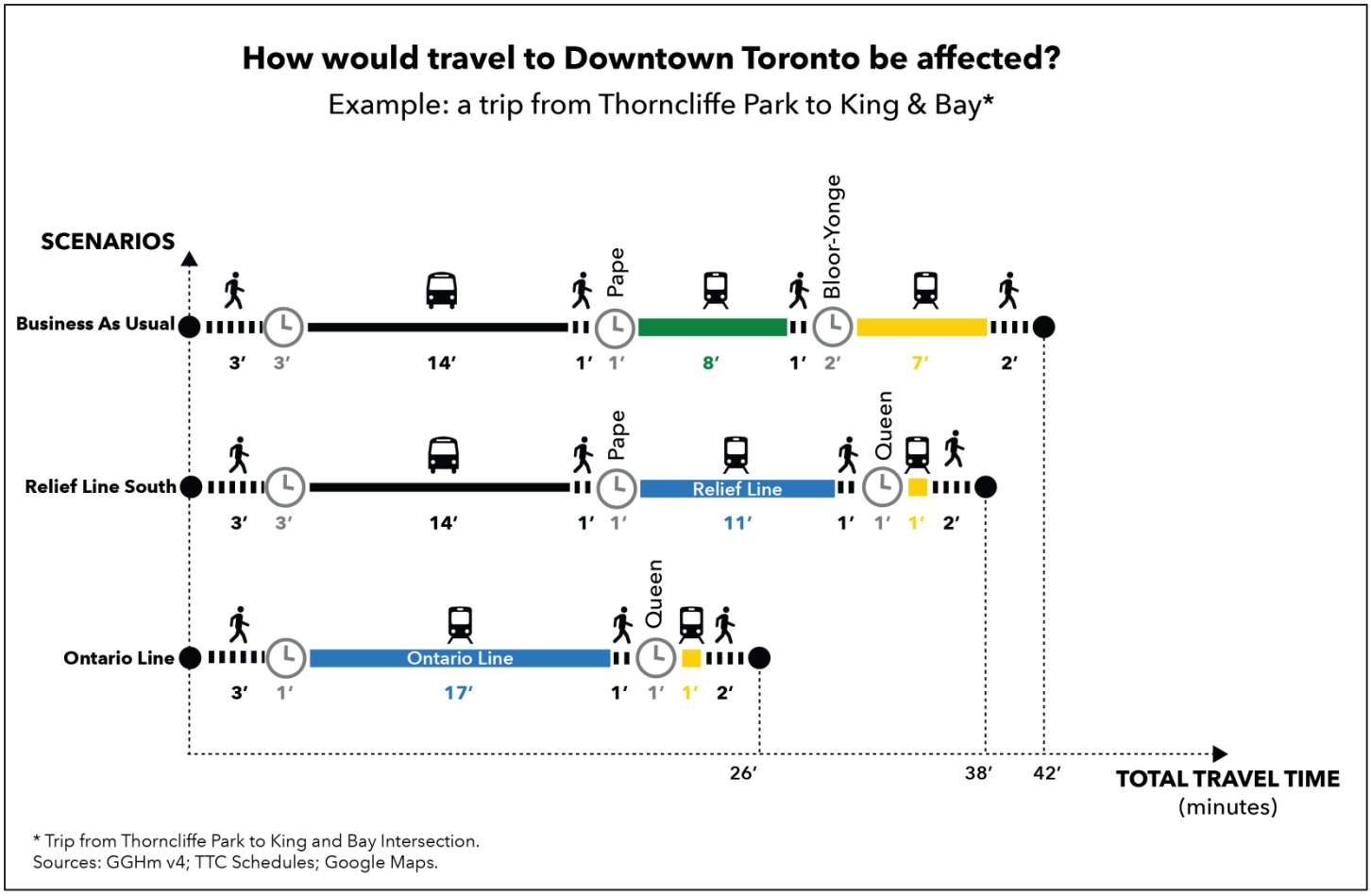


Figure 17: Comparison of Sample Trip Times

The Ontario Line and the Relief Line South are assumed to use Automatic Train Operation, enabling up to 40 trains per hour per direction. Both options are assumed to use platform edge doors which speeds dwell times, helps enable high frequencies, and reduces service delays. With a projected 2041 ridership of 13,700 passengers per hour per direction at the line's busiest point, Relief Line South would operate at up to 41% of its projected capacity in 2041, leaving room for ridership growth through 2095. The Ontario Line is forecasted to operate at 57% of its projected capacity with a maximum ridership of 19,500 passengers per hour per direction in 2041 and expected to provide adequate capacity until 2079.

Both Relief Line South and Ontario Line should improve service reliability on the subway network. Passengers on the busiest section of Line 1 would decrease by 7% under a Relief Line South scenario and 14% under an Ontario Line scenario, compared to BAU. This could result in a reduction in crowding-induced delays on Toronto's busiest subway line, as Line 1 would no longer be operating at maximum capacity. It is likely, however, that population and employment growth beyond 2041 would cause Line 1 ridership to grow, suggesting that further system improvement measures would be needed in the long-term in order to maintain operational and reliability benefits.

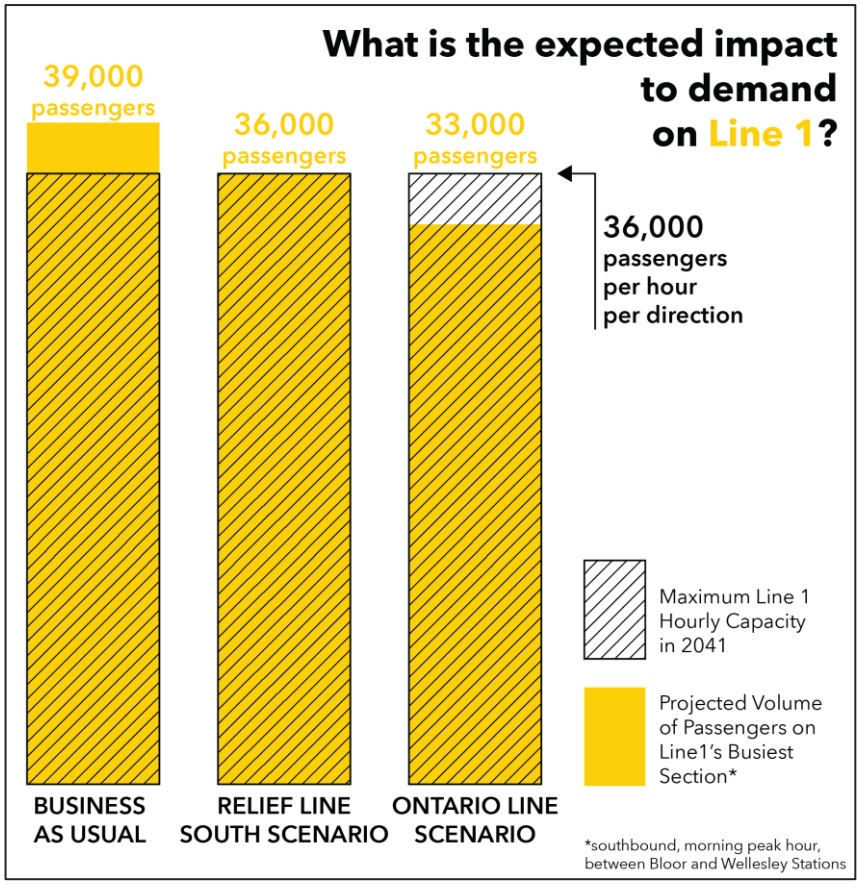


Figure 18: Line 1 Crowding. Source: GGHm v4.

New transit also means more choices and more ways for people to get to their destination faster. Ontario Line would provide one-seat rides to numerous origin and destination pairs and open up additional trips possible with a single transfer, thus delivering a total daily savings of 355,000 person-minutes on Toronto transit trips compared to BAU (see Figure 19). Relief Line South is expected to deliver 40% less transit travel time savings.

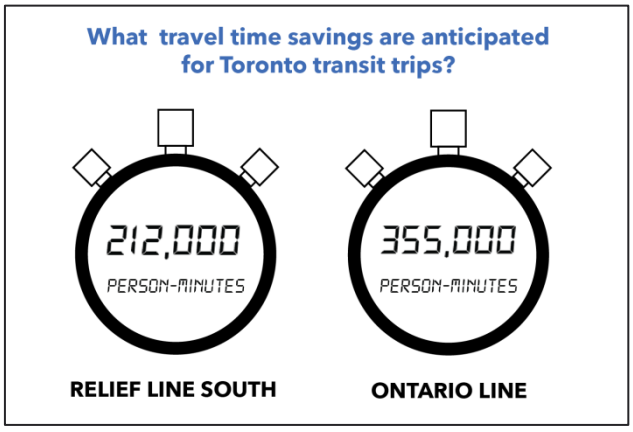


Figure 19: Total Transit Travel Time Savings, morning peak hour, Toronto Trips. Source: GGHm v4.

Table 15: Improve Travel Time and Reliability

Criteria	Relief Line South	Ontario Line
How will the option affect travel time to downtown Toronto for an example trip from East York Town Centre to King & Bay?	- 4 minutes	-16 minutes
What are the resulting total travel time savings?* * total travel time savings for all transit trips in Toronto, morning peak hour (perceived time). GGHm v4 outputs.	212,000 person-minutes	355,000 person-minutes
What is the option's potential to address crowding on Line 1?* * measured through change in volume of passengers at the line's busiest point, compared to BAU. GGHm v4 outputs.	-7% passengers (maximum demand of 36,000 pphpd)	-14% passengers (maximum demand of 33,000 pphpd)
Does the option offer sufficient capacity for ridership growth?* * volume to capacity ratio at the line's busiest point in 2041. GGHm v4 outputs.	Yes, Relief Line South trains are expected to operate at up to 41% of their maximum capacity in 2041 and allow for growth through 2095.	Yes, Ontario Line trains are expected to operate at 57% of their maximum capacity in 2041 and allow for growth through 2075.

OUTCOME 2: COMPLETE TRAVEL EXPERIENCES

BENEFIT 5: Improve Comfort and Safety

While transit crowding has an indirect impact on operations and service reliability, its primary consequences for passengers remain discomfort and potentially unsafe conditions. The addition of a new rapid transit line to the network should improve the overall comfort and safety of people traveling throughout the region, by diverting demand from existing lines and providing relief.

Overall, both Relief Line and Ontario Line would have a positive impact on crowding across the transit network. Ontario Line would have a larger impact, reducing the time that passengers spend in congested conditions by four times more than Relief Line South.

An analysis of several constrained points on the transit network confirms these findings. Both options, by intercepting westbound riders at Pape Station, are expected to provide comparable levels of significant relief to Bloor-Yonge Station and to Line 2 Bloor-Danforth, with 16% (Relief Line South) and 22% (Ontario Line) decreases in the volume of passengers on Line 2's busiest section respectively, compared to BAU. Due to its western and northern extensions, the Ontario Line would mitigate Union Station crowding (boardings and alightings) by 13% overall, compared to BAU (10% reduction in GO service crowding and 21% in TTC service crowding). Relief Line South would have very limited impact on Union Station crowding with no change in GO service crowding and 2% reduction in TTC service crowding. More importantly, the Ontario Line is projected to alleviate crowding by 15% in the future Eglinton Station hub now under construction, where a Relief Line South scenario would generate a 3% reduction only compared to BAU.

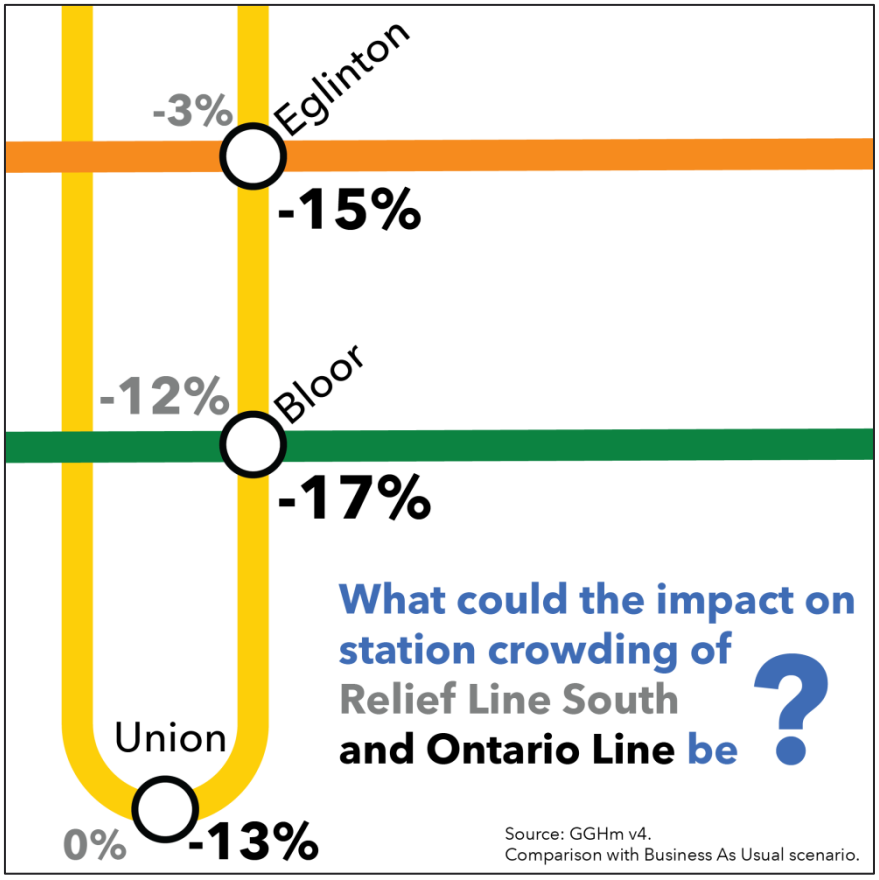


Figure 20: Impact of Options on Line 1 Station Crowding compared to BAU. Source: GGHm v4.

Table 16: Improve Comfort and Safety[17]

Criteria	Relief Line South	Ontario Line
What is the impact of the option on crowding on the transit network?* *change in total congested minutes for all Toronto transit trips	- 45,000 person-minutes compared to BAU	- 182,000 person-minutes compared to BAU
How will the option impact comfort on Line 1 Yonge?* *change in crowding perception factor[18]	-7% compared to BAU	-14% compared to BAU
What relief does the option provide to Line 2 Bloor-Danforth?* * change in volume of passengers at the line's busiest point	- 16% compared to BAU	- 22% compared to BAU
What is the option's impact on crowding at Union Station?* * change in number of boardings and alightings at the station	No change compared to BAU	-13% compared to BAU
What is the option's impact on crowding at Bloor-Yonge Station?* * change in number of boardings and alightings at the station	-12% compared to BAU	-17% compared to BAU
What is the option's impact on crowding at Eglinton Station?* * change in number of boardings, and alightings at the station	-3% compared to BAU	-15% compared to BAU

[17] Source: GGHm v4

[18] The crowding perception factor is a multiplier on real travel time to represent the onerous nature of travel on crowded vehicles. A trip on tightly packed vehicle which requires you to stand is perceived as longer than the equivalent trip on an empty vehicle where a seat is available.

OUTCOME 2: COMPLETE TRAVEL EXPERIENCES

BENEFIT 6: Build an Integrated Transportation Network

It is crucial to plan for an integrated transit network with a seamless and convenient customer experience. Transfers between transit lines help people to get as close as possible to their final destinations and also allow for operational efficiency.

Increase connections

Both Relief Line South and Ontario Line are designed to run as part of the existing transit network with a TTC fare, regardless of final ownership, operation, or maintenance arrangements. While they offer the same connections to Line 1 Yonge-University, Line 2 Bloor-Danforth, Lakeshore East GO, and Stouffville GO (which will both offer 15-minute two-way all-day service), the Ontario Line would also connect with Lakeshore West GO's 15-minute two-way all-day service at Exhibition Station, as well as Eglinton Crosstown's frequent service at Science Centre Station. Travel demand modelling forecasts 60% more transfers between Ontario Line and other rapid transit (39,000 during morning peak hour) than between Relief Line South and rapid transit (24,000), due partly to the two additional interchange stations.

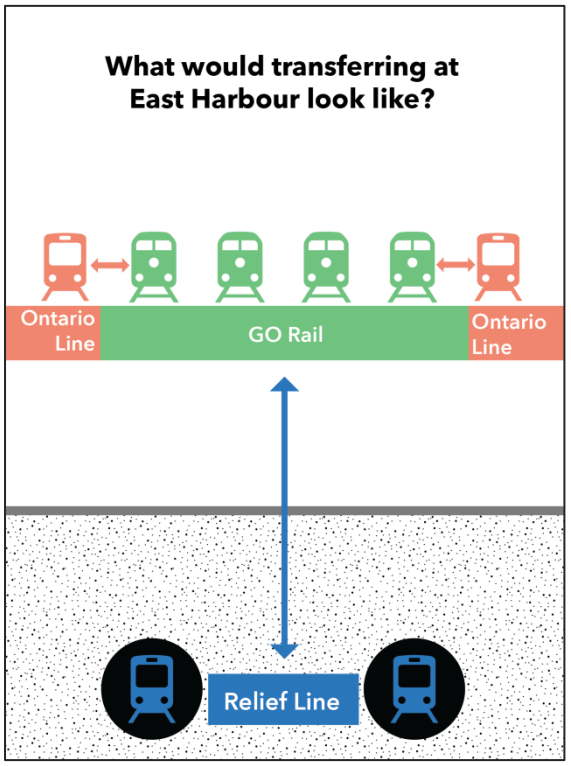


Figure 21: Transfering between GO and the new line at the proposed East Harbour station (Diagram not to scale)

Station Access and Egress

Additionally, key transfer stations provide an oportunity to further integrate the transit network. Where Relief Line South was designed with stations as deep as approximately 40 metres below ground, Ontario Line assumes some elevated guideways, especially at key transfer stations. Beyond reducing costs, building stations closer to the surface, under or above ground, reduces access and egress times to and from stations and makes transfers between transit modes more convenient. Travel demand modelling also looked at the overall impact of deep stations compared to stations close to street-level (either elevated or underground) to test how passengers might be expected to respond to different station access times. The impact of longer access time was substantial, suggesting up to a 15% decrease in ridership when stations are very deep compared to stations located close to street level.

Surface Integration

Surface routes, including buses and streetcars, are a first-mile solution to access rapid transit or last-mile solution to a destination. Integration with the surface route network is essential to ensure convenience for

passengers and to avoid shifts to less sustainable travel modes. Relief Line South would provide seven streetcar connections as opposed to ten streetcar connections for Ontario Line. Based on assumed future bus and streetcar service levels and routes[19], 445 peak hour surface route (streetcar and bus) trips would connect with Ontario Line, as opposed to 231 peak hour bus and streetcar trips connecting with the Relief Line South, demonstrating a high potential for integration with local surface transit.

Table 17: "Build an Integrated Transportation Network" Summary

Criteria	Relief Line South		Ontario Line	
How well does the option connect with rapid transit?	Line 1	2 connections	Line 1	2 connections
	Line 2	1 connection	Line 2	1 connection
	Stouffville GO	1 connection	Stouffville GO	1 connection
	Lakeshore East GO	1 connection	Lakeshore East GO	1 connection
			Lakeshore West GO	1 connection
			Eglinton Crosstown (Line 5)	1 connection
How often do surface transit routes connect to the line during the morning peak hour? * number of surface trips stopping within 100m of new stations during peak hour (routes that connect to more than one station are only counted once). GGHm v4 outputs.	231 surface route trip connections/hour		445 surface route trip connections/hour	
How attractive are transfers with rapid transit? * aggregated number of transfers between the new line and rapid transit at Exhibition GO, Osgoode, Queen, proposed East Harbour GO, Pape, and Eglinton, during the morning peak hour. GGHm v4 outputs.	24,000 total transfers between Relief Line South and rapid transit		39,000 total transfers between Ontario Line and rapid- transit	

[19] as provided by TTC

Outcome 3: SUSTAINABLE AND HEALTHY COMMUNITIES

The addition of a new rapid transit service will support the development of sustainable communities and travel patterns along the corridor.

This section will compare the options' performance on three objectives that support the realization of Outcome 3 "Sustainable and Healthy Communities":

7

Move People with Less Energy and Pollution

Do the options lead to a reduction in energy use for transportation?

8

Improve Quality of Life and Public Health

Do the options create conditions for healthy lifestyles and communities?

OUTCOME 3: SUSTAINABLE AND HEALTHY COMMUNITIES

BENEFIT 7: Move People with Less Energy and Pollution

Transit moves people more efficiently and sustainably than individual motorized vehicles, meaning it reduces the space and cost of getting people to their destinations. That is why a key objective of the new rapid transit line is to shift as many auto trips as possible to transit, to relieve road congestion and to minimize energy consumption in the process. Travel demand forecasting shows that building Relief Line South could result in 10,000 net new transit riders during the morning peak hour, compared to the Business As Usual scenario, whereas Ontario Line could generate 18,000 net new transit riders, 80% more than Relief Line South (see Figure 22).

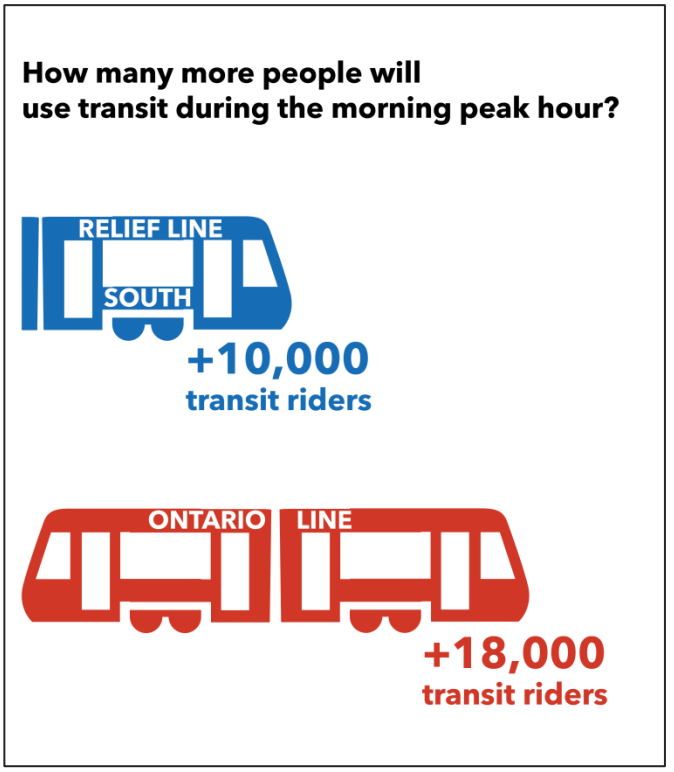


Figure 22: Net New Riders during morning peak hour compared to BAU. Source: GGHm v4 outputs.

Both options have been designed assuming the use of automatic operation and electric rail technologies, which will greatly reduce the amount of energy spent per trip and per passenger compared to automobile and bus modes. Ontario Line, through the use of lighter and smaller trains (12-ton axle load per train as opposed to 15-ton axle load for Relief Line South), and a grade of automation allowing for more control over acceleration and deceleration patterns, would require the least amount of power per train.

Vehicle Kilometres Travelled (VKT) measure the total distance travelled by cars, capturing traffic volumes as well as length of trips. A decrease in Vehicle Kilometres Travelled in Toronto gives an indication of congestion and Greenhouse Gas emissions reductions.The two lines are estimated to reduce Toronto's total number of Vehicle Kilometres Travelled during the morning peak hour, compared to

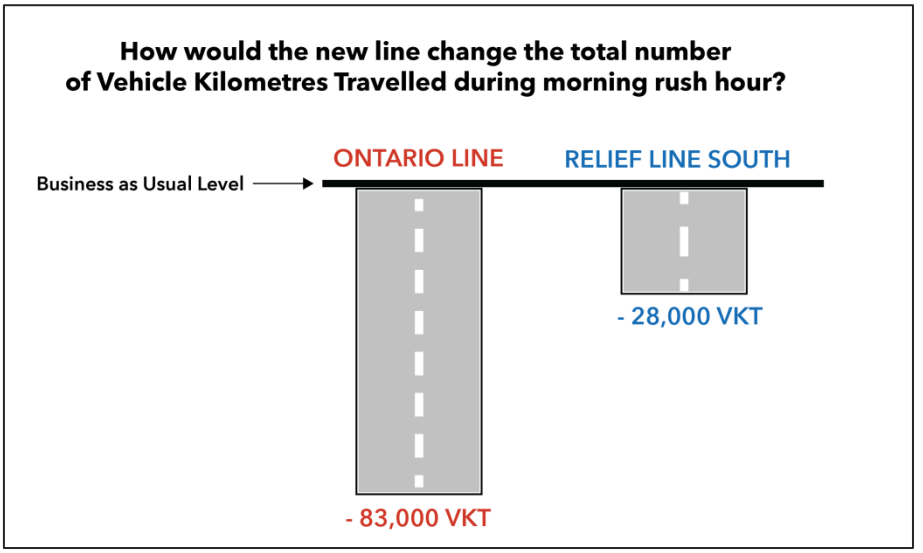


Figure 23: Change in Vehicle Kilometres Travelled in Toronto during morning peak hour, compared to BAU. Source: GGHm v4 outputs.

Business As Usual, with Ontario Line achieving a more significant decrease than the Relief Line South (Figure 23).

Relief Line South and Ontario Line would also benefit auto users by reducing road congestion. Travel demand modelling etimates that,with the Ontario Line in place, the number of kilometres spent driving in congested conditions[20] will decrease by 1.7% compared to BAU. Relief Line South is expected to result in a 0.6% decrease.

Table 18: "Move People with Less Energy and Pollution" Summary

Criteria	Relief Line South	Ontario Line
How will the option affect traffic congestion in Toronto?* *reduction in number of Vehicle-Kilometres Travelled in congested conditions during morning peak hour. Source: GGHm v4 outputs; GHG Accounting Tool (Metrolinx/UofT).	- 0.6% compared to BAU	- 1.7% compared to BAU
What impact will the option have on taking cars off the road?* *reduction in total Vehicle Kilometres Travelled during morning peak hour in Toronto. Source: GGHm v4 outputs.	- 28,000 km compared to BAU	- 83,000 km compared to BAU
What will the energy impacts of the new line be?	Electric Rail. Same levels as ATC TTC subways.	Electrical Rail. Lower levels, due to lighter fleet and infrastructure and higher grade of automation.
How many more people will use transit during the morning peak hour compared to BAU?* * Source: GGHm v4 outputs.	10,000 net new transit riders	18,000 net new transit riders

[20] Road congestion is defined here as a situation where road usage is at or over 90% of the road's maximum capacity.

OUTCOME 3: SUSTAINABLE AND HEALTHY COMMUNITIES

BENEFIT 8: Improve Quality of Life and Public Health

The new investment should reduce negative impacts to health and create appropriate conditions for healthy habits as compared to Business As Usual. Building transit close to people and jobs encourages transit usage, as well as walking as an access mode, rather than driving. A shift in travel mode to active transportation or transit reduces the amount of transportation-related Greenhouse Gases (GHG) emissions that have a detrimental impact to public health. Such a shift has the added social benefit of increasing physical activity among the population with a positive effect on general health. Travel demand projections show that building Relief Line South could result in a 2.6% yearly decrease in auto-generated GHG emissions, compared to BAU, while Ontario Line could generate a 3.2% decrease in emissions.

Beyond healthy commuting practices, new rapid transit can be leveraged to encourage the development of more active and healthy commuting options. Walking and cycling activity is highly dependent on convenience, density, built form and supportive infrastructure.

Ontario Line, by increasing transit service at Exhibition/Ontario Place, areas that have had increasing surrounding intensification pressures, supports this trend, as does the extension of the line to Thorncliffe Park and Flemingdon Park. The introduction of rapid transit provides the opportunity to develop active transportation infrastructure for access in areas that are currently auto-centered.
Relief Line South travels through areas served by streetcars, meaning they already benefit from active transportation supportive infrastructure. The addition of a subway line in these areas could reinforce the use of active modes for access.

Where impacts to the natural and built environment are concerned, a tunneled alignment, such as that proposed by Relief Line South, avoids major impacts to communities, fauna and flora. However, because of the type of soil, tunnelling under the Don Valley along Eastern Avenue would likely require some form of ground treatment to be undertaken, as described in the Relief Line South Environmental Project Report. Additionally, fire regulations require emergency egress in the form of emergency exit buildings at prescribed intervals along underground guideways, which increases the temporary and permanent footprint of a tunneled alignment.
The Ontario Line's bridges over the Don Valley at Eastern Avenue, Millwood Road and Overlea Boulevard, as well as the elevated viaduct sections through the proposed East Harbour, Thorncliffe Park and Flemingdon Park present a greater potential for disruption to the natural environment and communities. Piers are required to support the bridge structures which will result in the permanent displacement of natural features. Additionally, elevated guideways expose the trains to the open air, increasing potential for additional noise and vibration impacts for residents and other sensitive receptors (film studios, hospitals, concert halls, etc.) due to frequent train passage.
Yet, the elevated/at-grade sections would represent between six and seven kilometres out of the total

alignment (under half). South of the Millwood Bridge crossing, elevated/surface tracks are proposed to be located within the existing GO Rail corridor, expanding it rather than requiring the building of brand new infrastructure. Along Millwood Road, as well as sections of Overlea Boulevard and Don Mills Avenue, preserving the natural environment whilst building a bridge over the Don Valley and an elevated guideway will prove more challenging.

The Bentway Park in Toronto offers skating under the Gardiner Expressway in the winter. Source: TheBentway.ca

Underpass Park, under the Don Valley Parkway, is a community space for people of all ages. Source: ExploreWaterfrontToronto.ca

A number of mitigation strategies are available to eliminate or reduce impacts that will need to be identified in further environmental studies and assessed as part of future design development. For example, the number and spacing of bridge piers is highly dependent on the type of structure chosen, vehicle characteristics, and service frequency, and, on noise and vibration impacts. Mitigation strategies are available in systems, maintenance and track design to reduce or eliminate impacts. Additionally, to offset visual impact and footprint of the elevated structure, many design strategies can be leveraged to accommodate new community spaces and parks.

Table 19: "Improve Quality of Life and Public Health" Summary

Criteria	Relief Line South	Ontario Line
What is the option's impact on air quality and auto-related emissions?*	- 825,000 tonnes of auto-generated GHG emissions yearly (2.6% reduction) compared to BAU	- 1,012,000 tonnes of auto-generated GHG emissions yearly (3.2% reduction) compared to BAU
How does the option impact the public realm?	• Tunnelled alignment throughout the corridor minimizes impacts to the natural and built environment. • Tunnelling under the Don Valley would minimize impacts to the flood plain but would require ground treatment as determined in Relief Line South Environmental Project Report.	• Tunnelled alignment along 9 kilometres in built-up presents minimal challenges and impacts to public realm. • Elevated/At-Grade alignment along 6-7km has a higher potential for disruption to the natural environment and quality of life (noise, vibration, visual impact).
How do the options support the development of walkable communities?	Relief Line South serves walkable streetcar-oriented areas and can reinforce active transportation as a mode and supportive infrastructure.	Ontario Line also brings rapid transit to dense and/or intensifying auto-centered areas, thus encouraging active modes for access.

Strategic Case Summary

Table 20: Summarizing the Strategic Case

OUTCOME	OBJECTIVE	RELIEF LINE SOUTH	ONTARIO LINE
Strong Connections	Improve access to transit	The line attracts ridership with 206,000 daily boardings and increases access with + 87,000 residents within a 10-minute walk of rapid transit compared to BAU.	The longer line is able to attract 389,000 daily riders and grants walking access to rapid transit to + 154,000 people compared to BAU
	Increase access to economic opportunities	The line's strength is its ability to serve a considerable number of destinations and projected jobs (388,000 jobs within a 10-minute walk) while moderately increasing 45-minute transit access to employment opportunities by 25,000 for Toronto residents (26,000 for low-income residents)	The line is characterized by its significant improvement of access to employment opportunities for Toronto residents (+53,000 jobs within a 45-minute transit trip compared to BAU) and especially low-income residents (+66,000 jobs), although it only marginally increases the number of jobs (474,000) and destinations served by the line compared to Relief Line South. s
	Support a synergistic relationship between transit and city-building	The line serves Downtown Toronto and the Central Waterfront, which are planned to accommodate the largest part of future growth. Opportunities for TOD in station areas could lead to an additional 7,4000 daily passengers.	The line serves Downtown Toronto and the Central Waterfront while also increasing indirect access to Yonge-Eglinton. Opportunities for TOD at stations could lead to an additional 20,600 daily passengers.

	Improve travel time and reliability	The line delivers 212,000 person-minutes of time savings compared to BAU for morning rush transit trips in Toronto and lowers maximum demand on Line 1 Yonge to 36,000 pphpd this improving dwell times and operations.	By bringing rapid transit to currently underserved areas and delivering further travel time reductions for more transit riders, the line generates 355,000 person-minutes of travel time savings compared to BAU. It also contributes to an improvement in operations for Line 1 by lowering maximum demand below the line's maximum capacity, to 33,000pphpd.
Complete Travel Experiences	Improve comfort and safety	Compared to BAU, the line noticeably relieves crowding on Line 2 (-16% demand) and at Bloor-Yonge Station (-12% usage) thanks to its Pape Station interchange, and provides moderate relief to Line 1 Yonge (-7% demand) and passenger congestion on the transit network (-45,000 person-minutes)	Thanks to its western and northern extensions, the line provides significant relief to all constrained points on the rapid transit network (-13% usage at Union Station; -15% at Eglinton Station) beyond Line 2 (-22% demand) and Line 1 (-14%). This enables the line to reduce passenger congestion on the transit network by 182,000 person-minutes.
	Build an integrated transportation network	The option is well connected to the surface and rapid transit networks, providing interchanges with 2 subway lines and 2 GO Rail lines, though the depth of its tunnels in certain areas creates challenges to passenger transfers.	The option provides connections with 6 rapid transit lines (including 3 GO Rail lines) at 8 interchange stations and is well integrated with the surface network. Its elevated alignment in some areas allows for short passenger transfers, including

			cross-platform interchanges at 2 stations.
Sustainable and Healthy Communities	Move people with less energy	The option generates positive changes to transportation patterns, compared to BAU, with a 28,000km reduction in peak hour VKT in Toronto and 10,000 net new transit riders. The line itself limits energy spent per train through the use of semi-automatic and electric rail technologies.	The option provides an alternative to more, longer auto trips, generating an 83,000km decrease in peak hour VKT in Toronto, and attracting 18,000 net new riders to transit, compared to BAU. The use of a lighter fleet and fully automated and electric rail technologies allows for significant reduction in energy spent per train.
	Improve quality of life and public health	The option reduces auto-generated GHG emissions by a considerable 825,000 tonnes yearly (-2.6% compared to BAU). By offering more transit in transit-oriented areas, the option reinforces active habits, while its tunneled alignment minimizes impact to the natural and built environment.	The option delivers a significant 1,012,000 tonne reduction in yearly auto-generated GHG emissions yearly (- 3.2% compared to BAU). The introduction of rapid transit to auto-oriented areas encourages healthier transportation habits. Its 7km elevated/at-grade alignment has a potential for disruption, which will require mitigation through design.

5

Economic Case

Infrastructure ONTARIO

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Introduction and Assumptions

The Economic Case is one of two chapters focused on the rationale for pursuing an investment (the other being the Strategic Case). While the Strategic Case evaluates options based on a project specific policy/plan oriented evaluation framework, the Economic Case determines if the expected benefits of this investment exceed the costs required to deliver it, and articulates the overall benefit to society of pursuing each investment option.

This analysis considers the magnitude of costs and benefits for a 60-year lifecycle (the evaluation period) as well as:

- Benefit Cost Ratio (BCR) – the net benefits divided by the net costs, which is used to indicate benefits that are realized per dollar spent
- Net Present Value (NPV) – the net benefits minus net costs, which is used to indicate total net benefits to the region

Assumptions set out in Table 21 are provided by the Metrolinx Business Case Guidance.

Table 21: Economic Case Assumptions

Input	Impact Type
Analysis Approach	All benefits/costs are expressed in real terms in 2019$. Appraisal begins in 2019. It includes seven years of construction (2022-2028), with an opening year of 2029 and 60 years of operation (2029-2089) for Relief Line South and six years of construction (2022-2027), with an opening year of 2028, and 60 years of operation (2028-2088) for Ontario Line.
Evaluation Period	60 years
Economic Discount Rate	3.5%
Real Inflation	0%
Value of Time (VoT) (2017$)	$18.06/hour
VoT Growth Rate	0%
Auto Occupancy	1.077
Auto Operating Cost Savings (2019$)	Total operating cost: $0.66/km Marginal operating cost: $0.09/km
Decongestion Benefit (2019$)	0.01 hours/vehicle-km (peak) 0.0013 hours/vehicle-km (off-peak)
Safety Improvements (Accident Mitigation) (2019$)	$0.10/km
GHG Value	$0.011/km

Other assumptions:

- Property costs do not require rehabilitation
- Fleet costs have been scaled based upon line and train lengths
- Fleet cost growth per year is 1% Real (same as construction)

- Rehabilitation and refurbishment are assumed to continue for the full 60 year evaluation period, but no Terminal Value is assumed
- Transit-Oriented Development is not reflected in the costs or benefits

Costs

Table 22 provides a summary of capital and operating costs estimated for this IBC.

Table 22: Summarizing Economic Costs

Cost Category ($ 2019 Net Present Value)		Relief Line South	Ontario Line
Capital Costs	Infrastructure	$4,977.1 M to $5,972.2 M	$7,068.9 M to $8,482.2 M
	Fleet	$427.6 M to $512.0 M	$769.7 M to $923.7 M
	Rehab	$510.3 M to $612.3 M	$724.7 M to $869.6 M
Capital Cost Total*		$5,915.0 M to $7,096.5 M	$8,520.8 M to $10,232.9 M
Operating and Maintenance Costs		$2,126.5 M	$1,851.0 M
Total Present Value of Costs*		$8,041.5 M to $9,223.0 M	$10,371.8 M to $12,083.9 M
Total Present Value of Costs Adjusted for P3 Delivery		N/A	$9,592.4 M to $10,213.5 M

* Cost estimates reflect a range representing median to high forecasts to account for optimism bias at the early stages of project design

User Impacts

User Impacts are a key area of analysis for transport investments. They capture how the investment will improve the welfare of transport network users or travellers. This includes both travellers who will and will not make use of the Ontario Line since both groups benefit from travellers switching to transit from other modes.

The Ontario Line and Relief Line South change the cost of travel to three main groups:

- Existing Subway Passengers – Investment in subway expansion will reduce the generalized cost of travel below the current cost of travel for by expanding the subway network and providing new subway routes through Toronto. This investment will provide a direct benefit to users both of the existing subway as well as bus and streetcar users who have new opportunities to shift their journeys from buses or streetcars to frequent, reliable, grade-separated rapid transit.
- New Subway Passengers – The subway investment will reduce the generalized cost of travel on transit. This will attract new transit users tthat used to travel via other modes. These new users will receive a benefit equal to the difference in what they were willing to pay and the new generalized cost of travel on the new subway.
- Auto Users – Investment in new subway infrastructure will attract some auto users off of local roads. This leads to decongestion of said roads which in turn reduces the travel time and operating cost for travellers who remain on the auto network.

All user impacts included in this analysis are 'net impacts' across the investment; a sum of benefits and disbenefits.

Table 23 provides a summary of benefits to users of the transportation and transit network.

Table 23: Communicating Present Value of User Benefits

User Type	Impact Type ($2019, NPV)	Relief Line South	Ontario Line
Transit	Travel Time Benefits	$2,614.4 M	$4,396.1 M
	Crowding Benefits	$550.8 M	$2,253.0 M
Automobile[21]*	Congestion Reduction	$137.2 M	$402.5 M
	Operating Cost Reduction	$86.5 M	$253.6 M

[21] A single congestion impact can be portrayed for projects that do not estimate auto user impacts by impact type.

External Impacts

Every auto trip taken can contribute negative impacts to society through emissions that pollute the air or injuries and deaths that can occur from collisions. These impacts are called external impacts, or the 'social cost of transport.' Transportation investments are an opportunity to reduce these social costs by improving the economic efficiency of the transportation system, meaning less impact for the same amount of travel (measured in impacts per passenger kilometre).

For instance, motorists switching to transit decreases the number of trips on the GTHA's road network. This will lead to fewer collisions and emissions, making the GTHA's transportation network safer and healthier and contributing to the Province's greenhouse gas emissions reduction targets.

External impacts are estimated through the mode changes generated by the proposed investment. If travellers move from a less efficient mode to subway then there is an impact equivalent to the externalities per trip on the new subway, minus the externalities on their previously used mode. These benefits are calculated based on the change in automobile Vehicle Kilometres Travelled (VKT).

Table 24 provides a summary of benefits to broader society, beyond users of the transportation and transit network.

Table 24: Communicating Present Value of External Impacts

Impact Type	Impact ($2019, NPV)	Relief Line South (Present year $)	Ontario Line (Present year $)
Health and Safety	Collision Reduction	$27.1 M	$79.3 M
Environment	Greenhouse gases	$9.6 M	$28.2 M

Economic Case Summary

Table 25: Summarizing the Economic Case

Impact Type	Relief Line South	Ontario Line
Capital Costs ($ 2019 Net Present Value)	$5,915.0 M to $7,096.5 M	$8,520.8 M to $10,232.9 M
Operating and Maintenance Costs ($ 2019 Net Present Value)	$2,126.5 M	$1,851.0 M
Total Costs ($ 2019 Net Present Value)	$8,041.5 M to $9,223.0 M	$10,371.8 M to $12,083.9 M
Total Benefits ($ 2019 Net Present Value)	$3,425.6 M	$7,412.7 M
Fare Revenue Adjustment ($ 2019 Net Present Value)	$992.7 M	$1,760.9 M
Benefit-Cost Ratio (BCR)	**0.48 - 0.55**	**0.76 - 0.88**
Net Present Value (NPV) ($ 2019)	**$-4,804.7 M to $-3,623.2 M**	**$-2,910.3 M to $-1,198.2 M**
Benefit-Cost Ratio (BCR) Adjusted for P3 Delivery	**N/A**	**0.90 - 0.96**
Net Present Value (NPV) ($ 2019) Adjusted for P3 Delivery	**N/A**	**$-1,040. M to $-418.9 M**

Sensitivity Tests

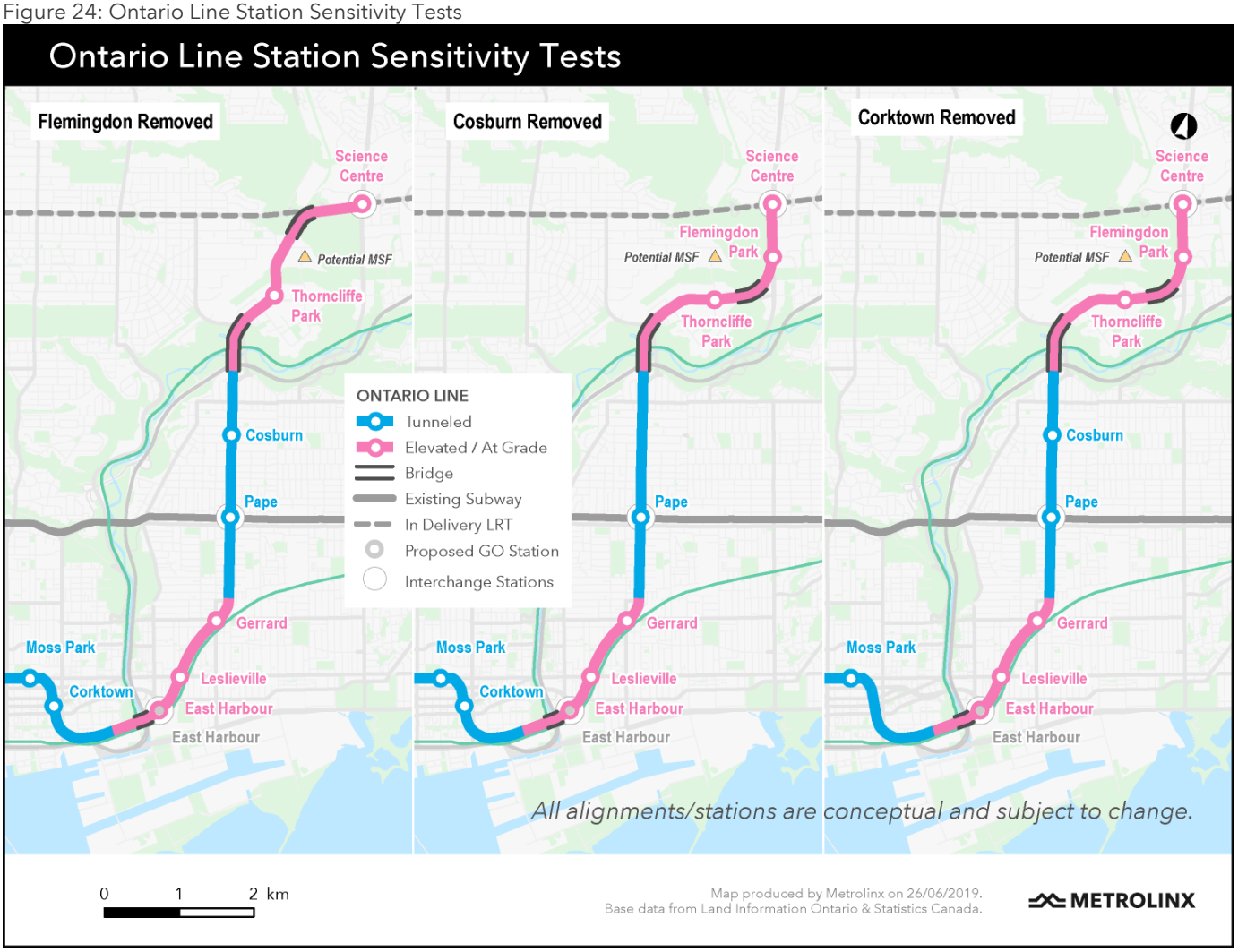
Sensitivity tests vary assumptions input into the model in order to identify key variables that would cause the economic performance or the BCR or NPV calculations to change enough to affect a decisionmakers' preferred option.

Station Sensitivity Tests

Sensitivity tests were run on three alternative Ontario Line scenarios:

- Ontario Line without a station at Cosburn (no change in alignment)
- Ontario Line without a station at Flemingdon Park (change in alignment described on page 33)
- Ontario Line without at Corktown Station (no change in alignment)

Figure 24: Ontario Line Station Sensitivity Tests



Each scenario generates an overall cost reduction of $ 300 to 500 million for the Ontario Line, due mostly to decreases in infrastructure, fleet and operating costs. Yet, the removal of Flemingdon Park station,Coburn Station or Corktown Station induces a significant reduction in benefits delivered. Though ridership modelling suggests that removing stations does not substantially reduce the number of passengers on Ontario Line as people re-allocate to adjacent stations, travel time savings are diminished because people have longer access times to the subway.

The Benefit-Cost Ratios (BCR) for the 3 station sensitivity scenarios remain higher than Relief Line South's BCR but are generally lower than the Ontario Line's BCR (see Table 25).

Table 26: Summarizing the Station Sensitivity Tests on the Economic Case

Impact Type	**Ontario Line without Cosburn Station**	**Ontario Line without Flemingdon Park Station**	**Ontario Line without Corktown Station**
Total Costs ($2019, Net Present Value)	$10,093.9 M to $11,764.5 M	$10,180.9 M to $11,862.1 M	$10,057.2 M to $11,720.1 M
Total Benefits ($2019, Net Present Value)	$6,787.8 M	$6,464.6 M	$6,475.7 M
Fare Revenue Adjustment ($2019, Net Present Value)	$1,753.9 M	$1,834.6 M	$1,726.4 M
Benefit-Cost Ratio (BCR)	**0.73 to 0.85**	**0.70 to 0.82**	**0.70 to 0.82**
NPV (Present Year $)	**$-3,222.9M to $-1,552.3 M**	**$-3,563.0 to $-1,881.7 M**	**$-3,518.0 M to $-1,855.1 M**
Benefit-Cost Ratio (BCR) Adjusted for P3 Delivery	**0.86 to 0.92**	**0.83 to 0.88**	**0.83 to 0.88**
Net Present Value (NPV) (Present Year $) Adjusted for P3 Delivery	**$-1,396.6 M to $-791.4 M**	**$-1,724.1 M to $-1,115.6 M**	**$-1,700.6 M to $-1,097.9 M**

Sensitivity Tests on Economic Parameters

The values of key economic parameters were varied to determine how the options would performance under different circumstances. These parameters are defined in Table 27. See Table 28 for test results.

Table 27: Defining the Economic Parameters Used in Sensitivity Tests

Parametre	Purpose
Value of Time Growth Rate	A parameter used to escalate the Value of Time across the investment lifecycle. Value of Time is a factor used to monetize changes in generalized time to determine the overall welfare benefit to transport network users.
Economic Discount Rate	Over time, the value of a cost or benefit will decrease – as a result, an economic discount rate is applied. The economic discount rate reflects society's time preference for money.
Ridership Growth Rate	A parameter used to escalate ridership throughout the investment lifecycle.
Operating Cost Growth Rate	A parameter used to escalate operating costs throughout the investment lifecycle.

Table 28: Summarizing the Economic Parameters Sensitivity Tests on the Benefit-Cost Ratio

Sensitivity Test		Benefit-Cost Ratio	
Parameter	**Value**	**Relief Line South**	**Ontario Line**
Value of Time Growth Rate	0.70%	0.56 to 0.64	0.87 to 1.01
Economic Discount Rate	2.50%	0.56 to 0.64	0.91 to 1.05
Ridership Growth Rate	1%	0.47 to 0.54	0.75 to 0.88
	3%	0.49 to 0.56	0.77 to 0.9
Operating Cost Growth Rate	0%	0.52 to 0.61	0.8 to 0.94
	3%	0.45 to 0.51	0.73 to 0.85

6
Financial Case

Infrastructure ONTARIO

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Introduction

The Financial Case assesses the overall financial impact of proposed investment options. While the Strategic Case and Economic Case outline how an investment achieves organizational goals and social value, the Financial Case is one of two cases (the other being the Deliverability and Operations Case) that focuses on the requirements to successfully deliver an investment. This includes a review of total revenue (fares) gained and expenditures (capital, operating and maintenance) required over the lifecycle of the investment incremental to the base case scenario. The Financial Case is agnostic with regard to procurement and delivery method but cost estimates are prepared based on a traditional design-bid-build approach.

Assumptions

Table 29 sets out the assumptions used in this Financial Case.

Table 29: Financial Case Assumptions

Parameter	Value
Discount Rate	5.5% (nominal)
Inflation Rate	2%

Capital Costs

The capital cost of building and delivering the proposed investment options forms the largest component of overall project costs. Estimates of probable capital costs were estimated in 2019$ (see Table 30). They include an allowance for property acquisition, as well as a professional services allowance to account for the completion of designs, procurement activities and support activities during construction. Cost estimates were prepared on a top-down, factor-based parametric approach and should be considered Class 5 estimates.

All cost estimates reflect 30% contingency to cover unknown risk events. The high end of the cost estimates also include an average of 20% uplift to individual cost items in order to balance optimism bias. Optimism bias is the tendency of individuals to expect better than average outcomes. In the context of infrastructure projects, optimism bias can lead to understimation of costs and project duration. An estimate of potential cost savings achievable through P3 delivery are also presented for Ontario Line, which was designed to allow for a range of procurement and delivery options. The cost savings associated with P3 delivery are

estimated at 10-20% of relevant project costs. Because Relief Line South was designed for traditional delivery, that variation is not presented.

Capital cost estimates were all developed by Turner & Townsend, a global consultancy with expertise in cost forecasting under contract to Infrastructure Ontario. Relief Line South costs were based on 15% designs provided by the TTC while Ontario Line costs were developed based on conceptual alignments.

Table 30: Capital Cost Summary in Financial Terms

Item ($ 2019)	Relief Line South		Ontario Line	
	Median Estimate	High Estimate	Median Estimate	High Estimate
Capital Cost Elements	$5,049 M	$6,059 M	$7,207 M	$8,649 M
Property Acquisition	$347 M	$417 M	$1,016 M	$1,220 M
Professional Services	$844 M	$1,013 M	$1,281 M	$1,537 M
Total Capital Costs	$6,241 M	$7,489 M	$9,504 M	$11,405 M

In financial cost, the Relief Line South investment would result in the lowest capital costs. Ontario Line costs vary based on length. However, Relief Line South costs are approximately 35% higher than Ontario Line costs on a per-kilometre basis (see Table 31).

Table 31: Capital Cost per Kilometre

Item	Relief Line South	Ontario Line
Length (km)	7.5	15.5
Cost per km	$832 M to $999 M	$613 M to $735 M

Other capital cost estimation assumptions include:

- Ontario Line is a mix of below-grade, at-grade and elevated guideway
- Tunnelling and underground stations are assumed to be built with a mix of tunnel-boring machine, cut and cover, and mining, depending on location.
- Underground stations are assumed to have platform, concourse and street levels, and a minimum of two entrances.
- Platform edge doors are provided.
- A maintenance and storage facility is included to accommodate up to 120 vehicles.

Ontario Line costs were benchmarked against other recent projects and are in line with incurred costs on Eglinton Crosstown LRT and Toronto-York-Spadina Subway Extension (TYSSE).

Table 32: Captital Cost Estimates by Element[22]

Item ($2019)	**Relief Line South**		**Ontario Line**	
	Median Estimate	High Estimate	Median Estimate	High Estimate
Track and Guideway	$1,267 M	$1,521 M	$1,827 M	$2,193 M
Stations	$1,742 M	$2,091 M	$1,738 M	$2,086 M
Maintenance and Storage Facility	$90 M	$108 M	$250 M	$300 M
Sitework	$81 M	$97 M	$446 M	$535 M
Systems	$195 M	$233 M	$501 M	$601 M
Vehicles	$309 M	$370 M	$556 M	$667 M
Property Acquisition	$347 M	$417 M	$1,016 M	$1,220 M
Professional Services	$844 M	$1,013 M	$1,281 M	$1,537 M
Contingency	$1,415 M	$1,698 M	$1,921 M	$2,305 M

[22] These cost estimates were prepared by Turner & Townsend. They have been adapted to Net Present Value in the Economic Case.

Item ($2019)	Relief Line South		Ontario Line	
Non-recoverable HST	$108 M	$130 M	$164 M	$197 M
Total Capital Costs	$6,241 M	$7,489 M	$9,504 M	$11,405 M
Total Capital Costs , Adjusted for P3 Delivery	N/A	N/A	$8,711 M	$10,453 M

Operating and Maintenance Costs

The operation and maintenance of a new subway will bring additional project costs, over the entire operational lifecycle of the investment. Operating and maintenance costs cover all aspects of the new subway including staffing, vehicle, track and station maintenance, power, and savings from reduced bus and streetcar costs. Further work will be required in the Preliminary Design phase to refine assumptions based on complexity of station layouts and better understanding of changes to the bus and streetcar network.

Table 33: Operating and Maintenance Costs in Financial Terms

Lifecycle Cost Line Item (NPV, $2019)	Relief Line South	Ontario Line
Project Operating Costs	$2,170.3 M	$ 2,463 M
Bus and Streetcar Operating Costs		-$562 M

Table 34: Revenue Impacts (Lifecycle NPV)

	Relief Line South	Ontario Line
Incremental Project Revenue ($2019, NPV)	$1,013.1 M	$1,797.2 M

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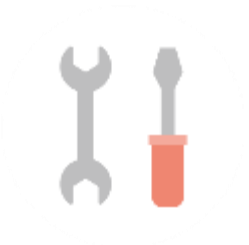
Deliverability and Operations Case



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Introduction

The Deliverability and Operations Case is an analysis of investment delivery, operations and maintenance, service plans and any other issues that may prevent the realization of an option. This includes delivering the project from original concept through to planning, design, environmental assessment, stakeholder engagement, procurement, construction and operations. The Deliverability and Operations Case is one of two cases (the other being the Financial Case) focused on requirements for delivering the investment.

Project Delivery

How advanced are the designs for Relief Line South and Ontario Line?

Both the Ontario Line and Relief Line South options build on work undertaken from 2013 to date to advance the project towards execution readiness. The Relief Line South project scope emerged out of a three-stage process.

The Relief Line Project Assessment (RLPA) was led by the City of Toronto and used extensive public engagement to establish station locations, preferred corridor, and finally a preferred alignment. Relief Line South design choices were shaped in the Relief Line Project Assessment's initial phases from 2014 to 2016 by the City of Toronto's Rapid Transit Evaluation Framework (RTEF). That process included an added phase of analysis and public consultation on using Carlaw versus Pape as the preferred alignment. City of Toronto completed an Initial Business Case in June 2016, although the document was not used to iterate design choices prior to the selection of a preferred configuration for advancing through the Transit Project Assessment Process (TPAP).

The Relief Line South Environmental Assessment (the study advanced through the TPAP) was a co-proponancy between City of Toronto, TTC, and Metrolinx. Approval was granted in October 2018. In keeping with typical practice for transit projects of this nature, the project was screened through the TPAP at a very early level of preliminary design, which were shared with the public at a series of public open houses. Subsequent to the TPAP Notice of Completion, the TTC, in partnership with Toronto and Metrolinx, procured design consultants to iterate the design work. The 15% design submission introduced adjustments to the EA scope to improve constructability. Some design changes were identified as necessitating an Addendum to the existing approved Environmental Project Report (EPR).

For segments of the Ontario Line that overlap with Relief Line South, analysis and design work will be valuable and the knowledge developed over time invested in the project will be applied to Ontario Line.

For the western section of Ontario Line, alignment selection, environmental approval and design work is required. The first step of that analysis can be found in this IBC.

For the northern section of Ontario Line (Pape Station to Ontario Science Centre), analysis through the in-flight Relief Line North Project Assessment has been used. Environmental approval and design work will be required. This IBC provides further analysis of the northern segment of Ontario Line. Ontario Line will also require further public and stakeholder engagement.

How could the projects be procured and delivered?

The Relief Line South is conceived of as a fully compatible expansion of the existing subway network; it would build on current system assets, including for vehicle maintenance, and be designed to existing standards. This premise introduces limitations in the range of available viable options for procurement and delivery methodology and interface risks.

Ontario Line has been developed with the potential to be a freestanding line from a systems and standards perspective, but still fully integrated and seamless from a customer perspective. This opens up new options in how it could be delivered, including consideration for a public-private partnership (P3) model like design-build-finance-maintain (DBFM).

The DBFM model is a form of P3 which is a long-term contract between a private party and a government entity, for providing a public asset and service, in which the private party bears significant risk and management responsibility with remuneration linked to availability and performance based incentives. There are five major mechanisms that drive the P3 value proposition:

1. **Fixed Price, Performance-Based Contracts** seek to protect the public from construction cost overruns and ensure that private partners execute on their contractual obligations; poor asset/service performance results in monetary deductions to the private partners.
2. **Optimal Risk Allocation** allocates risk based on the premise that the party which is best able to manage a given risk most efficiently, should assume that risk.
3. **Integration** of design, construction, and maintenance to enhance performance and residual asset value and performance resulting in savings associated with increased levels of competition and other efficiencies afforded through the private sector.
4. **Private Financing** provides access to capital and financing, and imposes the discipline of the market and an additional layer of oversight on the project.

5. **Innovation** The P3 model promotes private sector design innovation. The technical specifications are written as performance based, focused on customer experiences and technical outcomes. By relaxing specific constraints, the private sector can optimize its solution from a cost and deliverability perspective.

Through these mechanisms, the public sector is able to realize the benefits of the private partnership while retaining public control and ownership of the infrastructure being built and the functions it provides.

Are there any major constructability issues?

Relief Line South

- The Mid-Toronto Interceptor (MTI), a 3m diameter combined sewer along Gerrard St, requires careful coordination. The rail at Gerrard Station has been driven down to a depth of approximately 30m at the primary entrance and 38m at the secondary entrance (difference due to a slope at surface northward) in order to avoid the MTI.
- Questions remain as to whether some stations should be built using cut and cover or mined methods, and whether the alignment should follow streets or deviate so stations can be built in open-cut outside of the public right-of-way.
- Use of the Greenwood Yard for train maintenance will require various changes to Line 2 operations, a wye connection structure north of Pape Station, an additional tunnel connection directly to the yard.
- The proposed worksite for all tunnel boring launches are at the East Harbour site, in land vulnerable to flooding and potentially contaminated.
- The proposed tunnel boring machine extraction shafts downtown and near Pape Station are located in tight urban areas and may provide a number of challenges, which may result in the need to abandon components of the TBMs below grade.

Ontario Line

- The utilization of GO corridors will provide coordination challenges with both GO operations and expansion activities along both Lakeshore West and East rail corridors.
- The complexity of activities surrounding the Lower Don crossing – including Gardiner reconstruction and flood mitigation – require further study and careful coordination.
- The northern crossing of the Don River at Overlea Boulevard requires substantial further work in order to ensure that a new structure minimizes impacts on the natural environment and fits into the neighbourhood character.

- The western segment of Ontario Line (Osgoode Station to Exhibition) also requires further design work to identify a feasible alignment that conforms with existing strucures and provides an optimal interface with Exhibition GO. Additionally, impacts to the TTC's streetcar loops at Exhibition and Dufferin Gate need further study.
- Tunnel boring machine launch sites need to be identified.

How do the options compare with regard to delivery timelines?

Figure 25 shows the delivery timelines for both options andis subject to change and refinement.

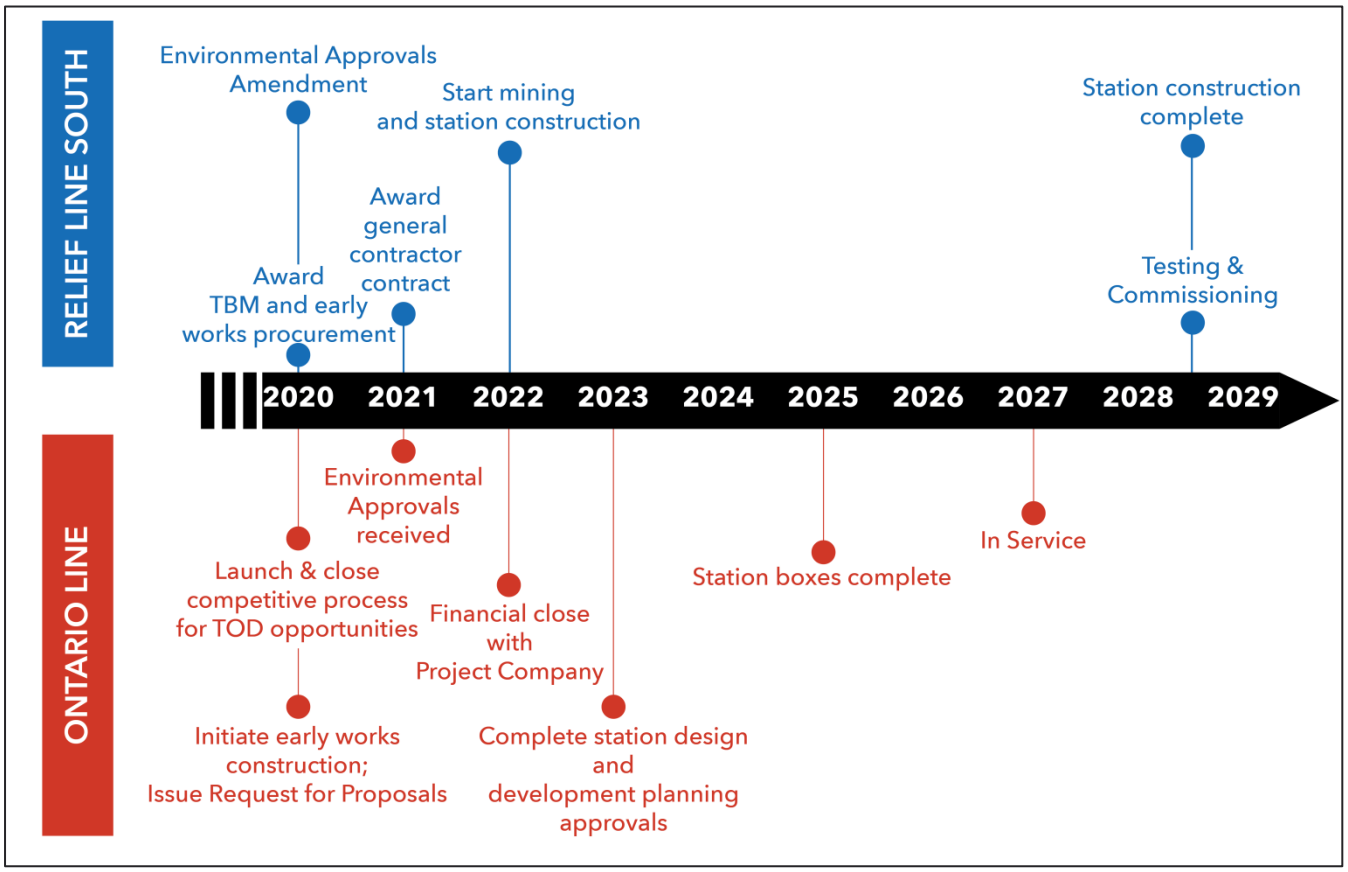

Figure 25: Comparison of Estimated Delivery Timelines

What are the major design and operational trade-offs?

Relief Line South

- Designing Relief Line South as an extension of the existing subway network locks in decisions regarding fleet and systems. Using compatible TTC subway fleet precludes possibility of steeper grades and tighter curves, possibilities which open up additional design options.

- Because TTC uses a bespoke gauge, trains need to be procured specially and modern, standard vehicles are not an option. This has the potential to drive up project costs.
- Using compatible TTC fleet also enables use of TTC yards and allows for the possibility of flexible operation between lines. Expansion of yard capacity, which may not be required for Relief Line South opening day but would likely be required in the future, is more complex than a dedicated yard for Ontario Line would be.

Ontario Line

- The above-grade sections of Ontario Line allow for less expensive and faster construction but may introduce additional maintenance challenges as well as winter-weather related issues that will require mitigation.
- Steeper grades and tighter curves enable additional design choices but their use will limit travel speed. Trade-offs can be assessed quantitatively, as design progresses.
- Lighter and potentially smaller fleet will be sized appropriately to meet demand but may allow for less passenger growth in the very long-term. This can be addressed by overall system expansion.
- Assuming a standalone line allows for use of standard gauge and procurement of modern standard vehicles which contains costs, but these vehicles are not inter-operable with the rest of the TTC subway system.