



VIVA BENEFITS CASE

November 2008





VIVANext Benefits Case

Final Report

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EXECUTIVE SUMMARY

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

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

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

This Benefits Case report is about the VIVANext ("VIVA") project in York Region which is one of the rapid transit projects announced by the Premier as part of *MoveOntario 2020* and identified in the RTP as a BRT / LRT project.

York Region is one of the fastest growing areas within the GTHA and has grown rapidly from a predominantly rural and agricultural area to an urban and employment centre. It is expected that the rapid population and employment growth will continue for the next 25 years. The strong growth is expected to generate some 50% more traffic on the region's roadways over the next 25 years and will add to congestion, particularly in the peak periods. Travel patterns are also changing and more commuters are travelling to York Region due to increasing employment.

York Region VIVA system opened in 2005 and currently consists of 90 clearly branded and mostly articulated buses, which run in mixed traffic. The existing VIVA system has been implemented as a precursor to the VIVANext - a BRT system where the main focus is on building completely segregated bus lanes with signal priority that would improve run times and service reliability, by giving buses exclusive use of bus lanes.

By building VIVANext York Region is seeking to address the following objectives:

- I Manage congestion in a rapidly growing community by increasing transit ridership and modal share. The existing mode share is less than 10% of all peak period trips in the region. York Region's goal is to increase the mode share to 33% within the Urban Growth Centres and 22% on a region-wide basis.
- I Improve mobility within York Region as well as between neighbouring communities and improve inter-modal connectivity and system-wide integration. Specifically, improve

connectivity to local bus services, GO Transit commuter rail and express buses and to the TTC subway system.

- I Promote mixed land use development, increase density and prevent urban sprawl by supporting intensification of land uses and encourage transit-oriented development along rapid transit corridors.

With the expected growth in York Region the existing VIVA system, comprised of buses operating in mixed traffic, will become inadequate in terms of capacity and reliability in a number of corridors, particularly in the 'core' of the network between Finch and 19th Avenue on Yonge Street and east and west of Richmond Hill Centre along Highway 7.

In collaboration with York Region and Metrolinx, two options for VIVANext have been identified:

Option 1

This option contemplates a full build-out of Rapidways (segregated and dedicated lanes for buses) by 2018 on all segments.

The frequency of service is assumed to be between 2 and 5 minutes in peak periods. Based on this range of service frequencies, capacity will be between 1,080-2,700 passengers per hour per direction. A total of 197 buses will be required in 2021.

The capital cost for this option is estimated at \$2.3 billion in 2008 "as-spent" dollars.

Option 2

This option is a phased approach which would ultimately see the full build-out similar to Option 1, but completed at a later date. The following four sections would be deferred:

- I Section Y3 - Yonge Street between 19th Avenue to Mulock Drive
- I Section H1 - Hwy 7: Hwy 50, east of Pine Valley in Vaughan
- I Section H4 - Hwy 7: Kennedy Road to Cornell
- I Section G1 - Green Lane in Newmarket

The deferral of these segments would result in approximately 40% of the capital costs being deferred, resulting in approximately \$1.3 billion in 2008 "as-spent" dollars for a phase I VIVANext program. The remainder of the program is assumed to be constructed by 2026, in line with the assumed service commencement date for those later sections.

Table A summarizes the Base Case and the two options that are evaluated in this Benefits Case. To illustrate the effect of deferring the sections outlined above, it is assumed in this analysis that all sections be completed by 2026. This is strictly an assumed date for the purpose of this comparative analysis.

TABLE A VIVA OPTIONS (OPENING YEAR IN BRACKETS)

Section	Base Case	Option 1	Option 2
Y1	Subway (2016)	Subway (2016)	Subway (2016)
Y2	No change	Rapidway (2013)	Rapidway (2013)
Y3	No change	Rapidway (2013)*	Rapidway (2013/2026)**
H1	No change	Rapidway (2018)*	Rapidway (2026)
H2	No change	Rapidway (2013)	Rapidway (2013)
H3	No change	Rapidway (2013)	Rapidway (2013)
H4	No change	Rapidway (2018)*	Rapidway (2026)
D1	No change	Rapidway (2011)	Rapidway (2011)
G1	No change	Rapidway (2018)*	Rapidway (2026)

* Between Mulock and Davis only, the remaining Y3 sections in 2018

** Between Mulock and Davis only, the remaining Y3 sections in 2026

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

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

The assessment is done by comparing each option to the Base Case and identifying any incremental costs or benefits that are generated by each option over a 30-year period (2009-2038). In order to compare the options on a “like-to-like” basis and to reflect time value of money the monetized values are discounted to today’s value at a real discount rate of 5%. These values, and other input variables used in this analysis are shown in Appendix A.

Table B summarizes the findings from the analysis.

TABLE B SUMMARY OF ASSESSMENT FOR VIVA OPTIONS

	Option 1	Option 2
Transportation User Benefits (NPV \$m)	1,560	1,530
Incremental Costs (NPV \$m)	(2,056)	(1,771)
Net Benefits (Cost)	(495)	(241)
Environmental Impacts		
Net GHG Reduction (NPV \$m)	1.9	1.7
Qualitative Impacts	Slight positive	Slight positive
Other Economic Impacts		
Construction impact	Positive and accelerated	Positive and partially delayed
Long-term impacts	Very positive	Very positive but delayed
Land value impact	Positive	Positive, but delayed in key sections
Social Community Impacts		
Land Shaping Potential	Positive	Positive, but delayed in some key sections
Health and Quality of Life	Neutral	Neutral
Traffic and Community Impacts	Positive	Positive, but delayed in some key sections

The analysis shows that the deferral of the outer segments - west of Vaughan Corporate Centre, east of Markham Centre and between 19th Ave and Mulock on Yonge Street - has a very limited effect on the transportation user benefits, but reduces the capital cost substantially. Option 2 has \$284 million lower cost but only \$30 million lower benefits compared to Option 1.

Even though Option 2 shows a higher net present value, the cost of building and operating the system outweighs the estimated transportation user benefits for both options. The negative net present value for Option 2 is \$241 million versus \$495 million for Option 1.

The negative net present value is balanced by the positive effects the project will have on the broader economic and social goals, such as employment, land values and land use shaping.

The VIVANext project and York Region's land use policies are closely aligned and it is expected that the project will have a major impact on accelerating intensification along the VIVANext

corridors. Many sections of the VIVANext corridors are heavily congested and additional transportation capacity (and therefore development) will only be feasible by increasing the efficiency of existing corridors, such as through VIVANext. From this perspective, Option 1 will have a more immediate and slightly larger effect than Option 2.

The project will also generate incremental employment in the York Region – some 18,900 person-years of employment during construction and approximately 830 jobs per year by 2031. Both options will ultimately have the same effect, but under Option 2 it will take longer to build the employment.

The results of the analysis are driven by the many assumptions made. To test the robustness of the assumptions and the conclusions a number of sensitivity analyses were conducted. Table C shows the reduction in capital costs, the value of time and the increase in travel time savings required for each of the options to break-even.

TABLE C SENSITIVITY ANALYSES

Discount Rate @ 5%	Option 1	Option 2
Reduction in Capital Costs	38%	19%
Value of Time (\$/hr)	17.35	15.25
Increase in Travel Time Savings (all users)	33%	16%

PART A PROJECT RATIONALE

Introduction

Purpose of Report

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

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

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

The VIVANext ("VIVA") project in York Region is one of the rapid transit projects announced by the Premier as part of *MoveOntario 2020* and identified in the RTP as a BRT / LRT project. The project involves the expansion and improvement of the existing VIVA system with the construction of dedicated and segregated busways "Rapidways" to improve travel time and service reliability.

Two options are being evaluated in this Benefits Case: Option 1 - a full build-out of the rapid bus network, and Option 2 - a phased build-out over a longer period. The two options are compared to the Base Case which is defined as the existing system ("business as usual"). The assessment of the options compares the relative strengths and weaknesses of each option on people, the economy and the environment against the cost of implementing the option. The objective of the assessment is to clearly outline the trade-offs among the criteria to enable decision makers to make an informed decision.

Report Structure

This report is structured in three parts:

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

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

Project Rationale

Context and Need

The *Growth Plan for the Greater Golden Horseshoe (2006)* which articulates the vision and goals of the *Places to Grow Act*, outlines the approach to land use planning to accommodate future population and employment growth while managing congestion, reducing greenhouse gas emissions and preserving the quality of life in the Greater Toronto Hamilton Area (GTHA). The core strategy is one of intensification to limit the spread of the urban region, and increasing transit modal share to help manage congestion on the roads.

York Region encompasses a large area, approximately 1,756 square kilometres. In an effort to focus growth, York has identified Markham Centre, Newmarket Regional Centre, Richmond Hill Centre and Vaughan Corporate Centre as Centres, which have also been designated as Urban Growth Centres in the *Growth Plan*. In these regional centres York Region and the local communities are committed to building compact, mixed-use developments. Consistent with this objective, York Region introduced the VIVA bus system in 2005 to provide a more reliable and dedicated bus-based transit service along the corridors to link the four town centres.

York Region is one of the fastest growing areas within the GTHA and has grown rapidly from a predominantly rural and agricultural area to an urban and employment centre. Between 1991 and 2008 the population of York Region doubled to more than one million people and the rapid growth is expected to continue with population increasing to an estimated 1.5 million people by 2031, an increase of 500,000, equivalent to half the population of the entire urban area of Ottawa-Gatineau.

It is also anticipated that employment growth will follow suit. Based on Provincial projections in *Places to Grow*, the employment levels in York Region will reach 780,000 in 2031, double the 2001 employment.

This strong growth is expected to generate some 50% more traffic on the region's roadways over the next 25 years and will add to congestion, particularly in the peak periods.

Travel patterns are also changing. Increasing employment in York Region has increased the trips made from Toronto to York Region. The Transportation Tomorrow Survey estimates that for

every 100 trips travelling south from York Region to Toronto, there are 60-65 trips¹ going north. East-west travel demand is also increasing as a result of York Region's growing employment centres in Markham and Vaughan.

Project Objectives

By building VIVANext York Region is seeking to address the following objectives:

- I Manage congestion in a rapidly growing community by increasing transit ridership and modal share. The existing transit mode share is less than 10% of all peak period trips in the region. York Region's goal is to increase the transit mode share to 33% within the Urban Growth Centres and 22% on a region-wide basis.
- I Improve mobility within York Region as well as between neighbouring communities and improve inter-modal connectivity and system-wide integration. Specifically, improve connectivity to local bus services, GO Transit commuter rail and express buses and to the TTC subway system.
- I Promote mixed land use development, increase density and prevent urban sprawl by supporting intensification of land uses and encourage transit-oriented development along rapid transit corridors.

With the expected growth in York Region the existing VIVA system, comprised of buses operating in mixed traffic, will become inadequate in terms of capacity and reliability in a number of corridors, particularly in the 'core' of the network between Finch and 19th Avenue on Yonge Street and east and west of Richmond Hill Centre along Highway 7.

With the proposed upgrades to the VIVA service identified by York Region as VIVANext, it is anticipated that York Region's regional and inter-regional transit connections will be improved by the faster, more frequent and reliable service made possible by segregated bus Rapidways. These improvements are considered to be critical to York Region's ability to manage congestion management, improve mobility and manage development.

Project Overview

The existing York Region VIVA system opened in 2005 and currently consists of 90 clearly branded and mostly articulated buses, which run in mixed traffic. In December 2008, 11 new articulated buses will be added to the fleet. Figure 1 shows the existing network.

The VIVA system utilizes clearly defined bus stops that provide real-time information about approaching buses. The bus stops also contain automated ticket machines for purchase and validation of tickets before boarding.

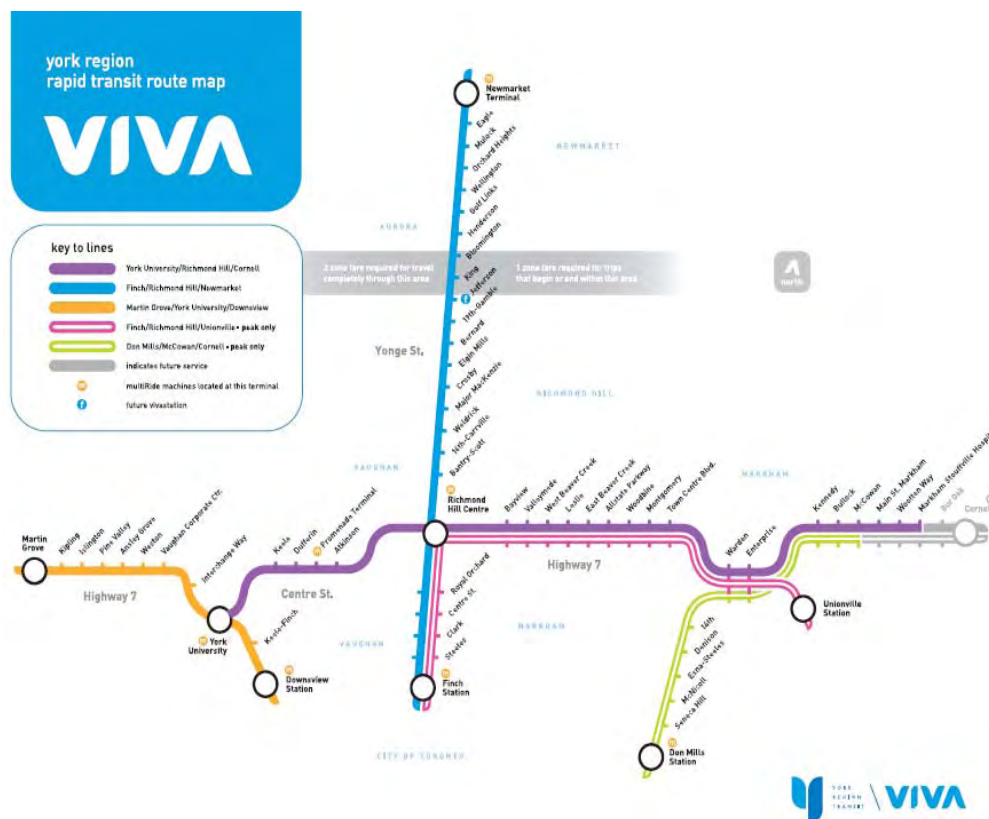
¹ Transportation Tomorrow Survey

Service is provided every 3 to 10 minutes (depending on route) in peak periods and every 15 minutes in non-peak. Since the VIVA system was introduced in 2005, VIVA ridership has experienced considerable growth and grew 16 percent between 2006 and 2007. This trend is expected to continue through 2008 with annual increase of 14 percent bringing the total annual passenger trips to approximately 6.8 million.

In addition to linking the four designated urban growth centres, the existing VIVA system also connects to transit services in the GTHA, not limited to, but including:

- | GO Rail and bus transit at Richmond Hill Centre;
- | Finch, Downsview and Don Mills subway stations in the City of Toronto;
- | Brampton Transit at Finch Station; and
- | Unionville and Newmarket GO stations.

FIGURE 1 - VIVA NETWORK MAP



The existing VIVA system has been implemented as a precursor to the VIVANext - a BRT system where the main focus is on building completely segregated bus lanes with signal priority that would improve run times and service reliability, by giving buses exclusive use of bus lanes.

In the future, the broader regional network connecting to VIVA would also include routes proposed in the draft Metrolinx Regional Transportation Plan:

- | Jane LRT
- | Don Mills LRT
- | Bolton regional rail
- | Havelock regional rail
- | Improved Barrie regional rail

PART B OPTIONS

Project Options

In collaboration with York Region and Metrolinx, two options for VIVANext have been identified – a full build-out of the bus rapid transit network by 2018 and a phased approach to be completed by 2026. These two options will be compared to the Base Case which is represented by the existing network.

Base Case

The Base Case is defined as the existing York VIVA network. Specifically this means:

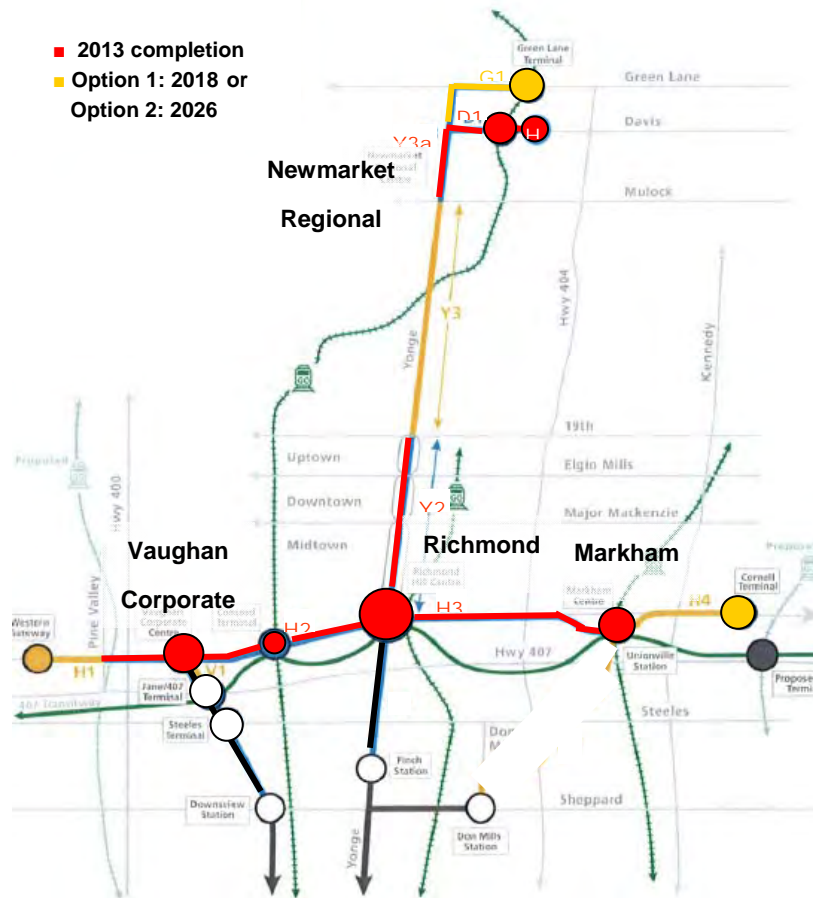
- | Buses will continue to operate in mixed traffic.
- | Frequency of service and capacity remain the same, but will include any planned enhancements anticipated with the addition of 11 new articulated buses in December 2008.
- | Additional buses will be procured in the future to provide sufficient capacity to meet the anticipated demand in the absence of any additional network improvements.
- | The Cornell Terminal will be built out by 2010.
- | The Toronto-York-Spadina subway extension will be in operation by 2015.
- | The Yonge North Subway (section Y1) between Richmond Hill and Finch Station will be converted to subway by 2016 / 17 as per the RTP².

Option 1 – York Region’s “Moderate Scenario”

Option 1 is what York Region refers to as the “Moderate Scenario” of VIVANext. This option assumes a full build-out of Rapidways (segregated and dedicated lanes for buses) on most, but not all of the network segments shown in Figure 2.

² The extension of Yonge North subway will be analyzed as a stand-alone project. The merits of a subway versus BRT in terms of increased capacity and economic gain will be assessed as part of the Yonge North subway extension project.

FIGURE 2 - YORK REGION RAPID TRANSIT NETWORK



Specifically, the sections that are contemplated for Rapidways are:

- | Section Y2 - Yonge St: Richmond Hill Centre north to 19th Avenue
- | Section Y3 - Yonge St: 19th Avenue to Green Lane in Newmarket
- | Section H1 - Hwy 7: Hwy 50, east of Pine Valley in Vaughan
- | Section H4 - Hwy 7: Kennedy Road to Cornell
- | Section D1 - Davis Drive in Newmarket
- | Section G1 - Green Lane in East Gwillimbury
- | Section H2 - Hwy 7: Pine Valley to Richmond Hill Centre
- | Section H3 - Hwy 7: Richmond Hill Centre to Kennedy Road in Markham

It should be noted that due to physical constraints or local conditions, rapidways are sometimes not planned for all of a segment's length.

Section Y1 is assumed to have the Yonge North subway extension in place by 2016 /17.

The frequency of service is assumed to vary between 2 and 5 minutes in peak periods. Based on this range of service frequencies, capacity will range between 1,080-2,700 passengers per hour per direction. A total of 197 buses will be required in 2021.

The capital cost for this option is estimated at \$2.3 billion in 2008 "as-spent" dollars.

Option 2 – Deferred Moderate Scenario

This option includes a deferral of some of the Rapidways sections to 2026 in order to reduce capital costs. The following four sections would be deferred:

- | Section Y3 - Yonge Street between 19th Avenue to Mulock Drive
- | Section H1 - Hwy 7: Hwy 50, east of Pine Valley in Vaughan
- | Section H4 - Hwy 7: Kennedy Road to Cornell
- | Section G1 - Green Lane in Newmarket

This would result in approximately 40% of the capital costs being deferred. The other segments would be implemented as planned in Option 1 because:

- | Sections H2, H3 and Y2 represent the 'core' of the system;
- | Section D1 links Southlake Regional Health Centre, Newmarket GO station, and the Newmarket Centre Urban Growth Centre, and has been identified as a priority area by York Region; and
- | Section Y3 (between Mulock Drive and Davis) through the middle of Newmarket Urban Growth Centre to ensure the value of Section D1 is maximised.

Consideration was given to providing HOV lanes within the existing road space to create a lane for buses to bypass general traffic congestion. This was seen as a cost mitigation measure while allowing most of the users of the system to benefit from the Rapidways travel time savings in the most congested and busiest sections of the network. However ultimately this concept was excluded from the option as it raised a number of issues that deemed it impractical including:

- | Potential policy and public support issues within York Region;
- | Significant increase in general traffic congestion;
- | Ridership potential and effect on the VIVA brand; and
- | Effect on operating costs and fleet size.

The capital cost for this option is estimated at \$1.3 billion in 2008 “as-spent” dollars for the sections to be immediately constructed, with the remainder of the system constructed before operations commence in 2026.

Summary of Options

Table 1 summarizes the Base Case and the two options that are evaluated in this Benefits Case. To illustrate the effect of deferring the sections outlined above, it is assumed in this analysis that all sections be completed by 2026. This is strictly an assumed date for the purpose of this comparative analysis.

TABLE 1 VIVA OPTIONS (OPENING YEAR IN BRACKETS)

Section	Base Case	Option 1	Option 2
Y1	Subway (2016)	Subway (2016)	Subway (2016)
Y2	No change	Rapidway (2013)	Rapidway (2013)
Y3	No change	Rapidway (2013)*	Rapidway (2013/2026)**
H1	No change	Rapidway (2018)*	Rapidway (2026)
H2	No change	Rapidway (2013)	Rapidway (2013)
H3	No change	Rapidway (2013)	Rapidway (2013)
H4	No change	Rapidway (2018)*	Rapidway (2026)
D1	No change	Rapidway (2011)	Rapidway (2011)
G1	No change	Rapidway (2018)*	Rapidway (2026)

* Between Mulock and Davis only, the remaining Y3 sections in 2018

** Between Mulock and Davis only, the remaining Y3 sections in 2026

PART C ASSESSMENT

Evaluation Framework

The comparative analysis uses a Multiple Account Evaluation (MAE) methodology. The MAE is a framework that provides a systematic identification and analysis of broader implications and criteria of an option. It systematically compares the benefits accruing to people and communities, the broader economy and environment against the cost of building and operating the project and clearly shows the trade-offs among the often conflicting criteria.

The MAE framework includes a number of evaluation accounts that together address the most significant project performance and policy considerations for a specific project. The criteria within each account can be tailored to fit each specific project and situation. The relevant accounts for the analysis of the VIVANext project are:

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

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

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

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

Transportation User Benefits

This account considers the direct incremental benefits that accrue to the transportation users as a result of the investment in VIVANext. The monetized benefits include travel time savings for both transit users and road users, automobile operating cost savings achieved by individuals as their trip times or overall automobile usage declines; and reduction in accidents as a result of declining automobile usage.

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

Travel Time Benefits

With the construction of the dedicated Rapidways, the journey time and reliability of the service will improve and reduce the travel time for existing as well as for new transit users and drivers. Travel time savings for transit users are substantial, over 20 minutes for trips between Aurora and Markham, between Aurora and Vaughan and between Markham and Aurora³. However the differences between Option 1 and Option 2 are small e.g. from Pine Valley to Vaughan there is less than a minute difference in time savings between the options.

The time savings for auto users are also substantial and grow over time as congestion increases. Total travel time savings for both transit and auto users are estimated at 6.7 million hours in 2021 increasing to 11.4 million hours in 2031 for Option 1. Option 2 shows slightly less travel time savings in 2021 6.3 million hours, but has the same amount of travel time savings in 2031 (which is expected as the improvements are identical).

The value of this “saved” time is estimated at an average value of \$13 per hour⁴ and is expected to grow, in real terms, by 1.6% per year over the period. Total travel time savings are estimated to \$1,490 million under Option 1 and \$1,461 million under Option 2 expressed in net present value.

The relatively small difference in travel time benefits between the two options is explained by the fact that the majority of travel time savings are concentrated in the core of the system, where the bulk of the trips are, and most congestion is projected to be.

³ This is based on forecast travel in the AM peak hour in 2031.

⁴ See Appendix A for details on how this estimate was derived.

Automobile Operating Cost Savings

The analysis shows that the investment in VIVANext will reduce automobile usage. Under Option 1 in 2021 an estimated 18 million fewer vehicle kilometres will be driven annually. Option 2 is slightly less at 16.7 million kilometres (or 8% less). By 2031, the reduction is estimated at 44.5 million kilometres per year and is identical between the two options. The value of automobile savings over the period is estimated at \$53.1 million for Option 1 and \$51.9 million for Option 2 in net present value.

Safety Benefits

Safety benefits stem from a reduction in accidents as there is less congestion and fewer kilometres driven. The total value of safety benefits over the period is estimated at \$17.7 million for Option 1 and at \$17.3 million for Option 2, in net present value.

Qualitative Transportation User Benefits

It is envisioned that VIVANext will be a state-of-the-art bus system to enhance the appeal to prospective users and reduce the negative aspects often associated with buses. Stations will be more like light rail stations, covered and offering protection from the elements for waiting passengers and built to very high standards.

New, state-of-the-art buses will be equipped with internet capabilities to appeal to the business professional commuter. Features that are currently in place, like ticket vending machines allowing the passengers to pre-purchase the ticket and real-time information displays at the station will continue to be available and further emphasize the appeal of the bus system.

The segregated Rapidways will ensure more reliable service and the frequency of service will increase. These benefits are already captured in the travel time benefits, but need special mention as any demand model will still have a difficult time valuing this objectively and it is uncertain as to the true impact on ridership.

The difference in customer convenience and comfort is negligible between the two options due to relatively low ridership in those sections that will be built later. However, even the passengers travelling from Newmarket and from east of Markham will benefit from more reliable, frequent and faster service due to the improvements in the core.

Summary

As shown in Table 2, Option 1 has approximately \$31 million, or 2%, higher transportation user benefits compared to Option 2; the difference in benefits between the full VIVANext network being in place earlier, and deferring the construction of the outer sections.

TABLE 2 INCREMENTAL TRANSPORTATION USER BENEFITS

All Values in NPV \$m	Option 1	Option 2	Difference (2-1)
Travel Time Savings	1,490	1,461	(29)
Automobile Operating Cost Savings	53	52	(1)
Accident Reductions	18	17	(0)
Total Transportation User Benefits	1,561	1,530	(31)

Financial Account

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

Capital Costs

The capital costs include all costs associated with the construction and acquisition of the infrastructure, revenue collection, vehicles, and a new maintenance centre. The estimates also include, design, management & administration, insurance, environmental permitting, property, contingencies and interest during construction.

The estimated incremental capital cost compared to Base Case expressed in non-inflated dollars is the same for both options -\$2,210 million. However, expressed in “as-spent” (inflated) dollars the capital cost for Option 1 is estimated at \$2,322 million based on a construction period of 2009 to 2018; and \$2,659 million for Option 2 based on having the core of the system, costing \$1,330 million, complete by 2018 and the whole system completed by 2026.

In order to allow a like-with-like comparison between the two options and to reflect time value of money, the capital cost cash flows are discounted which results in a net present value of \$1,778 million for Option 1 and \$1,509 million for Option 2. The \$269 million lower cost for Option 2 is a reflection of the capital costs occurring further out in the future.

Operating Costs

Annual operating costs are based on York Region’s average operating cost per service hour. Total incremental operating costs over the period for Option 1 are estimated at \$278 million and for Option 2 at \$263 million, in net present value terms. Higher operating costs in Option 1 are as a result of more buses coming into operation earlier than in option 2, in line with the earlier opening of certain Rapidway sections.

Ridership and Revenues

Ridership demand for the VIVA system under the Base Case is estimated to grow to 28 million in 2021 and 31 million in 2031. The demand model results⁵ show that with the investment, ridership would increase approximately 8% to 30 million riders in 2021 and 34 million in 2031.

As shown in Table 3, the difference in ridership between the two options is very small and when rounded to nearest 100,000¹ the estimated annual ridership is the same. Option 1 has slightly more trips in 2021 compared to Option 2, which is to be expected given that the Rapidways are fully built out under Option 1. In 2031 the ridership is identical between the two options as the networks are the same. The results suggest there are relatively few new additional passengers as a result of the investment in the outer sections of the system. The majority of new riders are found in the core of the system.

TABLE 3 RIDERSHIP

	Base Case	Option 1	Option 2
Annual Ridership in 2021 (million)	28.0	30.3	30.3
Annual Ridership in 2031 (million)	31.3	34.0	34.0

Note that the Greater Golden Horseshoe Travel Forecasting Model, in common with most forecasting models, assumes the same land use for the Base Case and the two options i.e. any densification and/or additional development spurred by transit is not reflected in these results. Therefore these results represent a conservative estimate of projected ridership.

The incremental fare revenues generated by additional riders attracted to the system over the period are almost identical under the two options - \$66 million for Option 1 and \$65 million for Option 2 in net present value.

⁵ Forecasts presented are based on the Greater Golden Horseshoe Travel Forecasting Model. This model has been used for the development of the Regional Transportation Plan (RTP) and ensures consistency with that work. The model is strategic in nature and the effect of small projects can be minimal. However the main purpose of the benefits case work is of a comparative nature and we consider the model adequate for this purpose.

Summary

As shown in Table 4, the net incremental cost for Option 1 is \$284 million higher compared to Option 2. This differential is driven by the higher capital and operation costs for Option 1. The difference in incremental revenues is negligible.

TABLE 4 INCREMENTAL COSTS AND REVENUES

All Values in NPV \$m	Option 1	Option 2	Difference (2-1)
Capital Costs	(1,778)	(1,509)	269
Operating Costs	(278)	(263)	15
Incremental Costs	(2,056)	(1,771)	284
Incremental Fare Revenues	66	65	(1)

Comparing Benefits and Costs

Table 5 summarizes the incremental user benefits generated by the VIVA project compared with the incremental costs of building and operating the system. As shown, Option 2 has a slightly higher benefit-cost ratio of 0.9 compared to 0.8 for Option 1, but both options have a negative net present value - Option 2 has a negative net present value of \$241 million and Option 1 has a negative net present value of \$495 million.

As mentioned previously, the transportation user benefits should be viewed as conservative as the Greater Golden Horseshoe Travel Forecasting Model assumes that the land use is fixed and does not account for incremental ridership and travel time savings as a result of building more compact communities as is planned in the York Region.

TABLE 5 INCREMENTAL COSTS AND REVENUES

All Values in NPV \$m	Option 1	Option 2
Transportation User Benefits	1,561	1,530
Incremental Costs	(2,056)	(1,771)
Net Benefits (Costs)	(495)	(241)
B/C Ratio	0.8	0.9

Environmental Impacts

This account examines the environmental impacts of the options. The major environmental impact with respect to urban transit projects is the ability of the project to reduce greenhouse gas emissions.

In addition, and where applicable, this section will also summarize the differences between the options as to the nature and significance of the environmental impacts of the construction. These will be addressed qualitatively and at a high summary level and strictly for the purpose of comparing the relative impacts of the options. The majority of the sections of the VIVA project have received environmental clearance. The only outstanding sections are Y3, D1 and G1. More detailed environmental impact analysis will be undertaken as part of the mandatory environmental assessment process for the preferred option that is selected, to go forward to implementation.

Greenhouse Gas Emissions

Due to the total reduction in automobile kilometres driven, there will be some reduction in greenhouse gas emissions. Total reduction in CO₂ emissions in 2021 compared to the Base Case is estimated at 3,800 tonnes for Option 1 and 3,300 tonnes for Option 2. In 2031 the amount increases to an estimated 8,800 tonnes of CO₂ reduced for both options. This is based on CO₂ emissions of 0.21kg per km in 2021 and taking account of anticipated changes in fuel efficiency e.g. emissions reduce to 0.20kg per km in 2031.

The total value of the reduced CO₂ emissions over the 30-year period is estimated at \$1.9 million for Option 1 and \$1.7 million for Option 2 - a relatively insignificant portion of the overall benefits of the project.

Other Environmental Impacts

Most sections of the VIVA project have gone through the Environmental Assessment process and received the environmental certificate required to proceed. The environmental impacts were in most cases deemed to have a positive or neutral impact on the environment and where the project would cause negative impacts, mitigation measures will be implemented. For example, noise from increased amount of buses is mitigated by locating the Rapidway in the median, the visual impact and in some places, intrusion, of the structure will be mitigated through landscaping and design. The capital cost estimate has an allowance for mitigation costs.

The Environmental Assessment did not uncover any “shows-stoppers” that would either increase the cost prohibitively or create un-mitigable environmental impacts. Also, the environmental impacts would be the same under both options, with the impacts happening sooner under Option 1.

Other Economic Impacts

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

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

Temporary Economic Impacts Generated by Construction

The construction of the Rapidways will generate both direct and indirect economic benefits that are temporary in nature and span the schedule of construction. As shown in Table 6, it is estimated that the construction of the VIVANext will generate more than \$1 billion in GDP, including approximately \$460 million in aggregate wages that will support 12,000 person-years⁶ of employment over a ten-year construction period for Option 1 (2009-2018) and over a 16-year construction period for Option 2 (2009-2025).

The total direct and indirect regional effects will generate almost 19,000 person-years of employment and \$1.6 billion in GDP. The indirect impacts represent the effects from buying supplies and material from regional suppliers that in turn generate employment.

As the construction schedule for Option 2 stretches to 2025, regional construction impacts will lag until Option 2 is fully implemented.

⁶ Based on Province of Ontario Multipliers, 2004.

TABLE 6 IMPACTS DURING CONSTRUCTION PERIOD

	Direct Impacts			Regional (Direct + Indirect) Impacts		
	Employment (person years)	Wages (\$m)	GDP (\$m)	Employment (person years)	Wages (\$m)	GDP (\$m)
Option 1 (By 2018)	12,200	\$460	\$1,020	18,900	\$710	\$1,580
Option 2 (By 2018)	7,200	\$270	\$600	11,200	\$420	\$940
Option 2 (By 2026)	12,200	\$460	\$1,020	18,900	\$710	\$1,580

Long-term Economic Impacts

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

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

Table 8 summarizes the annual direct and indirect economic impacts the VIVA project will have during the operational phase for the years 2021 and 2031. As shown, there is not a large difference in economic impacts between the options in 2021. Option 1 shows slightly higher direct economic benefits than Option 2 and is estimated to generate an incremental \$20 million in GDP, \$9 million in wages and to create more than 200 jobs. If indirect effects are included the SDP increased to \$28 million per year, with \$13 million in incremental wages and 335 new jobs.

In 2031 the impacts are identical under the two options. The direct economic impacts are estimated to double by 2031 and the total (direct and indirect) economic impacts are expected to triple in the same period.

TABLE 7 DIRECT AND INDIRECT ANNUAL ECONOMIC IMPACTS

	Direct Annual Impacts			Direct and Indirect Annual Impacts		
	Employment. (Jobs)	Wages (\$m)	GDP (\$m)	Employment. (Jobs)	Wages (\$m)	GDP (\$m)
Option 1 (2021)	232	\$9	\$20	335	\$13	\$28
Option 2 (2021)	222	\$8	\$19	320	\$12	\$27
Option 1 (2031)	570	\$21	\$48	820	\$31	\$69
Option 2 (2031)	570	\$21	\$48	820	\$31	\$69

Land Value Changes

Based on experience from around the world, there is evidence that investment in rapid transit can have a positive impact on property values, specifically around station areas. The area of influence around a transit station varies with the technology - the more permanent and the faster (higher capacity) the technology, the larger the area of influence. The catchment area around BRT stations is typically found to be 400 meters.

There have been a very wide range of studies of North American transit projects to identify the impacts of transit investment on land values. These studies show that the premium placed on property values can fluctuate widely for different transit projects. There is relatively little documented work on the impacts of BRT compared to other transit technologies, and while the BRT may be viewed as positive in terms of increased accessibility, it is also often cited as having a less desirable impact on urban environments due to emissions and noise.

York Region has the benefit of directing planning for both land use and transit. The York Regional Official Plan⁷ has designated the proposed VIVA corridors as high density corridors to promote the development of intensification and mixed-use communities (particularly within the four Urban Growth Centres/Mobility Hubs). This creates a unique situation where transit planning can support the regional goal of densification and act as a catalyst for development. While a distinction must be made between the land value uplift generated by planning policy, and the uplift generated by transit accessibility, in this case the two are inextricably linked, as congestion in the corridor and the Region's planning documents are founded on the VIVANext program proceeding.

⁷ Regional Official Plan Amendment #43, The Centres and Corridors Strategy, York Region

As such, the provision of additional capacity in the transportation system will facilitate higher density in the corridor through higher permitted densities in areas served by the VIVA rapidways. Due to this coordinated planning it is expected that the VIVANext system would have a more significant impact on land values than the average rapid bus system in North America.

Also, the new segregated and dedicated Rapidways as contemplated in the VIVANext system, will be viewed as fairly permanent and therefore may have an impact closer to LRT projects in North America than to BRT projects. While noise, emissions, and rider preference for rail will continue to have an influence, VIVANext can be expected to perform better than a BRT system that uses curb lane priority measures or similar alignments.

Based on the average for North America and benchmarks from the Government of Canada, a rapid bus system would have a modest positive impact a 2-4% premium on residential and office space and 1-2% on retail on property values within a 400-meter radius of the stations. However, based on York Region's integrated planning the land uplift will likely be higher. Preliminary work indicates that the premium could be 5% or more, but more detailed work is being undertaken to substantiate this value.

The impact of VIVA on property values would be strongest in areas where high employment and population growth is expected, including:

- | Highway 7 from Vaughan to Markham Centre,
- | Highway 7 between Markham Centre and Cornell, and
- | Yonge Street around Newmarket.

Given York Region's direction to structure growth in Regional Centres and Corridors, the phasing plan indicates that Option 1 will have a greater impact, sooner, in most of the corridors. Since land value uplift and land use impacts of transit investment are tied to the certainty and timing of construction, many developers will not commit to major projects until the transit investment is a certainty (or in some cases, until construction begins). Consequently, the timing of construction for H1, H4, and Y3 could affect the timing of land value impacts and broader land use impacts.

Option 2 will have a later impact on land use and, although the impact may ultimately be the same as in Option 1, the overall land value benefit would likely be lower in Option 2 as the benefits would not only be achieved some eight years later in certain segments, but also because their growth potential may be constrained by development that has occurred in the subject areas during this period of time.

However, even though these areas do not get the Rapidways in 2018, the passengers will benefit from the improved travel time, frequency and reliability of service in the core resulting in improved accessibility for the outer areas.

Summary

Table 8 summarizes some of the key results of the other economic impacts of the VIVA project.

TABLE 8 INCREMENTAL ECONOMIC IMPACTS

	Option 1	Option 2
Direct and Indirect Impacts during Construction (2021):		
Employment (PY)	18,900	11,200
GDP (\$m)	\$1,600	\$940
Direct and Indirect Long-term Impacts (annual 2021):		
Employment (jobs)	335	320
GDP (\$m)	\$13	\$12
Land value increase	Generalized premium of at least 5%; higher in key station areas and Hubs/Urban Centres.	Generalized premium of at least 5%; higher in key station areas and Hubs/Urban Centres. Delayed in Newmarket and east of Markham Centre.

Social Community Impacts

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

Land Use

York Region is quickly changing from a rural area mostly serviced by cars to a more urban, more compact environment with more transit. The investment in VIVA is a tool to further support transit oriented development and prevent urban sprawl. As mentioned in the section on *Land Value Changes* the benefit York Region has is that it can influence and direct both land and transit planning and ensure that they work together to support intensification of communities while reducing the dependence on the automobile.

Compact, dense communities require good transportation choices. The development in and around Markham Centre is an example of where mixed use development is integrated and supported by transit. It is an example of where transit acts as an enabler – it makes it possible to reduce the number of parking spaces for residences as well as offices, which in turn will attract people and employees that do not necessarily have a car.

Although rapid bus generally have a lower impact on land values than other type of transit technologies, in combination with York Region's land planning policies and the permanence of Rapidways, VIVANext will support and accelerate the development of more compact and complete communities in the four Urban Growth Centres. Complete communities with mixed use development encourage more walking and bicycling.

There is very little difference between the two options in their ability to promote mixed use and compact communities. Under Option 2, Newmarket and Highway 7 east of Markham, could possibly see a delay, but even those communities will benefit from the improvements in the core where the congestion is by getting more reliable and frequent service.

Health

Bicycle lanes and improved pedestrian facilities are included in VIVA's plans to further promote more cycling and walking in the communities.

Due to the regional nature of the demand model and the fact that it cannot pick up nuances such as new bike lanes in a specific location, there is no noticeable difference in mode share for pedestrians and cyclists by the investment in VIVA. The non-motorised mode share in 2021 is estimated at 4% increasing to 5% in 2031 under all scenarios. However, improved transit is an important part of fostering the development of transit-oriented and pedestrian-friendly communities, which in turn encourages healthy lifestyles which incorporate walking and cycling.

Traffic and Community Impacts

New lanes will be added to Highway 7 and Yonge Street to accommodate the Rapidways in the median. It is expected that there will be limited disruption to traffic during construction as road capacity is added on the side.

The introduction of the Rapidways will provide York Region with the opportunity to create streetscapes which reduce the influence of the car e.g. banning left turns, reducing road widths, etc. A further advantage of the Rapidways is that they create pedestrian refuges in the median improving the ability of pedestrians to cross the road, particularly for seniors.

Under Option 2 these impacts would be delayed and the full benefits not achieved until at a later date.

The construction of new lanes will require the purchase of new right-of-way and this is being addressed in the Environmental Assessment process. Environmental approval has been received for all sections except for segments Y3, D1 and G1.

Summary

TABLE 9 INCREMENTAL SOCIAL COMMUNITY IMPACTS

	Option 1	Option 2
Land Use Impacts	Modest catalyst for more compact development	Modest catalyst for more compact development, but delay in Newmarket and east of Markham Centre.
Health	New transit riders may arrive by foot or bicycle	New transit riders may arrive by foot or bicycle
Traffic and Community Impacts	Positive effect as improved streetscapes	Positive effect as improved streetscapes, but delay in Newmarket and east of Markham Centre.

Sensitivity Analysis

The results in this report are based on a number of assumptions with inherent uncertainties. Costs and ridership forecasts are based on the best available information, but are in the end just forecasts. In order to test the robustness of the assumptions, sensitivity analyses are undertaken to measure the importance of the assumption.

Discount Rate

Since the VIVANext analysis is about comparing the timing of the implementation of the system, the cash flows have been discounted using different discount rates (3% and 7%) to ensure that the ranking of the options does not change or is dependent on a certain discount rate.

As shown in Table 10, the ranking between the two options does not change – Option 2 still has the highest benefit-cost ratio under all three discount rates.

TABLE 10 DISCOUNT RATE SENSITIVITY ANALYSIS

All Values in \$m	Net Benefits (Cost)		
	NPV @ 3%	NPV @ 5%	NPV @ 7%
Option 1	(39)	(495)	(751)
Option 2	139	(241)	(452)
Difference (2-1)	178	254	298

Break-Even Analysis

Table 11 below summarizes the reduction required in capital costs, the value of time and increase in transit travel time savings for the VIVA project to break even assuming a 5% discount rate.

TABLE 11 BREAK-EVEN ANALYSIS

Discount Rate @ 5%	Option 1	Option 2
Reduction in Capital Costs	38%	19%
Value of Time (\$/hr)	17.35	15.25
Increase in Travel Time Savings (all users)	33%	16%

Summary Results

This section summarizes the results from the assessment indicating each option's performance relative to the Base Case.

TABLE 12 SUMMARY OF ASSESSMENT FOR VIVA OPTIONS

	Option 1	Option 2
Transportation User Benefits (NPV \$m)	1,560	1,530
Incremental Costs (NPV \$m)	(2,056)	(1,771)
Net Benefits (Cost)	(495)	(241)
Benefit-Cost Ratio	0.8	0.9
Environmental Impacts		
Net GHG Reduction (NPV \$m)	1.9	1.7
Qualitative Impacts	Slight positive	Slight positive
Other Economic Impacts		
Construction impact	Positive and accelerated	Positive and partially delayed
Long-term impacts	Very positive	Very positive but delayed
Land value impact	Positive	Positive, but delayed in key sections
Social Community Impacts		
Land Shaping Potential	Positive	Positive, but delayed in some key sections
Health and Quality of Life	Neutral	Neutral
Traffic and Community Impacts	Positive	Positive, but delayed in some key sections

The analysis shows that the deferral of the outer segments - west of Vaughan Corporate Centre, east of Markham Centre and between 19th Ave and Mulock on Yonge Street - has a very limited effect on the transportation user benefits, but reduces the capital cost substantially. Option 2 has \$284 million lower cost but only \$30 million lower benefits compared to Option 1.

Even though Option 2 shows a higher net present value, the cost of building and operating the system outweighs the estimated transportation user benefits for both options. The negative net present value for Option 2 is \$241 million versus \$495 million for Option 1.

The negative net present value is balanced by the positive effects the project will have on the broader economic and social goals, such as employment, land values and land use shaping.

The VIVANext project and York Region's land use policies are closely aligned and it is expected that the project will have a major impact on accelerating intensification along the VIVANext corridors. Many sections of the VIVANext corridors are heavily congested and additional transportation capacity (and therefore development) will only be feasible by increasing the efficiency of existing corridors, such as through VIVANext. From this perspective, Option 1 will have a more immediate and slightly larger effect than Option 2.

The project will also generate incremental employment in the York Region - some 18,900 person-years of employment during construction and approximately 830 jobs per year by 2031. Both options will ultimately have the same effect, but under Option 2 it will take longer to build the employment.

APPENDIX
A
INPUT VARIABLES AND ASSUMPTIONS

Factor	Value	Source
Discount Rate	5% (real terms)	Province of Ontario
Sensitivity Analysis	3% and 7%	
CPI	3% per annum	
Value of Time Business Other Weighted Average	\$35.16 (2008\$) \$10.82 \$13.02	Transport Canada, Greater Golden Horseshoe Model
Value of Time Growth	1.64% per annum	Based on GDP per capita increases, GDP/Population estimates from www.greatertoronto.org
Average Accident Cost	\$0.07 per km	Collision Statistics: 2004 Canadian Motor Vehicle Traffic Collision Statistics, TP3322. Vehicle Kilometers: Statistics Canada, Catalogue No. 53-223-XIE, "Canadian Vehicle Survey"
Greenhouse Gas Emissions 2006 2021 2031	0.23 kg /km driven 0.21 0.20	Urban Transportation Emissions Calculator, Transport Canada
Average Cost of CO ₂	\$0.01 / km driven	Several literature sources, Transport and Environment Canada, Greater Golden Horseshoe Model and http://envirovaluation.org/index.php/2007/09/06/university_of_hamburg_forschungsstelle_n_1
Auto Operating Costs 2006 2021 2031	In 2008\$: \$0.15 /km \$0.20 \$0.23	Greater Golden Horseshoe Model
Average Cost per Service Hour	\$107	York Region
Annualisation Factors: Inter-regional BRT/LRT Road	Peak-daily/Daily-Annual 3 / 300 10 / 300	Greater Golden Horseshoe Model

CONTROL SHEET

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